Smoking, Drinking, and Income

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ABSTRACT

In an effort to increase understanding of the "alcohol/income puzzle"—the finding that drinking appears to lead to higher income—this paper presents maximum simulated likelihood estimates of a system of limited dependent variables governing smoking and drinking patterns and income. With all else held constant, moderate drinking is associated with 10 percent higher income, and heavy drinking associated with 12 percent higher income, than drinking abstention. Smoking is associated with larger effects on income than drinking: Single-equation estimates suggest smokers earn 8 percent less than nonsmokers, and the smoking penalty rises to 24 percent after correcting for endogeneity.

I. Introduction

The possibly counterintuitive but oft-replicated finding that moderate and even heavy drinking increases wages—the "alcohol-income puzzle"—has been of much interest recently (Berger and Leigh 1988; Cook 1991; Heien 1996; MacDonald and Shields 2001). The result is consistent with the medical literature which finds that moderate alcohol consumption may improve health (Shaper 1988), but remains even when controlling for health status and correcting for endogeneity. However, Mullahy and Sindelar (1989, 1991, 1993) find that problem drinking is associated with lower income, and the existence of a penalty for heavy versus moderate drinking is in dispute (French and Zarkin 1995; Hamilton and Hamilton 1997). The effect of smoking on

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[Submitted January 2000; accepted April 2004]
ISSN 022-166X E-ISSN 1548-8004

income, conversely, has received relatively little attention, and the effect of drinking is usually estimated without controlling for smoking status. Smoking and drinking are highly correlated, therefore failing to control for one when estimating the effect of the other may lead to serious bias. Kenkel and Wang (1999), for example, discover that controlling for smoking reduces the estimated impact of drinking on receiving major fringe benefits. Leigh and Berger (1989) and Levine, Gustafon, and Velenchik (1997) report that smoking is associated with lower wages. This study extends previous results by presenting estimates of the effects of drinking patterns and smoking on income, treating use of both substances as potentially endogenously determined.

The possible endogeneity of substance abuse to income has been emphasized in the literature. Changes in income may cause changes in abuse patterns leading to "reverse" causation in wage equations. Further, unobserved personal characteristics, such as rate of time preference, may affect both substance use and wages. Studies estimating the impact of alcohol use on labor market outcomes which treat substance abuse as exogenous often come to significantly different conclusions from those which do not. These estimates are often implausible in magnitude and are not consistent across studies.[1] In this paper a novel econometric model is developed to study the joint determination of both drinking and smoking patterns along with income. The equation of interest has a limited dependent variable and multiple endogenous dummy variables, which are in turn determined by probit and multinomial probit submodels.

The model is estimated using repeated cross-sections on Canadian prime-age male workers. The major results are as follows. After correcting for endogeneity, the effect of smoking on wages (–24 percent) is estimated to be larger in magnitude than that of either drinking absention (–10 percent) or heavy drinking (+2 percent) relative to moderate drinking. Robustness checks suggest these results are not sensitive to choice of instruments or to whether health status is held constant. Not controlling for smoking when estimating the effect of drinking on wages leads to modest bias. Similarly, failure to control for drinking when estimating the effect of smoking on wages leads to a moderate underestimate of the effect of smoking on wages. Overall, the results suggest that controlling for endogenously determined smoking choices does not substantially reduce the puzzling aspects of the relationship between drinking and labor market outcomes, and also suggest a new puzzle: In cross-section analysis, the negative effect of smoking on income is estimated to be very large.

