Rational addiction to alcohol: panel data analysis of liquor consumption

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Summary

Utilizing a panel data set of 42 states over the period 1959–1994, this paper estimates a rational addiction model for liquor consumption for the US. The empirical evidence is consistent with the rational addiction hypothesis proposed by Becker and Murphy. However, the results are sensitive to the assumption of homogeneity across states or over time. Copyright © 2002 John Wiley & Sons, Ltd.

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Keywords panel data; liquor demand; rational addiction; heterogeneous panel

Introduction

Becker and Murphy [1] proposed a theoretical model in which forward-looking, utility maximizing consumers may become addicted to the consumption of a good. Consumers are rational in the sense that they anticipate the expected future consequences of their current actions. Consumers recognize the addictive nature of their choices but they may elect to make them because the gains from the activity exceed the costs through future addiction. Like most goods, the more one consumes of this good, the higher is the current utility derived. However, the individual recognizes that he or she is building up a stock of this addictive good that is harmful. The individual rationally trades off these factors to determine the appropriate level of consumption. While this theory is not without its critics, see for example [2–5], it provides an intriguing and conceptionally simple testable empirical model. A key feature of this theory is that consumption of an addictive good will depend on future as well as past consumption. Finding future consumption statistically significant is a rejection of the myopic model of consumption behavior, see [6,7]. In the myopic model of addictive behavior, only past consumption stimulates current consumption, because individuals ignore the future in making their consumption decisions. More recently, Gruber and Köszegi [5] questioned the ‘time-consistent preferences’ assumption required by the Becker and Murphy [1] theory. Dropping this assumption yields forward looking behavior but strikingly different normative policy implications.

Tests of the rational addiction model have been applied to cigarette consumption by Becker et al. [8] and Chaloupka [9] to mention a few. Becker et al. [8] used annual per capita sales data for US states over the period 1955–1985, while Chaloupka [9] used microdata on cigarette consumption from
the National Health and Nutrition Examination Survey. The latter is a national survey of approximately 28,000 individuals between the years 1976–1980. Both studies reject the myopic model of addictive behavior and find support for the rational addiction model. Olekalns and Bardsley [10] test rational addiction to caffeine using annual data on coffee consumption for the US over the period 1967–1992. Imposing an annual discount rate of 0.10, they find support for the rational addiction theory with significant coefficients on lagged and future consumption. However, their long-run price elasticity has the wrong sign. Grossman et al. [11] used surveys of high school seniors as part of the monitoring of the future research program to test the rational addiction hypothesis for liquor consumption. Consumption is measured as the number of drinks of alcohol consumed in the past year. The price variable is that of a six-pack of beer. Grossman et al. [11] find support for the rational addiction theory rather than the myopic theory of addiction. They report negative and significant price effects, positive and significant future consumption effects and a long-run price elasticity which is approximately 60% larger than the short-run price elasticity. However, Grossman et al. [11, p. 46] report that their estimates are not fully consistent with rational addiction because their estimates of the discount rate were negative and implausibly high yielding interest rates in the range of −20 to −60%. They conclude that these results along with the detailed analysis of Becker et al. [8] suggest that the data on alcohol consumption or cigarette smoking are not rich enough to pin down the discount factor with precision even if the rational addiction model is accepted. Their long-run price elasticity estimates range from −0.26 to −1.26 with an average of −0.65, while their short-run price elasticity ranges from −0.18 to −0.86 with an average of −0.41. Other applications include Bentzen et al. [12] who use time series data over the period 1960–1994 to test the rational addiction model for alcohol consumption across the four Nordic countries: Denmark, Finland, Norway and Sweden. Also, Auld and Grootendorst [13] who critique the empirical application of rational addiction models use aggregate data showing that non-addictive commodities such as milk, eggs and oranges are rationally addictive.

Using annual per capita distilled spirits consumption for 42 states over the period 1959–1994, our results are in general supportive of the rational addiction hypothesis for liquor. However, these results are sensitive to the assumption of homogeneity across states or over time. Based on the results of Becker et al. [8] and ours for cigarettes, see Baltagi and Griffin [14], aggregate panel data does not seem likely to provide sharp estimates for the discount rate. A more promising approach is to use micropanel data.

