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Interdependence of Tobacco and Alcohol Consumption: A Natural Experiment Approach

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Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013

Preliminary Draft - Please do not cite

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In this paper, we analyze the impact of smoking bans on restaurant and at-home alcohol consumption using rational addiction model. We use a pseudo-panel data approach which has many advantages compared to aggregate and panel data. While cigarette and restaurant alcohol consumptions fit well with the rational addiction model, at-home-alcohol consumption does not. This result might be due to possible inventory effects. Our results suggests that although cigarettes and alcohol reinforce each other in consumption, consumers substitute them when there are permanent changes in prices. In the semi-reduced system, the cross-price elasticity of restaurant(at-home) alcohol demand with respect to cigarette price is positive and significant. We find that smoking bans increase restaurant alcohol consumption, but decrease at-home alcohol consumption. After a smoking ban is imposed, nonsmokers are likely to stay longer at restaurants and consume more alcohol. On the other hand, when smokers are not allowed to smoke at the restaurants, they are likely to compensate it by increasing their restaurant alcohol consumption. As smoking bans builds on social drinking habits, we observe a decrease at at-home alcohol consumption. On the other hand, when blood alcohol concentration (BAC) limits decrease, both alcohol and cigarette consumptions decrease.

Key words: *cigarette, alcohol, smoking ban, rational addiction, pseudo panel*

On November 23, 1998 US state attorneys general signed a tobacco settlement with the five largest tobacco manufacturers. Since then many US states have also imposed smoking bans in a variety of locations (e.g., restaurants, schools, work places). As more cities and states consider smoking bans, it becomes necessary to analyze the economic impacts of these smoking bans.

Many studies find that smoking bans reduce cigarette consumption (e.g., Yurekli and Zhang, 2000; Gallet, 2004). If cigarette and alcohol are related in consumption, as suggested by some previous studies (e.g., Bask and Melkersson, 2004; Pierani and Tiezzi, 2009), smoking bans are likely to affect alcohol consumption too. In particular, smoking bans at restaurants create a natural experiment for studying the relationship between cigarette and alcohol consumption. Although there is a vast literature investigating the impact of smoking bans on cigarette consumption, there are only a few studies that analyze the impact of smoking bans on alcohol consumption.

Picone et al. (2004) examine how smoking bans and cigarette prices affect alcohol consumption within a dynamic framework. To account for the addictive nature of these two goods, they add past consumption to the regression models. They find that smoking bans reduce alcohol consumption, but increases in cigarette prices increase alcohol consumption. On the other hand, Gallet and Eastman (2007), using a static model to examine the effects of smoking bans on the state-level demand for beer, wine, and spirits, find that smoking bans at restaurants/bars decrease beer and spirits consumption, but increase wine consumption.

In this study, a rational addiction framework (Becker and Murphy, 1988) is employed to analyze the impact of smoking bans on restaurant alcohol consumption. Consumer

Expenditure Survey (CEX), Diary data by U.S. Bureau of Labor Statistics (BLS) is used for the analysis. CEX data are ideal for the purpose of our study as they provide information on alcohol expenditures at restaurants and at home. Thus, rather than analyzing how “overall alcohol consumption” is affected by smoking bans, the focus is given on how “restaurant alcohol consumption” and "at home alcohol consumptions" are affected by smoking bans at restaurants. As emphasized by Gallet and Eastman (2007), once a smoking ban is applied to restaurants, it is natural to expect the distribution of customers to shift from smokers towards nonsmokers. Because we have the information on “restaurant alcohol consumption” we are able to analyze how “restaurant alcohol consumption” is affected by this redistribution of customers due to smoking bans.

The Diary Data set is composed of repeated cross sections. Thus, in order to estimate the dynamic demand models, a pseudo panel data approach is employed.

Theoretical Model

Following Bask and Melkersson (2004), we assume:

$$U_{it} = U(C_{it}, R_{it}, H_{it}, S_{it}, D_{it}, L_{it}, N_{it}) \quad (1)$$

where C_{it} is the quantities of cigarettes consumed, R_{it} and H_{it} are the restaurant and at-home alcohol consumption; S_{it}, D_{it} and L_{it} are the habit stocks of cigarettes, alcohol-at-restaurant and alcohol-at-home respectively; N_{it} is the consumption of a non-addictive composite good. We assume that restaurant- and at-home- alcohol consumptions are related goods that have different attributes and thus different habit stocks.

We assume a strictly concave utility function. The marginal utility derived from each good is assumed to be positive (i.e., $U_C > 0$, $U_R > 0$, $U_H > 0$ and $U_N > 0$; concavity implies $U_{CC} < 0$, $U_{RR} < 0$, $U_{HH} < 0$ and $U_{NN} < 0$). Following the rational addiction literature, we assume that habit stocks of cigarettes and alcohol affect current utility negatively due to their adverse health effects (i.e., $U_S < 0$, $U_D < 0$ and $U_L < 0$; concavity implies $U_{SS} < 0$, $U_{DD} < 0$ and $U_{LL} < 0$).

Reinforcement implies $U_{CS} > 0$, $U_{RD} > 0$ *and* $U_{HL} > 0$. Cigarette and alcohol consumption are assumed to have no effect on the marginal utility derived from the consumption of the composite good (i.e., $U_{CN} = U_{RN} = U_{HN} = U_{SN} = U_{DN} = U_{LN} = 0$).