II. Data

Cycles 1 (1985) and Cycle 6 (1991) of the Canadian General Social Survey are the main data sources (hereafter, GSS-1 and GSS-6). Each is a random sample of Canadians aged 15 and over, the former conducted in Fall 1985 and the latter

1. For example, Zarkin et al. (1998) do not report estimates from an instrumental variables approach since the estimated effects of alcohol use range from 50 percent to 200 percent. Berger and Leigh (1988) estimate returns to alcohol use of 45 percent for males, whereas the effect is 8 percent when drinking is treated as exogenous. Hamilton and Hamilton (1997) estimate heavy drinking reduces income by –76 percent; the effect is –7 percent when drinking in treated as exogenous. Heien's (1996) estimates show a return on alcohol consumption of up to roughly $8,900 when mean incomes are roughly $18,000, implying a return to drinking of up to just under 50 percent.

conducted between January and December, 1991. A sample of employed men aged 25 through 59 is extracted. The estimated impacts of drinking and smoking behavior then reflect both effects on wages and on hours worked, however, variation in hours worked among employed prime age men is small so presumably most of the effect reflects wage differentials (Hamilton and Hamilton 1997). Because men who are not employed are excluded, the coefficients in the income equation should be interpreted as reflecting variation in wages conditional on employment rather than the determinants of the more fundamental relationship governing both rejected and accepted wage offers.[2] After removing observations with missing data, the final sample consists of 1,701 observations from GSS-1 and 2,190 observations from GSS-6 for a pooled sample of 3,891 observations. Descriptive statistics and definitions of variables are presented in Table 1. Nominal prices are deflated using the all—items CPI as reported by Statistics Canada.

Income is measured subject to right-censoring in GSS-1 and as grouped data in GSS-6. The GSS-1 measure is censored at $50,000. The GSS-6 measure is only reported in intervals: $5,000 brackets from $0 to $20,000, $10,000 brackets from $20,000 to $40,000, $20,000 brackets from $40,000 to $80,000, and an over $80,000 group. These measurement difficulties are dealt with explicitly in the construction of the likelihood function; see the next section for details.

Following Hamilton and Hamilton (1997), alcohol use is categorized as one of drinking abstention, moderate drinking, or heavy drinking. An abstainer has not had a drink at least once per month during the last year.[3] A heavy drinker drinks at least once a week and had eight or more drinks in one sitting on at least one occasion in the last week. All other respondents, those who drink at least once per month, but who do not meet the criteria for heavy drinking, are moderate drinkers. The heavy drinking measure requires both frequent alcohol use and an episode of binge drinking, which is a strong predictor of problem drinking (Knupfer 1984). The indicator also classifies a similar portion of the sample as having a potential alcohol problem as Mullahy and Sindelar's (1989, 1991, 1993) measure based on medical diagnosis of alcoholism, and with estimated prevalence of alcohol dependence reported by Stinson et al. (1992).

III. Econometric Framework

The goal of the analysis is to estimate the causal effects of drinking and smoking patterns on log-income. The analysis is complicated by the nature of the

2. A probit regression including the explanatory variables in Table 2 (except occupation dummies) suggests smoking is associated with approximately 2 percent lower probability of employment (t = 1.8). Drinking abstention is associated with 7 percent lower probability of employment relative to moderate drinking (t = 5.7), whereas heavy drinking does not have a statistically or economically significant effect. Mullahy and Sindelar (1996) and Terza (2002) suggest that controlling for endogeneity may reveal a negative effect of heavy drinking on employment. Nonetheless, Zarkin et al. (1998) and MacDonald and Shields (2001) find inclusion of an inverse Mill's ratio term in wage regressions to control for sample selection into employment does not have a significant effect on wage equation estimates.

3. Unfortunately, an indicator for past drinking problems cannot be constructed from the GSSs. As in most previous related studies, lifetime abstainers cannot be differentiated from former drinkers. A mitigating consideration is that the coefficient on the dummy for "ex-drinker" Heien (1996) includes in his earnings equation has neither statistical nor economic significance, suggesting that lifetime abstainers do not earn substantially more or less than former drinkers.