### Model specification

Following Becker et al. [8], denoted by BGM, the consumer’s problem is to maximize the sum of lifetime utility discounted at rate $r$

$$
\sum_{t=1}^{\infty} \beta^{t-1} U(C_t, C_{t-1}, Y_t, \epsilon_t),
$$

where $\beta = 1/(1+r)$, $C_t$ is the quantity of liquor consumed in period $t$, $Y_t$ is the consumption of a composite commodity in period $t$ and $\epsilon_t$ reflects the impact of unmeasured life-cycle variables on utility. BGM take the composite commodity $Y$ as the numeraire and the rate of interest is assumed to be equal to the rate of time preference. This maximization is subject to the following constraints:

$$
C_0 = C^0 \quad \text{and} \quad \sum_{t=1}^{\infty} \beta^{t-1} (Y_t + P_t C_t) = A^0
$$

where $P_t$ is the price of liquor at period $t$, $C^0$ is the initial condition indicating the level of liquor consumption at period zero, $A^0$ is the present value of wealth. Assuming the utility function is quadratic and solving the first-order conditions for $C_t$, BGM obtain the following first-difference equation:

$$
C_t = \theta C_{t-1} + \beta \theta C_{t+1} + \theta_1 P_t + \theta_2 \epsilon_t + \theta_3 \epsilon_{t+1},
$$

where current liquor consumption is a function of past and future liquor consumption, $P_t$ and the unobservable shift variables $\epsilon_t$ and $\epsilon_{t+1}$ reflecting the impact of unmeasured life cycle variables. For a derivation and interpretation of this equation as well as the implied restrictions on the coefficients, see [8, pp. 398–399]. An alternative rational addiction model considered by Chaloupka [9] for cigarettes includes leads and lags of prices. BGM recognize that $\epsilon_t$ is serially correlated. Even if it is not, $\epsilon_t$ affects utility in each period and affects consumption at all dates through the optimizing.
equation (3). Therefore, BGM treat $C_{it-1}$ and $C_{it+1}$ as endogenous and use lagged and future prices as instruments. Their empirical equation also includes other exogenous variables such as income, short and long distance smuggling indexes and taxes.

For our empirical implementation, we write a variant of (3) as follows:

$$C_{it} = \delta_0 + \delta_1 C_{it-1} + \delta_2 C_{it+1} + \delta_3 P_{it} + \delta_4 Y_{it} + \delta_5 P_{nit} + \epsilon_{it} \tag{4}$$

where the subscript $i$ denotes the $i$th state ($i = 1, \ldots, 42$) and the subscript $t$ denotes the $t$th year ($t = 1, \ldots, 36$). The data used in this study are obtained from Baltagi and Griffin [15] and updated from 1982 to 1994 so that the panel covers 42 states over 36 years (1959–1994). $C_{it}$ is per capita consumption of liquor (measured in gallons of distilled spirits per head) by persons drinking age (16 years and older). $P_{it}$ is the average retail price of 750 ml of Seagram 7 deflated by the CPI. $Y_{it}$ is real per capita disposable income. For data sources, as well as details on the construction of the neighboring price, see [15].

Per capita sales of liquor are obtained from the Distilled Spirits Institute and the average retail price per 750 ml of Seagram 7 is obtained from various issues of The Liquor Handbook and updated using the price of alcoholic beverages from the inter city cost of living index published quarterly by the American Chamber of Commerce Researchers Associates. Per capita disposable income data on a state basis are published in various issues of the Survey of Current Business. Population data are obtained from various issues of the Current Population Reports. Price deflators are obtained from the Bureau of Labor Statistics. $P_{nit}$ denotes the minimum real price of liquor in any neighboring state. The last variable allows for possible ‘border purchasing effects,’ which Baltagi and Griffin [15] found important in explaining why some very low tax states enjoy much higher per capita liquor sales than neighboring states with higher taxes. Similar findings for cigarettes are obtained by Becker et al. [8].

One of the advantages of a panel is its ability to control for all time-invariant variables or state-invariant variables, whose omission could bias the estimates in a typical cross-section or time-series study. Following BGM, both state and time effects are assumed to be fixed. This can be justified given the numerous policy interventions as well as health warnings and Surgeon General’s reports. Therefore, we include time dummies to control for government intervention such as (i) the Alcohol Traffic Safety Act of 1983 which provided financial incentives for states to enact and enforce stringent drunk-driving laws. Kenkel [16] reports that between 1981 and 1986, 729 state laws pertaining to drunk driving were enacted. (ii) The Federal Uniform Drinking Age Act of 1984 passed by Congress to pressure all states into raising the minimum legal drinking age to 21. (iii) The introduction of warning labels on all alcoholic beverages warning pregnant women about the dangers of drinking and the public about the dangers of drinking and driving. Similarly, state dummy variables are included to control for state-specific characteristics including but not limited to the following: (i) States like Montana, New Mexico and Arizona with Indian reservations that are allowed to sell tax-exempt liquor, (ii) States like Florida, Texas, Washington and Georgia with tax exempt military bases, (iii) A state like Utah with a high percentage of Mormon population (a religion which forbids drinking). Utah’s adult per capita consumption in 1994 was 1.20 gallons. This was less than the national average of 1.82 gallons per adult. (iv) A highly touristic state, such as Nevada with a per capita consumption of liquor in 1994 of 4.68 gallons which is more than twice the national average of 1.82 gallons.