If cigarette consumption decreases the marginal utility derived from restaurant-alcohol consumption, $U_{RC} < 0$ and $U_{DS} < 0$; if cigarette consumption reinforces restaurant-alcohol consumption and vice versa, $U_{RC} > 0$ and $U_{DS} > 0$.

If past restaurant-alcohol consumption increases the marginal utility from current cigarette consumption, $U_{CD} > 0$; if past cigarette consumption increases the marginal utility from current restaurant-alcohol consumption, $U_{RS} > 0$. Pierani and Tiezzi (2009) name this intertemporal cross-reinforcement effect the quasi-gateway effect.[1]

The intertemporal budget constraint is

$$\sum_{t=1}^{\infty} \beta^{t-1} \left(P_{Ct}C_{it} + P_{Rt}R_{it} + P_{Ht}H_{it} + N_{it} \right) = W_i \qquad (2)$$

[1] A true gateway effect refers to the condition that consumption of one addictive substance leads to later *initiation* of another addictive substance (Pacula,1997).

where $\beta = 1/(1+r)$ with r being the discount rate, P_{Ct}, P_{Rt} and P_{Ht} are prices of cigarettes, restaurant-alcohol consumption and at-home-alcohol consumption, respectively, and W_i is the present value of wealth. The composite good, *N*, is taken as the numeraire good.

Then the consumer's problem is:

$$\max \quad \sum_{t=1}^{\infty} \beta^{t-1}\, U\,(C_{it}\,, R_{it}, H_{it}, S_{it}, D_{it}, L_{it}, N_{it})$$

$$s.t. \quad \sum_{t=1}^{\infty} \beta^{t-1}\,(\,P_{Ct}C_{it} + P_{Rt}R_{it} + P_{Ht}H_{it} + N_{it}\,) = W_i \tag{3}$$

As in previous studies, we assume that $S_{it} = C_{it-1}$, $D_{it} = R_{it-1}$ and $L_{it} = H_{it-1}$. When the utility function is quadratic, first order conditions generate the following demand equations[2]:

$$C_{it} = \beta_{10} + \beta_{11}\,C_{it-1} + \beta_{12}C_{it+1} + \beta_{13}R_{it-1} + \beta_{14}R_{it} + \beta_{15}R_{it+1} + \beta_{16}H_{it-1} + \beta_{17}H_{it} + \beta_{18}H_{it+1} + \beta_{19}\,P_{Ct} \tag{4}$$

$$R_{it} = \beta_{20} + \beta_{21}\,R_{it-1} + \beta_{22}R_{it+1} + \beta_{23}C_{it-1} + \beta_{24}C_{it} + \beta_{25}C_{it+1} + \beta_{26}H_{it-1} + \beta_{27}H_{it} + \beta_{28}H_{it+1} + \beta_{29}\,P_{Rt} \tag{5}$$

$$H_{it} = \beta_{30} + \beta_{31}\,H_{it-1} + \beta_{32}H_{it+1} + \beta_{33}C_{it-1} + \beta_{34}C_{it} + \beta_{35}C_{it+1} + \beta_{36}R_{it-1} + \beta_{37}R_{it} + \beta_{38}R_{it+1} + \beta_{39}\,P_{Ht} \tag{6}$$

For k=1,2,3 economic theory implies $\beta_{k9} < 0$. Rational addiction implies $\beta_{k1} > \beta_{k2} > 0$ with $\beta_{k1} = (1+r)\beta_{k2}$.

$\beta_{14} > 0$ if smoking and restaurant-alcohol consumption reinforce each other; and $\beta_{14} < 0$ if restaurant-alcohol consumption makes it easier to abstain from smoking, and vice

[2] See Appendix A for derivation of Equations (4)-(6).

versa. If $\beta_{34} > 0$ then at-home alcohol consumption and cigarette consumption reinforce each other. If $\beta_{37} < 0$ then restaurant-alcohol consumption makes it easier to abstain from at-home-alcohol consumption.

If $\beta_{13} > 0$ restaurant-alcohol consumption is a quasi-gateway for cigarette consumption. If $\beta_{36} > 0$, restaurant-alcohol consumption is a quasi-gateway for at-home-alcohol consumption.

The empirical specification is based on the basic specification augmented with individual fixed effects, real income and some exogenous policy variables representing demand shifters:

$$C_{it} = \alpha_{1i} + \beta_{10} + \beta_{11} C_{it-1} + \beta_{12} C_{it+1} + \beta_{13} R_{it-1} + \beta_{14} R_{it} + \beta_{15} R_{it+1} + \beta_{16} H_{it-1} + \beta_{17} H_{it} + \beta_{18} H_{it+1} + \beta_{19} P_{Ct} + \gamma_{11} I_{it} + \gamma_{12} D_{\mathrm{t}} + \gamma_{13} BAC_{\mathrm{t}} + u_{1it} \quad (7)$$

$$R_{it} = \alpha_{2i} + \beta_{20} + \beta_{21} R_{it-1} + \beta_{22} R_{it+1} + \beta_{23} C_{it-1} + \beta_{24} C_{it} + \beta_{25} C_{it+1} + \beta_{26} H_{it-1} + \beta_{27} H_{it} + \beta_{28} H_{it+1} + \beta_{29} P_{Rt} + \gamma_{21} I_{it} + \gamma_{22} D_{\mathrm{t}} + \gamma_{23} BAC_{\mathrm{t}} + u_{2it} \quad (8)$$