Table 1
Descriptive Statistics

Endogenous outcomes			
Income	Income in 1991 $cdn	37,802.98	17,498.60
Drinking abstainer	=1 does not drink at least once/month	0.204	0.403
Moderate drinker	=1 not abstainer or heavy drinker	0.703	0.457
Heavy drinker	=1 drinks weekly and binges	0.093	0.291
Smoker	=1 daily smoker	0.329	0.470
Exogenous outcomes			
Age	Age	37.921	9.018
Age*age/100	Age-squared	15.193	7.346
High school dropout	=1 did not complete high school	0.254	0.435
High school grad	=1 graduated high school but no further	0.170	0.376
Some college or other	=1 further than high school but no degree	0.154	0.361
College grad	=1 bachelor's degree or better	0.423	0.494
Managerial	=1 managerial occupation	0.154	0.362
Professional	=1 professional occupation	0.169	0.376
Administrative	=1 administrative occupation	0.053	0.226
Service	=1 service occupation	0.156	0.362
Production/agriculture	=1 production or agricultural occupation	0.465	0.499
Excellent health	=1 self-reported health excellent	0.307	0.461
Good/very good health	=1 health good or very good	0.641	0.480
Poor/fair health	=1 health poor or fair	0.052	0.221
Physical activity	Kilocalories/week, leisure-time activity	1,788.405	1,573.801
Married	=1 currently married	0.722	0.448
Religious	=1 attends services at least once per month	0.288	0.453
Catholic	=1 religious and Roman Catholic	0.163	0.370
Alcohol price	Alcoholic beverages real price index	100.248	7.400
Cigarette price	Tobacco products real price index	100.286	25.355
Quebec	=1 resides in Quebec	0.197	0.398
Ontario	=1 resides in Ontario	0.215	0.411
Western provinces	=1 resides in prairie provinces or B.C.	0.395	0.489
Maritime provinces	=1 resides in maritime province	0.191	0.394
GSS-1	=1 observation is from GSS-1	0.437	0.496

Notes: Income statistics calculated ignoring censoring in GSS-1 and taking interval midpoints in GSS-6. n = 3,891, except for *physical activity* on which there are 3,831 observations.

endogenous variables: Drinking status is polychotomous, smoking status is binary, and income is observed as grouped data or subject to censoring. To model these simultaneously determined and limited outcomes, suppose that latent income and substance abuse patterns are jointly determined by the system

$$
\begin{aligned}
&W_i^* = Z_i\beta_1 + \phi_1 S_i + \phi_2 A_i + \phi_3 H_i + \varepsilon_{1i}\\
&S_i^* = X_i\beta_2 + \varepsilon_{2i}\\
(1)\quad &A_i^* = X_i\beta_3 + \varepsilon_{3i}\\
&M_i^* = X_i\beta_4 + \varepsilon_{4i}\\
&H_i^* = X_i\beta_5 + \varepsilon_{5i}
\end{aligned}
$$

where W_i^* is respondent i's latent income, S_i^* is latent smoking propensity, A_i^* is latent drinking abstention propensity, M_i^* is latent moderate drinking propensity, H_i^* is latent heavy drinking propensity, X_i and Z_i are vectors of exogenous covariates with $Z_i \subset X_i$ as described below, and (β, φ) are parameters to be estimated. For observations from GSS-1 income is reported as a continuous variable unless right censored at $\overline{W}$ = \$50,000 1985 dollars. For these observations, the mapping between the latent wage and its observable counterpart is $W_i = \min\{\overline{W}, W_i^*\}$. For observations from GSS-6 income is reported in interval ranges as described in the previous section. For these observations, W_i^* lies in the observable range W_i^L to W_i^H when $W_i^L \leq W_i^* \leq W_i^H$. Based on marginal distributions and assuming the errors are distributed multivariate normal, the contributions to the likelihood for this equation take the (Type 1) Tobit form for observations from GSS-1 and are integrals over intervals (W_i^L, W_i^H) for observations from GSS-6. The observed counterpart of latent smoking status is an indicator $S_i = 1(S_i^* > 0)$ for daily smoking. Drinking status is determined as follows: A_i is unity if and only if $A_i^* = \max\{A_i^*, M_i^*, H_i^*\}$; M_i and H_i are analogously defined. The system to be estimated then comprises an equation of interest with a limited dependent variable and multiple endogenous dummy regressors which are in turn determined by probit and multinomial probit (MNP) submodels.

Formal identification of the drinking MNP submodel can be achieved by normalizing the coefficients and error variance of one equation to zero and imposing one restriction on the remaining free parameters in the covariance matrix (Bunch 1991). Moderate drinking propensity is normalized to zero and the variance of ε_3 is normalized to unity to achieve identification up to scale.[4] Similarly, the scale of the smoking equation is not identified; its variance is normalized to unity. After the above restrictions are imposed, the nonlinear system is identified by the distributional assumptions even without exclusion restrictions (Maddala 1983). However, identification from functional form alone is not satisfying, so exclusion restrictions are placed on the

4. Because there are no exclusion restrictions across the equations of the drinking MNP submodel, a potential concern is poor identification of the drinking equations. Keane (1992) suggests further restrictions on the covariance matrix in such circumstances, but I did not find such restrictions to be necessary in the present context.

income equation.[5] Religious status and an indicator for Catholicism if religious are assumed to affect substance use decisions but not (directly) wages. Similar assumptions are made by Berger and Leigh (1988), Kaestner (1991, 1994), Heien (1996), and Hamilton and Hamilton (1997). The prices of alcohol and tobacco are likewise assumed to be conditionally uncorrelated with wages, but to influence smoking and drinking decisions

The strength of the instruments and overidentifying restrictions are difficult to test within the context of nonlinear system estimation. Suggestive evidence can be obtained from linear probability estimates of the substance abuse equations and linear two-stage least squares estimates of the wage equation, taking midpoints for censored observations. Staiger and Stock (1997) suggest F-statistics on excluded instruments of less than ten as a rule of thumb for flagging weak instruments. The F-statistics on the excluded instruments in the smoking, drinking abstention and heavy drinking equations are 23.45, 32.34, and 11.16, suggesting the instruments explain adequate variation in the endogenous regressors. A test of the overidentifying restriction, taking the form suggested by Davidson and MacKinnon (1993), yields a p-value of 0.87, indicating the data do not reject the assumption that the only manner in which religious sentiment and prices affect wages is through their effect on substance abuse patterns. Nonetheless, the validity of religious status indicators as instruments is questionable.

The system is estimated using a method of full information maximum simulated likelihood (FIMSL) implemented using the simulator due to Geweke, Hajivassiliou, and Keane (GHK); see Hajivassiliou and Ruud (1994) for details of the simulator.[6] The FIMSL estimator requires distributional assumptions, but has the advantages of being consistent and simulation consistent, asymptotically efficient up to simulation chatter, and yields an asymptotically correct covariance matrix estimate. The likelihood is derived in Appendix 1.

IV. Results

Table 2 presents estimates of the income equation. Specification I treats smoking and drinking status as exogenous by restricting the appropriate off-diagonal elements of the error covariance matrix to zero, whereas Specification II treats use as endogenous. In both specifications sociodemographic characteristics typically have the expected sign and are generally precisely estimated. The estimated

5. Earlier versions of this paper presented estimates of structural forms of the substance abuse equations, which require further (difficult to justify) exclusion and covariance restrictions. Further investigation showed such versions of the model to be poorly identified and sensitive to exclusion restrictions. Writing the substance use equations in quasi-reduced form precludes estimation of the causal effect of income on smoking and drinking decisions, but avoids these problems. The models reported in the present version of the paper converged rapidly and did not exhibit instability.

6. Computational details are as follows. Standard errors were derived from the outer product of the gradient approximation to the information matrix. The simplex algorithm and a Newton-Raphson based algorithm were used for optimization. Code was written in Fortran 90 and compiled and executed on the MACI cluster, a high performance computing facility comprised at the time of this writing of Compaq machines of the DS10, DS20E, XP1000, ES40, and ES45 families.