$$H_{it} = \alpha_{3i} + \beta_{30} + \beta_{31} H_{it-1} + \beta_{32} H_{it+1} + \beta_{33} C_{it-1} + \beta_{34} C_{it} + \beta_{35} C_{it+1} + \beta_{36} R_{it-1} + \beta_{37} R_{it} + \beta_{38} R_{it+1} + \beta_{39} P_{Ht} + \gamma_{31} I_{it} + \gamma_{32} D_{\mathrm{t}} + \gamma_{33} BAC_{\mathrm{t}} + u_{3it} \quad (9)$$

where α_i is the individual fixed effect that accounts for unobserved individual heterogeneity, D_t is a vector of two binary variables that show if the state restricted or banned smoking at restaurants, BAC_t is blood alcohol concentration limit for drivers, and I_i is real income after taxes.

Data

2002-2008 CEX Diary Survey data are used. Consumer Unit (CU) expenditures, together with price variables, are used to calculate (average weekly) consumption (i.e., “alcohol

consumption at restaurants" = "alcohol expenditures at restaurants"/ "restaurant alcohol prices"). Because state information is used to match CUs with state level cigarette prices, households that have missing state variables are dropped.

Annual state level cigarette prices are collected from the website of Department of Health and Human Services, Centers for Disease Control and Prevention (CDC). To obtain alcoholic beverages prices at restaurants and at home, we construct Lewbel(1989) price indices which enable us to have household specific price variation. Lewbel price indices are calculated from restaurant (at home) expenditures of each CU for different subcategories of alcoholic beverages, i.e., beer, wine, spirits. To obtain real prices, all price variables are deflated by "Consumer Price Index (CPI) for all items" reported on the BLS webpage.

Data on clean indoor air laws are collected from the website of CDC. For the purposes of this study, the focus is given on the smoking bans that are applied to restaurants. We create two binary variables showing if, at the time of the survey, the state had restricted (i.e., allowed smoking only in designated areas) or banned smoking in restaurants. Table 1 gives a list of the states that imposed smoking bans at the restaurants over the sample period 2002-2008. State BAC limits for drivers are gathered from Alcohol Policy Information System (APIS) at the National Institute on Alcohol Abuse and Alcoholism (NIAAA) website.

Methodology

While aggregate data fail to give detailed information about individual behavior, panel surveys generally span short time periods. Deaton (1985) suggested using pseudo-panel approach as an alternative method for estimating individual behavior models. The pseudo-

panel approach is an instrumental variables approach in which cohort dummies are used as the instruments in the first-stage (i.e., the first stage predicted values are equivalent to cohort averages). This approach enables one to follow cohorts of people through repeated cross-sectional surveys

Because cohorts are followed over time, they are constructed based on time invariant characteristics, such as the birth year of the reference person. We form pseudo-panels based on the geographic region (northeast, midwest, south, west) and the household head's year of birth (born before 1950, born between 1950-1964, born in 1965 or later). For example, all household heads born before 1950 that reside in the northeast would form one cohort and all households born before 1950 that reside in the midwest would form another cohort. The resulting pseudo-panel consists of a total of 336 observations over 12 cohorts and 28 quarters. This allocation results in around 100 households per cohort on average.

Because pseudo-panel approach is an instrumental variables (IV) method, standard IV conditions should be satisfied for identification (Verbeek and Vella, 2005). The time-invariant instruments should have correlation not only with the lagged and lead consumption variables but also with the exogenous variables in the model (i.e., sufficient cohort-specific variation should be present in the exogenous variables). When we construct our cohorts, we take into account standard instrumental variables (IV) conditions. To have (time-variant) correlation between the model variables and the time invariant instruments (i.e., cohort dummies), we construct our cohorts based on household head's year of birth and the geographic region. The three generations (born before 1950, born between 1950-1964, born in 1965 or later) are likely to have different consumption patterns which are subject to

change over time as the generations age. There are also differences across regions in terms of prices and consumption patterns which would change over time because of migration, local policy changes, etc.

In repeated cross-sectional surveys, at each time period different individuals are observed. Thus, the lagged and lead variables are not observed for the individuals in cohort c at time t. Therefore following previous literature, we replace these variables with the sample means of the individuals at time t−1 and t+1 respectively. Taking cohort averages of equations (7) - (9) over n_c individuals observed in cohort c at time t results in the following equations at the cohort level:

$$\bar{C}_{c(t),t} = \bar{\alpha}_{1c,t} + \beta_{10} + \beta_{11}\,\bar{C}_{c(t-1),t-1} + \beta_{12}\bar{C}_{c(t+1),t+1} + \beta_{13}\bar{R}_{c(t-1),t-1} + \beta_{14}\bar{R}_{c(t),t}$$
$$+ \beta_{15}\bar{R}_{c(t+1),t+1} + \beta_{16}\bar{H}_{c(t-1),t-1} + \beta_{17}\bar{H}_{c(t),t} + \beta_{18}\bar{H}_{c(t+1),t+1}$$
$$+ \beta_{19}\,\bar{P}_{Ct} + \gamma_{11}\bar{I}_{it} + \gamma_{12}\bar{D}_{\mathrm{t}} + \gamma_{13}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{1c,t} \tag{10}$$