Table 2
Maximum Likelihood and FIMSL Estimates of Income Equation

	I	II
Age	0.074	0.074
	(8.51)	(8.34)
Age*age/100	–0.800	–0.790
	(7.55)	(7.43)
High school graduate	0.177	0.163
	(6.35)	(5.77)
Some college or other	0.166	0.150
	(5.99)	(5.34)
College grad	0.223	0.192
	(9.20)	(7.58)
Managerial	0.216	0.207
	(8.04)	(7.40)
Professional	0.161	0.140
	(5.72)	(5.31)
Administrative	–0.008	0.028
	(0.017)	(0.065)
Service	–0.070	0.069
	(3.04)	(2.93)
Poor/fair health	–0.058	–0.046
	(1.40)	(1.01)
Good health	–0.031	–0.024
	(1.70)	(1.28)
Married	0.134	0.122
	(7.08)	(6.23)
Ontario	0.196	0.185
	(8.21)	(7.16)
Quebec	0.128	0.127
	(4.43)	(4.34)
Western provinces	0.196	0.186
	(8.21)	(7.58)
GSS-1	–0.031	0.002
	(1.66)	(0.14)
Drinking abstainer	–0.099	–0.103
	(4.51)	(4.64)
Heavy drinker	0.019	0.025
	(0.55)	(0.70)
Smoker	–0.083	–0.268
	(4.40)	(5.31)
Drinking and smoking treated as	exogenous	endogenous
System log-likelihood	−10,238.6	−10,227.1

Notes: n = 3,891. Absolute t-ratios in parentheses. Omitted categories are: *Education*: high school dropout; *Occupation*: production and agricultural; *Health*: excellent health; *Region*: Maritime provinces; *Drinking type*: moderate drinker. Both models include a constant.

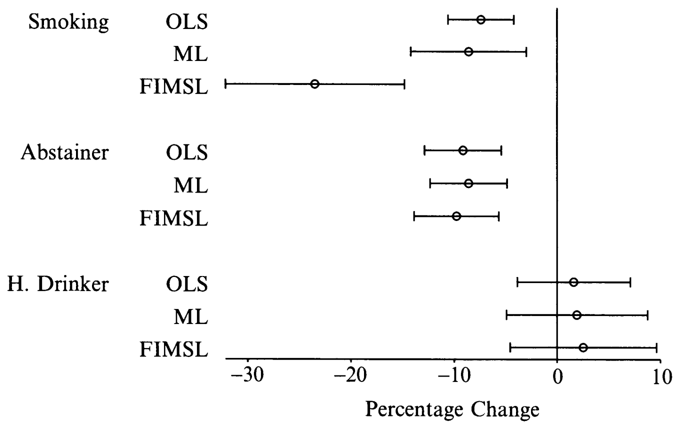

Figure 1
Effect of Substance Abuse Pattern on Income, by Estimation Method
Point estimates and 95 percent confidence intervals. OLS is linear regression using income midpoints. Maximum likelihood (ML) estimates treat use as exogenous, and full information maximum simulated likelihood (FIMSL) estimates treat drinking and smoking as endogenous.

effects of the substance abuse indicators on income are displayed in Figure 1, which shows point estimates and 95 percent confidence intervals for Specifications I and II and (unreported) OLS estimates taking midpoints to handle the grouped nature of the income variable. The figure shows OLS estimates are very similar to the maximum likelihood estimates treating use as exogenous.

Model I, which treats use as exogenous, reproduces the "alcohol-income puzzle," with drinking abstainers earning about 9 percent less than moderate drinkers ($t = 4.5$) and heavy drinkers earning slightly, albeit statistically insignificantly, more than moderate drinkers. Smokers earn about 8 percent less than nonsmokers ($t = 4.4$). However, the exogeneity of the alcohol and tobacco use dummies is rejected by an LR test ($p < 0.01$) of Model I against Model II. Treating use as endogenous dramatically increases the estimated smoking penalty. Daily smoking is estimated to cause a loss in earnings of 24 percent ($t = 5.3$). The effect of drinking on income is not sensitive to whether drinking and smoking are treated as exogenous or endogenous. These results are consistent with the estimates of the covariance matrix parameters (unreported), which suggest positive selection into smoking and small correlations between the unobserved determinants of drinking and income.

The estimates of the substance abuse equations are quite similar across specifications I and II so only those from Model II are reported, in Table 3. The estimates on the excluded instruments, substance prices and religious status indicators, are of key concern. Higher tobacco prices are associated with lower smoking probability ($t = 2.36$) and higher alcohol prices are associated with lower probability of heavy drinking ($t = 1.69$). Price has little effect on probability of drinking abstention, and the cross-price elasticities are not statistically significant. The religious status indicators are highly significant: Non-Catholic religious individuals are less likely to be smokers

Table 3
Substance Abuse Equation Estimates from Model II

	Daily Smoking	Drinking Abstention	Heavy Drinking
Age	0.007	0.005	–0.018
	(0.37)	(0.23)	(0.59)
Age*age/100	–0.015	0.005	0.004
	(0.61)	(0.17)	(0.11)
High school graduate	–0.067	–0.357	–0.097
	(0.95)	(4.80)	(1.09)
Some college	–0.066	–0.145	–0.184
	(0.09)	(1.95)	(1.97)
College graduate	–0.315	–0.311	–0.291
	(5.05)	(4.90)	(3.58)
Managerial	–0.158	–0.262	–0.31
	(2.47)	(3.50)	(1.43)
Professional	–0.303	–0.199	–0.224
	(4.00)	(2.70)	(2.36)
Administrative	–0.117	0.003	–0.023
	(1.11)	(0.34)	(0.19)
Service	–0.001	–0.040	–0.077
	(0.01)	(0.40)	(0.91)
Poor/fair health	0.286	0.203	0.170
	(2.69)	(1.95)	(1.25)
Good health	0.216	–0.018	–0.049
	(4.19)	(0.36)	(0.77)
Married	–0.303	–0.085	–0.289
	(5.80)	(1.36)	(4.45)
Ontario	0.053	–0.058	–0.285
	(0.73)	(0.84)	(2.67)
Quebec	0.085	–0.058	–0.285
	(1.00)	(0.67)	(1.87)
Western provinces	–0.158	–0.116	–0.198
	(2.48)	(1.80)	(2.50)
GSS-1	0.375	–0.269	0.292
	(4.40)	(2.46)	(1.84)
Alcohol price	–0.009	0.040	–0.014
	(0.11)	(0.40)	(1.69)
Tobacco price	–0.008	–0.016	0.077
	(2.36)	(0.25)	(0.90)
Religious	–0.454	0.625	–0.480
	(5.56)	(9.16)	(3.41)
Catholic	0.177	–0.530	0.292
	(1.82)	(6.35)	(1.84)

Notes: Omitted categories as in Table 2. Estimated simultaneously with income equation. Based on marginal distributions, smoking status is determined by probit regression and drinking status by multinomial probit. Each equation includes a constant.

($t = 5.56$), more likely to be drinking abstainers ($t = 9.16$), and less likely to be heavy drinkers ($t = 3.41$) than nonreligious respondents. Catholic religious respondents tend to drink and smoke more than their non-Catholic counterparts.

V. Alternate Specifications

This section reports on a number of alternate specifications in order to assess robustness and contrast results with simpler specifications sometimes used in previous literature. First, the preferred model, II, was estimated omitting the smoking equation. This model replicates the approach taken in most previous work on alcohol and earnings. When smoking status is ignored, the penalty to heavy drinking on log-income changes to –0.005 (compared with 0.025 in the full model), and the penalty to drinking abstention decreases in magnitude to –0.09 from –0.10. These results indicate that failing to control for smoking status mistakenly attributes some of the smoking penalty to heavy drinking and leads to overestimation of the abstention penalty. However the biases are modest. Removing instead the drinking submodel—such that income and smoking are estimated simultaneously but drinking status is omitted—results in an estimated smoking penalty of –19 percent compared with –24 percent in the full model.