$$\bar{R}_{c(t),t} = \bar{\alpha}_{2c,t} + \beta_{20} + \beta_{21}\,\bar{R}_{c(t-1),t-1} + \beta_{22}\bar{R}_{c(t+1),t+1} + \beta_{23}\bar{C}_{c(t-1),t-1} + \beta_{24}\bar{C}_{c(t),t}$$
$$+ \beta_{25}\bar{C}_{c(t+1),t+1} + \beta_{26}\bar{H}_{c(t-1),t-1} + \beta_{27}\bar{H}_{c(t),t} + \beta_{28}\bar{H}_{c(t+1),t+1}$$
$$+ \beta_{29}\,\bar{P}_{Rt} + \gamma_{21}\bar{I}_{it} + \gamma_{22}\bar{D}_{\mathrm{t}} + \gamma_{23}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{2c,t} \tag{11}$$

$$\bar{H}_{c(t),t} = \bar{\alpha}_{3c,t} + \beta_{30} + \beta_{31}\,\bar{H}_{c(t-1),t-1} + \beta_{32}\bar{H}_{c(t+1),t+1} + \beta_{33}\bar{C}_{c(t-1),t-1} + \beta_{34}\bar{C}_{c(t),t}$$
$$+ \beta_{35}\bar{C}_{c(t+1),t+1} + \beta_{36}\bar{R}_{c(t-1),t-1} + \beta_{37}\bar{R}_{c(t),t} + \beta_{38}\bar{R}_{c(t+1),t+1}$$
$$+ \beta_{39}\,\bar{P}_{Ht} + \gamma_{31}\bar{I}_{it} + \gamma_{32}\bar{D}_{\mathrm{t}} + \gamma_{33}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{3c,t} \tag{12}$$

where $\bar{\alpha}_{c,t}$ is the average of the fixed effects for individuals in cohort *c* at time *t*.

Verbeek and Nijman (1992) explain that if there is sufficient number of observations per cohort, $\bar{\alpha}_{c,t}$ can be treated as the unobserved cohort fixed effect (α_c). They showed that when

cohorts contain at least 100 individuals and the time variation in the cohort means is sufficiently large, the bias in the standard fixed effects estimator will be small and can be ignored. In that case, models can be estimated at the cohort level by adding cohort dummies or cohort fixed effects. McKenzie (2004) shows that in dynamic pseudo-panel data models, the fixed effects estimator on cohort averages is consistent when $n_c \to \infty$. In our sample, the number of observations in each cohort is sufficiently large (i.e., around 100 observations), so the fixed effects estimator is applied to cohort averages. The number of households in each cohort and time period is not the same which might induce heteroskedasticity. Following Dargay (2007), to correct for heteroskedasticity, all cohort level variables are weighted by the square root of the number of households in each cohort. To have consistent standard errors, bootstrapped standard errors are calculated (1000 replications).

Empirical Results

First, equations (10) - (12) are estimated as separately. The results are shown in Table II. Own price has a negative coefficient in all equations, but it is only significant for alcohol demand equations. Cigarette consumption and at-restaurant-alcohol consumption are consistent with rational addiction (i.e., lag and lead consumption coefficients are positive and significant) and discount rates are positive (i.e., the coefficient on lag consumption is higher than the coefficient on lead consumption). In at-home-alcohol consumption equation, lag and lead coefficients are negative which might be due to inventory effects.

In the restaurant-alcohol(at-home-alcohol) consumption equation, current cigarette consumption and current at-home-alcohol (restaurant-alcohol) consumption have positive

and significant coefficients which suggests cigarette and at-home-alcohol(restaurant-alcohol) consumption reinforces restaurant-alcohol(at-home-alcohol) consumption. Based on model coefficients as habit stocks of restaurant alcohol consumption increase marginal utility derived from at-home alcohol consumption decrease. Because at-restaurant and at-home alcohol consumptions have different attributes, it is likely that as the social drinking habits builds on, at-home drinking is becoming less satisfactory.

As pointed out by Bask and Melkersson (2004), decisions regarding cigarette and alcohol consumption are often determined jointly. Thus the solution of the optimization problem is in fact a system of demand equations. Following previous literature, we combine equations (10) - (12) to obtain a semi-reduced system:

$$\begin{aligned}\bar{C}_{c(t),t} = {} & \bar{\alpha}_{4c,t} + \beta_{10} + \beta_{41}\,\bar{C}_{c(t-1),t-1} + \beta_{42}\bar{C}_{c(t+1),t+1} + \beta_{43}\bar{R}_{c(t-1),t-1} \\ & + \beta_{44}\bar{R}_{c(t+1),t+1} + \beta_{45}\bar{H}_{c(t-1),t-1} + \beta_{46}\bar{H}_{c(t+1),t+1} + \beta_{47}\,\bar{P}_{Ct} + \beta_{48}\,\bar{P}_{Rt} \\ & + \beta_{49}\,\bar{P}_{Ht} + \gamma_{41}\bar{I}_{it} + \gamma_{42}\bar{D}_{\mathrm{t}} + \gamma_{43}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{4c,t} \qquad (13)\end{aligned}$$

$$\begin{aligned}\bar{R}_{c(t),t} = {} & \bar{\alpha}_{5c,t} + \beta_{50} + \beta_{51}\,\bar{R}_{c(t-1),t-1} + \beta_{52}\bar{R}_{c(t+1),t+1} + \beta_{53}\bar{C}_{c(t-1),t-1} \\ & + \beta_{54}\bar{C}_{c(t+1),t+1} + \beta_{55}\bar{H}_{c(t-1),t-1} + \beta_{56}\bar{H}_{c(t+1),t+1} + \beta_{57}\,\bar{P}_{Rt} + \beta_{58}\,\bar{P}_{Ct} \\ & + \beta_{59}\,\bar{P}_{Ht} + \gamma_{51}\bar{I}_{it} + \gamma_{52}\bar{D}_{\mathrm{t}} + \gamma_{53}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{5c,t} \qquad (14)\end{aligned}$$

$$\begin{aligned}\bar{H}_{c(t),t} = {} & \bar{\alpha}_{6c,t} + \beta_{60} + \beta_{61}\,\bar{H}_{c(t-1),t-1} + \beta_{62}\bar{H}_{c(t+1),t+1} + \beta_{63}\bar{C}_{c(t-1),t-1} \\ & + \beta_{64}\bar{C}_{c(t+1),t+1} + \beta_{65}\bar{R}_{c(t-1),t-1} + \beta_{66}\bar{R}_{c(t+1),t+1} + \beta_{67}\,\bar{P}_{Ht} + \beta_{68}\,\bar{P}_{Ct} \\ & + \beta_{69}\,\bar{P}_{Rt} + \gamma_{61}\bar{I}_{it} + \gamma_{62}\bar{D}_{\mathrm{t}} + \gamma_{63}\,\overline{BAC}_{\mathrm{t}} + \bar{u}_{6c,t} \qquad (15)\end{aligned}$$

The systems of demand equations are estimated using iterated seemingly unrelated regression (ITSUR). The results are shown in Table III.

Cigarette consumption and at-restaurant-alcohol consumption are still consistent with rational addiction. Higher BAC limits increase alcohol consumptions. Higher BAC limits also increase cigarette consumption, which suggests that alcohol consumption reinforces cigarette consumption. Smoking bans and restrictions in restaurants do not have a statistically significant effect on cigarette consumption. It might be possible that people respond to smoking bans at restaurants by compensating and smoking more in other locations. On the other hand, smoking bans and restrictions at restaurants increase restaurant alcohol consumption but decrease at-home alcohol consumption. After a smoking ban, even if smokers decrease alcohol consumption in restaurants the increase in the consumption of nonsmokers could be more than the decrease in the consumption of smokers, causing the net effect of a smoking ban in restaurants to increase alcohol consumption.

The long-run price and income elasticities calculated at the sample mean are shown in Table IV. Long-run own price elasticities are negative for all goods. Long-run cigarette demand is inelastic while long-run alcohol demands are elastic. These results are consistent with the similar studies in the literature.

The income elasticity is positive and less than one for cigarettes and at-home alcohol consumption but it is greater than one for restaurant alcohol consumption. Income elasticities are significant for all three goods. This finding suggests that restaurant alcohol consumption is a luxury good while cigarettes and at-home-alcohol consumption are normal goods.

Cross-price elasticities are positive. Our results are consistent with that of Goel and Morey (1995); the cross-price elasticity of alcohol is larger than the cross-price elasticity of cigarette with both elasticities being positive. Picone et al.(2004) claim that although alcohol

and cigarettes can complement each other for social drinkers, they are gross substitutes in price. As cigarette prices increase many smokers reduce or quit smoking and substitute alcohol for cigarette as a source of pleasure. In addition, as cigarette expenditures decrease alcohol consumption increases due to positive income effect given that alcohol is a normal good. In an analysis of smoking and drinking participation, Decker and Schwartz (2000) come up with a similar explanation.

We believe that while cigarettes and alcohol might reinforce each other in consumption, they are substitutes in prices. Increasing cigarette prices will give smokers an incentive to cut cigarette consumption given that smoking is associated with serious health problems. As mentioned in Picone et al.(2004) and Decker&Schwartz (2000), people who quit smoking are likely to compensate the induced stress by increasing alcohol consumption.

Policy Implications of Smoke-free Laws

By reducing exposure to second-hand smoke, smoking bans decrease the negative externalities created by smoking behavior. However, the tobacco industry has constantly attacked smoking bans claiming that smokers will be driven away from restaurants and bars; and the establishments will lose revenue. Bar and restaurant owners have also voiced concerns on the possible adverse effects of smoking bans on the revenues. Contrary to these concerns, studies published in peer-reviewed journals have either found an increase in the restaurant/bar revenues after a smoking ban (Cowling and Bond, 2005; Glantz, 2000), or failed to find any statistically significant effect (Bartosch and Pope, 2002; Hyland at al., 1999). Gallet and Eastman (2007), using a static model, find that smoking bans at

restaurants/bars decrease overall (i.e., at home and restaurants) beer and spirits consumption, but increase overall (i.e., at home and restaurants) wine consumption.

In the current study, it is found that smoking bans increase restaurant alcohol consumption, but decrease at-home alcohol consumption. There might be two different effects going on. As pointed out by previous studies, prior to a smoking ban, individuals who are sensitive to second-hand smoke are likely to avoid public places in which smoking is allowed. Once a smoking ban is implemented in restaurants, these individuals are likely to go to restaurants more often and stay longer which leads to an increase in their restaurant alcohol consumption. Moreover, because smoking is no longer allowed in the restaurants after a smoke-free law, smokers are likely to engage in a compensating behavior and consume more alcohol while they are in these establishments.