Health may be endogenous to substance use decisions. Model II was estimated removing health status from each equation to investigate the effects on the system of not holding health constant. Although one might conjecture this change would increase the income penalty associated with unhealthy behaviors such as smoking or heavy drinking, the changes in the estimated coefficients on the smoking drinking abstention, and heavy drinking indicators in the income equation were negligible. To further investigate this result, a measure of leisure-time physical activity was included in each equation. This measure may proxy both health status and unobserved behavioral traits such as the discount rate and preferences over health status (for example, Barefoot et al. 2002 report wine drinkers are more likely to exercise regularly than nondrinkers). The coefficients on this covariate were of the anticipated sign: More physically active respondents earned statistically higher wages ($t = 2.2$), were less likely to be smokers ($t = 4.3$) or drinking abstainers ($t = 1.7$) and were slightly more likely to be heavy drinkers, albeit not statistically significantly so ($t = 0.77$).[7] However, holding physical activity constant had very small effects on the drinking and smoking measures in the income equation. These results suggest that health is not an important mechanism through which smoking and drinking affect labor market outcomes for employed prime-age men. Further, they call into doubt the hypothesis that the wage penalty associated with drinking abstention is attributable to unobserved health problems, because if that were so we would expect the abstention penalty to rise when the health measure is omitted and fall when physical activity is held constant.[8]

7. The sample size for models including physical activity was reduced by 60 observations, to 3,831, because of missing observations.

8. It is worth noting that the estimated correlation between unobserved determinants of drinking abstention and heavy drinking is 0.71 ($t = 5.95$), suggesting that *some* unobserved factor drives decisions to drink in an extreme manner, either heavily or not at all. These results suggest that that factor is not health status, but perhaps other unobserved personal characteristics.

In light of previous results that drinking patterns are related to occupational sorting (Kenkel and Wang 1999), Model II was estimated with the occupational dummies removed from each equation. These restrictions resulted in an increase in the drinking abstention penalty to 11 percent (from 9 percent) and that of smoking to 27 percent (from 24 percent). These results both confirm previous estimates and also suggest that not only do smokers earn less conditional on occupation, they also tend to be in lower-paying occupations than nonsmokers.

The credibility of the estimates depends on the validity of the exclusion restrictions. Religious beliefs may affect labor market outcomes through mechanisms other than through their effect on substance abuse patterns; they may lead to or proxy attributes which are valued by employers (Ewing 2000). If both prices and religious sentiment are valid instruments the estimates should not be sensitive to estimation excluding the religious sentiment indicators from all equations. The remaining instruments, prices, are fairly weak (although recall the system obtains formal identification even with no exclusion restrictions). The changes to the coefficients of interest were modest: The drinking abstention penalty fell in magnitude to 8 percent from 9 percent and the penalty to smoking increased to 28 percent from 24 percent. These results suggest that the potentially invalid religious sentiment instruments are not driving the results.

Finally, the system was estimated stratifying by age and, separately, stratifying by education level in order to investigate the possibility that the effects of drinking and smoking on labor market outcomes fall mostly on subsets of the population. The estimates of the effect of drinking on income were very similar across age and education levels. College graduates and respondents with less than college education had 11 percent and 9 percent lower wages if they were abstainers and roughly 3 percent and 1 percent higher wages if they were heavy drinkers (neither of the latter two results was statistically significant). Estimation using only younger (age 25 through 39) workers yielded drinking effects very similar to estimation using only older (age 40 through 59) respondents. Conversely, the negative effects of smoking were found to be considerably higher for younger or for better educated workers. The sample of younger workers and the sample of individuals with college degrees each experience roughly 32 percent lower wages if they are smokers ($t = 6.7$ and $t = 5.0$, respectively). There was no statistically significant effect of smoking on wages for respondents with less education than a college degree. The effect of smoking on income for older workers was imprecisely estimated at −12 percent ($t = 1.44$).