Concluding Remarks

In recent years, more and more U.S. states have imposed smoking bans in a variety of locations including restaurants. If cigarette and alcohol are related in consumption as suggested by previous studies, smoking bans in restaurants are likely to affect restaurant alcohol consumption too. In this study, employing a pseudo-panel data approach within a rational addiction framework, we analyze the effects of smoking bans at-restaurant and at-home alcohol consumption. We found that cigarette and restaurant-alcohol consumptions are consistent with rational addiction. The structural specification suggests cigarettes and alcohol reinforce each other in consumption, whereas the cross-price elasticities derived from semi-reduced demand system suggest substitutability due to price changes. Our findings are

consistent with Picone et al.(2004) who also found people respond differently to physical restrictions/conditions and changes in prices. We believe that even if drinking reinforces smoking and vice versa, when there are permanent price changes, consumers adjust their behavior and reallocate their spending on these two goods. Especially when cigarette prices increase, it is expected that many people decrease cigarette consumption or quit completely, which would accelerate stress levels given that cigarette is a highly addictive substance. Thus, it is very plausible to expect that these people would increase their alcohol consumption to cope with the resulting stress.

Our findings suggest useful public policy implications. Although cigarette taxation has been cited as an effective public policy tool for cigarette control, our results suggest that increasing cigarette prices would increase alcohol consumption. The cross-price elasticity of alcohol (both at restaurants and at home) with respect to the cigarette prices is positive. There is a similar trade-off when smoking bans are imposed. Smoking bans increase restaurant alcohol consumption. On the other hand, when BAC limits decrease, both alcohol and cigarette consumption decrease. Reducing the BAC limit would reduce the consumption of alcohol. Because drinking reinforces smoking, decreasing the BAC limit would also decrease cigarette consumption. Reducing the BAC limit and increasing road controls would also eliminate negative externalities such as fatalities due to drunk driving.

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Table I. Smoking Bans (at Restaurants) over 2002- 2008 period

2002	2003	2004	2005	2006	2007	2008
Utah	Utah	Utah	Utah	Utah	Utah	Utah
Delaware	Delaware	Delaware	Delaware	Delaware	Delaware	Delaware
	New York	New York	New York	New York	New York	New York
	Florida	Florida	Florida	Florida	Florida	Florida
		Maine	Maine	Maine	Maine	Maine
		Idaho	Idaho	Idaho	Idaho	Idaho
		Massachusetts	Massachusetts	Massachusetts	Massachusetts	Massachusetts
			Rhode Island	Rhode Island	Rhode Island	Rhode Island
			Montana	Montana	Montana	Montana
			Washington	Washington	Washington	Washington
				New Jersey	New Jersey	New Jersey
				Colorado	Colorado	Colorado
				Hawaii	Hawaii	Hawaii
				Ohio	Ohio	Ohio
				Neveda	Neveda	Neveda
					Dictrict of Columbia	Dictrict of Columbia
					Louisiana	Louisiana
					Oregon	Oregon
					Tennessee	Tennessee
					New Hampshire	New Hampshire
					Minnesota	Minnesota
						Illinois
						Maryland
						Iowa
						Pennsylvania

Table II. Demand equations estimated separately

Cigarettes			***Alcohol-at-restaurant***			***Alcohol-at-home***		
Constant	-9.804***	(2.108)	Constant	6.658	(14.328)	Constant	103.115***	(23.873)
C_{t-1}	0.139***	(0.050)	R_{t-1}	0.105**	(0.050)	H_{t-1}	-0.055	(0.041)
C_{t+1}	0.121**	(0.051)	R_{t+1}	0.087*	(0.049)	H_{t+1}	-0.082**	(0.041)
R_{t-1}	-0.005	(0.006)	C_{t-1}	0.038	(0.338)	C_{t-1}	0.432	(0.439)
R_t	0.010	(0.007)	C_t	0.776**	(0.369)	C_t	1.062**	(0.517)
R_{t+1}	-0.001	(0.006)	C_{t+1}	-0.112	(0.360)	C_{t+1}	0.447	(0.422)
H_{t-1}	0.004	(0.004)	H_{t-1}	-0.037	(0.032)	R_{t-1}	-0.164***	(0.062)
H_t	0.006	(0.005)	H_t	0.094***	(0.035)	R_t	0.200**	(0.078)
H_{t+1}	0.005	(0.005)	H_{t+1}	-0.081***	(0.030)	R_{t+1}	-0.027	(0.059)
P_{Ct}	-0.037	(0.095)	P_{Rt}	-19.088***	(3.044)	P_{Ht}	-28.137***	(4.070)
rincome	0.004*	(0.002)	rincome	0.123***	(0.017)	rincome	0.089***	(0.023)
banned	-0.068	(0.181)	banned	6.943***	(1.279)	banned	-2.257	(1.789)
restricted	0.027	(0.247)	restricted	8.092***	(1.676)	restricted	-3.664	(2.241)
BAC	14.132***	(4.026)	BAC	109.68***	(29.092)	BAC	290.050***	(41.115)
R^2	0.70		R^2	0.63		R^2	0.42	

Note: Bootstrapped standard errors (1000 reps.) are reported in parenthesis. *** denotes significance at 1%, **denotes significance at 5%, * denotes significance at 10%.

Table III. Semi-reduced system estimated using ITSUR

Cigarettes			***Alcohol-at-restaurant***			***Alcohol-at-home***		
Constant	-9.690***	(2.048)	Constant	-3.430	(13.898)	Constant	56.473**	(24.962)
C_{t-1}	0.147***	(0.054)	R_{t-1}	0.086*	(0.048)	H_{t-1}	-0.045	(0.042)
C_{t+1}	0.118**	(0.053)	R_{t+1}	0.077	(0.050)	H_{t+1}	-0.082**	(0.040)
R_{t-1}	-0.006	(0.006)	C_{t-1}	0.400	(0.335)	C_{t-1}	0.894**	(0.451)
R_{t+1}	-0.001	(0.006)	C_{t+1}	0.061	(0.352)	C_{t+1}	0.715*	(0.428)
H_{t-1}	0.003	(0.004)	H_{t-1}	-0.049	(0.031)	R_{t-1}	-0.162***	(0.060)
H_{t+1}	0.003	(0.005)	H_{t+1}	-0.095***	(0.031)	R_{t+1}	-0.004	(0.060)
P_{Ct}	-0.112	(0.118)	P_{Rt}	-29.674***	(3.990)	P_{Ht}	-43.412***	(5.390)
P_{Rt}	0.036	(0.535)	P_{Ct}	2.627***	(0.827)	P_{Ct}	4.293***	(1.262)
P_{Ht}	0.495	(0.557)	P_{Ht}	5.872	(3.973)	P_{Rt}	6.500	(5.321)
rincome	0.005**	(0.002)	rincome	0.125***	(0.016)	rincome	0.108***	(0.020)
banned	0.002	(0.192)	banned	7.096***	(1.379)	banned	-4.379**	(2.151)
restricted	0.159	(0.247)	restricted	7.742***	(1.719)	restricted	-4.520*	(2.300)
BAC	12.166**	(4.976)	BAC	74.707**	(30.736)	BAC	235.130***	(45.859)
R^2	0.70		R^2	0.64		R^2	0.42	

Note: Bootstrapped standard errors (1000 reps.) are reported in parenthesis. *** denotes significance at 1%, **denotes significance at 5%, * denotes significance at 10%.

Table IV. Long-run Elasticities

	semi-reduced system	
ε_{CC}	-0.556	(0.507)
ε_{RR}	-4.897***	(0.757)
ε_{HH}	-3.295***	(0.534)
ε_{CR}	0.415	(0.598)
ε_{CH}	0.183	(0.596)
ε_{RC}	1.429***	(0.550)
ε_{RH}	1.722***	(0.622)
ε_{HC}	1.231***	(0.463)
ε_{HR}	1.049**	(0.519)
ε_{CY}	0.272**	(0.110)
ε_{RY}	1.026***	(0.124)
ε_{HY}	0.417***	(0.101)

Note: Bootstrapped standard errors (1000 reps.) are reported in parenthesis. *** denotes significance at 1%, **denotes significance at 5%, * denotes significance at 10%.

Appendix A: Derivation of Equations (4) - (6)

The quadratic utility function is:

$$U = \frac{1}{2}u_{CC}C_t^2 + \frac{1}{2}u_{RR}R_t^2 + \frac{1}{2}u_{HH}H_t^2 + \frac{1}{2}u_{NN}N_t^2 + \frac{1}{2}u_{SS}S_t^2 + \frac{1}{2}u_{DD}D_t^2 + \frac{1}{2}u_{LL}L_t^2$$

$$+u_{CR}C_tR_t + u_{CH}C_tH_t + u_{CS}C_tS_t + u_{CD}C_tD_t + u_{CL}C_tL_t + u_{RH}R_tH_t + u_{RS}R_tS_t$$

$$+ u_{RD}R_tD_t + u_{RL}R_tL_t + u_{HS}H_tS_t + u_{HD}H_tD_t + u_{HL}H_tL_t + u_{SD}S_tD_t + u_{SL}S_tL_t$$

$$+ u_{DL}D_tL_t + u_CC_t + u_RR_t + u_HH_t + u_NN_{it} + u_SS_{it} + u_DD_{it} + u_LL_{it}$$

u_{ij} are parameters carrying the sign of their respective derivatives (e.g., $u_{CC} < 0$ because $U_{CC} < 0$). We assume that $S_t = C_{t-1}$, $D_t = R_{t-1}$ and $L_t = H_{t-1}$.

$$\max L = \sum_{t=1}^{\infty} \beta^{t-1}\, U(C_t\,, R_t, H_t, C_{t-1}, R_{t-1}, H_{t-1}, N_t)$$

$$-\lambda(W - \textstyle\sum_{t=1}^{\infty} \beta^{t-1}\,(\,P_{Ct}C_t + P_{Rt}R_t + P_{Ht}H_t + N_t\,))$$

Derive the first order condition(FOC) with respect to C_t:

$$\frac{\partial L}{\partial C_t} = \frac{\partial U(C_t\,, R_t, H_t, C_{t-1}, R_{t-1}, H_{t-1}, N_t)}{\partial C_t} + \beta\frac{\partial U(C_{t+1}\,, R_{t+1}, H_{t+1}, C_t, R_t, H_t, N_{t+1})}{\partial C_t}$$

$$- \lambda P_{C_t}$$

$$= u_{CC}C_t + u_{CR}R_t + u_{CH}H_t + u_{CS}C_{t-1} + u_{CD}R_{t-1} + u_{CL}H_{t-1} + u_C + \beta(u_{SS}C_t$$

$$+u_{CS}C_{t+1} + u_{RS}R_{t+1} + u_{HS}H_{t+1} + u_{SD}R_t + u_{SL}H_t + u_S) - \lambda P_{Ct} = 0$$