VI. Concluding Remarks

After controlling for the endogeneity of substance abuse patterns to income, moderate drinking is estimated to cause 10 percent higher income than drinking abstention and 2 percent lower income than heavy drinking. Smoking is estimated to cause larger changes in income than drinking. Daily smoking is associated with 8 percent lower income in single-equation estimates, and system estimates suggest smoking causes 24 percent lower wages. A mechanism driving this result may be higher rates of injury and lower compensating differentials for dangerous work among smokers (Viscusi 2001). This effect of smoking on income is sensitive to stratification by age or by education, with younger and better educated workers experiencing greater losses as a result of smoking. The effect of drinking on income is similar across these age and education strata.

The results are fairly robust to alternate specifications. Estimation of restricted specifications suggests that failing to control for smoking status when estimating the effect of drinking on wages leads to small downward bias in the estimated effect of heavy drinking on income and small upward bias in the effect of drinking abstention. Failure to control for drinking status when estimating the effect of smoking leads to underestimation of the smoking penalty. Thus, focusing on the effect of one substance while ignoring others may yield misleading results; however, in this context the bias is modest. If occupation dummies are omitted from the model estimated drinking and smoking effects increase in magnitude, suggesting occupational sorting on both drinking and smoking behavior. Controlling for a measure of leisure-time physical exercise or omitting self-reported health status measures has little effect on the estimated smoking and drinking effects, suggesting that the results are not driven by unobserved components of health status. Similarly, income equation estimates change little if both prices and religious sentiment are used as instruments or if only prices are used as instruments, which suggests that the estimates are not artifacts of false exclusion restrictions. However, the possibility that either invalid instruments or in-correct distributional assumptions are influencing the estimates cannot be ruled out.

Appendix 1

The Likelihood Function

Assume $\varepsilon_i = \{\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4, \varepsilon_5\}$ is distributed multivariate normal with zero means and covariance matrix Σ. It follows that $Y_i^* \sim N_5(\mu_i, \Sigma)$, where Y_i^* is the five-vector of latent endogenous outcomes, N_j denotes the j dimensional normal distribution, and μ_i denotes the vector of means defined by Equation 1. A standard change of variables modified slightly to allow for the embedding of the MNP model with a larger system of equations is used to express the MNP submodel as a two-dimensional integral over the positive orthant. Suppose the individual is a drinking abstainer. Let Δ_A denote the 4 by 5 matrix that expresses the drinking utilities in Y_i^* in terms of differences with respect to A_i^* such that

$$\Delta_A Y_i^* = (W_i^*, S_i^*, A_i^* - M_i^*, A_i^* - H_i^*)' \sim N_4(\Delta_A \mu_i, \Delta_A \Sigma \Delta_A').$$

Define Δ_M and Δ_H analogously. The likelihood, L, can then be expressed

$$L = \prod_i \int_{W_i^L}^{W_i^H} \int_{-\infty}^{0} \int_{-\infty}^{0} \int_{-\infty}^{0} \phi(s - \Delta_i D_i \mu_i; \Delta_i \Sigma \Delta_i')\, ds,$$

where $\phi(\cdot; V)$ denotes the multivariate normal density with mean zero and covariance matrix V, $D_i = vec(1\ d_i\ 1\ 1\ 1)$, $d_i = 1$ if the individual is a daily smoker and $d_i = -1$ otherwise, Δ_i is Δ_A, Δ_M, Δ_H as appropriate for i's observed drinking status, and W_i^L and W_i^H are bounds on latent income for individual i as described in Section II.

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