Solving FOC for C_t:

$$C_t = \beta_{10} + \beta_{11}\, C_{t-1} + \beta_{12} C_{t+1} + \beta_{13} R_{t-1} + \beta_{14} R_t + \beta_{15} R_{t+1} + \beta_{16} H_{t-1} + \beta_{17} H_t$$
$$+\beta_{18} H_{t+1} + \beta_{19}\, P_{Ct}$$

where

$$\beta_{10} = -\frac{u_C + \beta u_S}{(u_{CC} + \beta u_{SS})} \qquad \beta_{14} = -\frac{u_{CR} + \beta u_{SD}}{(u_{CC} + \beta u_{SS})} \qquad \beta_{18} = -\frac{\beta u_{HS}}{(u_{CC} + \beta u_{SS})}$$

$$\beta_{11} = -\frac{u_{CS}}{(u_{CC} + \beta u_{SS})} > 0 \qquad \beta_{15} = -\frac{\beta u_{RS}}{(u_{CC} + \beta u_{SS})} \qquad \beta_{19} = \frac{\lambda}{(u_{CC} + \beta u_{SS})} < 0$$

$$\beta_{12} = -\frac{\beta u_{CS}}{(u_{CC} + \beta u_{SS})} > 0 \qquad \beta_{16} = -\frac{u_{CL}}{(u_{CC} + \beta u_{SS})}$$

$$\beta_{13} = -\frac{u_{CD}}{(u_{CC} + \beta u_{SS})} \qquad \beta_{17} = -\frac{u_{CH} + \beta u_{SL}}{(u_{CC} + \beta u_{SS})}$$

Solving FOC , $\frac{\partial L}{\partial R_t} = 0$, for R_t:

$$R_t = \beta_{20} + \beta_{21}\, R_{t-1} + \beta_{22} R_{t+1} + \beta_{23} C_{t-1} + \beta_{24} C_t + \beta_{25} C_{t+1} + \beta_{26} H_{t-1} + \beta_{27} H_t$$
$$+\beta_{28} H_{t+1} + \beta_{29}\, P_{Rt}$$

where

$$\beta_{20} = -\frac{u_R + \beta u_D}{(u_{RR} + \beta u_{DD})} \qquad \beta_{24} = -\frac{u_{CR} + \beta u_{SD}}{(u_{RR} + \beta u_{DD})} \qquad \beta_{27} = -\frac{u_{RH} + \beta u_{DL}}{(u_{RR} + \beta u_{DD})}$$

$$\beta_{21} = -\frac{u_{RD}}{(u_{RR} + \beta u_{DD})} > 0 \qquad \beta_{25} = -\frac{\beta u_{CD}}{(u_{RR} + \beta u_{DD})} \qquad \beta_{28} = -\frac{\beta u_{HD}}{(u_{RR} + \beta u_{DD})}$$

$$\beta_{22} = -\frac{\beta u_{RD}}{(u_{RR} + \beta u_{DD})} > 0 \qquad \beta_{26} = -\frac{u_{RL}}{(u_{RR} + \beta u_{DD})} \qquad \beta_{29} = \frac{\lambda}{(u_{RR} + \beta u_{DD})} < 0$$

$$\beta_{23} = -\frac{u_{RS}}{(u_{RR} + \beta u_{DD})}$$

Solving FOC , $\frac{\partial L}{\partial H_t} = 0$, for H_t:

$$H_t = \beta_{30} + \beta_{31} H_{t-1} + \beta_{32} H_{t+1} + \beta_{33} C_{t-1} + \beta_{34} C_t + \beta_{35} C_{t+1} + \beta_{36} R_{t-1} + \beta_{37} R_t + \beta_{38} R_{t+1} + \beta_{39} P_{Ht}$$

where

$$\beta_{30} = -\frac{u_H + \beta u_L}{(u_{HH} + \beta u_{LL})} \qquad \beta_{34} = -\frac{u_{CH} + \beta u_{SL}}{(u_{HH} + \beta u_{LL})} \qquad \beta_{38} = -\frac{\beta u_{RL}}{(u_{RR} + \beta u_{LL})}$$

$$\beta_{31} = -\frac{u_{HL}}{(u_{HH} + \beta u_{LL})} > 0 \qquad \beta_{35} = -\frac{\beta u_{CL}}{(u_{HH} + \beta u_{LL})} \qquad \beta_{39} = \frac{\lambda}{(u_{RR} + \beta u_{LL})} < 0$$

$$\beta_{32} = -\frac{\beta u_{HL}}{(u_{HH} + \beta u_{LL})} > 0 \qquad \beta_{36} = -\frac{u_{HD}}{(u_{HH} + \beta u_{LL})}$$

$$\beta_{33} = -\frac{u_{HS}}{(u_{HH} + \beta u_{LL})} \qquad \beta_{37} = -\frac{u_{RH} + \beta u_{DL}}{(u_{HH} + \beta u_{LL})}$$

For k=1,2,3: $\beta_{k2} = \beta * \beta_{k1}$ or $\beta_{k1} = (1 + r)\beta_{k2}$ since $\beta = \frac{1}{(1+r)}$ with r being discount rate.