The Distilled Spirits Council (DISCUS) reports that adult per capita liquor consumption in the US dropped from a high of 3.05 gallons per head in 1974 to 1.97 gallons per head in 1992. In 1992, excise taxes on distilled spirits generated $7.7 billion in tax revenues in federal, state and local taxes. The Federal excise tax on distilled spirits remained the same from 1951 till 1985 at $10.50 per proof gallon, when it was increased by 19% to reach $12.50 per proof gallon. This was increased again in 1991 by 8% to $13.50 per proof gallon. In fact, Grossman et al. [17] argue that the real prices on alcoholic beverages have declined by 32% between 1975 and 1990 due to the stability of these taxes. States have also taxed liquor quite differently, ranging in 1983 from $1.50 per gallon in a low tax state like Maryland to a high of $6.50 per gallon in Florida. Variations in state tax rates are primarily responsible for substantial interstate variation in liquor prices especially among neighboring states. Another factor is state versus privately owned liquor stores. In 1984, apparent per capita consumption of alcohol for persons 14
years and older in New Hampshire was 4.91 gallons, a little less than twice the national median of 2.63 gallons per capita. This does not imply that New Hampshire residents are heavy drinkers. Carlson [18, p. 31] reports that ‘about 55% of New Hampshire’s 155 million in annual liquor sales is to out of state tipplers.’ Figure 1 plots the gallons of liquor sold per capita for selected states. These figures show that consumption rose throughout the 60s and most of the 70s and started declining in the late 70s and early 80s.

Heterogeneous rational addiction model estimates

Allowing the coefficients of equation (4) to vary from state to state we obtain a heterogeneous second difference equation across states. We estimated these heterogeneous equations using time-series data. The effective sample period is 1960–1993. Only 22 states have estimates that yield real roots for the second difference equation. Using the notation in equation (3), the second difference equation has real roots provided $4\beta \theta^2 < 1$. Appendix A of [8] characterizes this condition as a ‘stability condition’. Given that the solution to a rational addiction model is generally assumed to be a saddle point, its roots could not pass a stability test, see [19]. However, a saddle point solution does require that the roots be real and in that context this condition is useful and has to be checked. For these state by state heterogeneous time-series estimates, all of the coefficients of $C_{t-1}$ and $C_{t+1}$ are significant and positive rejecting the myopic model in favor of the rational addiction model. Pesaran and Smith [20] suggest averaging these heterogeneous estimates to obtain a pooled estimator. This average OLS estimator across states is reported in Table 1, panel A. The implied short- and long-run liquor price elasticity estimates at the mean of the data are $-0.52$ and $-1.39$, respectively, and the implied interest rate for the mean estimates is $-6\%$. Becker et al. [8] derived the formulas used to compute the short- and long-run price elasticities. In fact, for the short-run price elasticity $dC_t/dP_t = 2\delta_3/[1 - 2\delta_3 + (1 - 4\delta_1 \delta_2)^{1/2}]$ and for the long-run price elasticity $dC_{<t}/dP = \delta_3/(1 - \delta_1 - \delta_2)$. The corresponding elasticities are evaluated at the means of the data. The mean neighboring price effect is positive and significant while the mean real per capita income effect is small and insignificant. If we apply 2SLS using two period lagged and forward variables which include price, neighboring price

Figure 1. Consumption of distilled spirits for selected states (gallons per capita). Source: Distilled Spirits Council of the US and Adams/Jobson’s Liquor Handbook
and income, the results yield 20 states with real roots for the second difference equation. For these state by state heterogeneous time-series regressions, most of the coefficients of lagged and future consumption are significant and positive rejecting the myopic model in favor of the rational addiction model. The implied interest rate at the mean of the data is \( 7\% \) and the implied short and long-run liquor price elasticity estimates at the mean are \( 0.51 \) and \( 0.38 \), respectively. We also performed the Breusch and Godfrey LM test for first-order serial correlation across 42 states. This yields a rejection of the null of no serial correlation in 41 out of 42 cases at the 5\% level.

Recently, Auld and Grootendorst [13] argued that time-series data are generally insufficient to differentiate true rational addiction from serial correlation. Allowing the coefficients of equation (4) to vary from year to year, we obtain a heterogeneous second difference equation over time. We estimated these heterogeneous equations using cross-section data for 42 states. Only 21 years have estimates that yield real roots for the second difference equation. For these year by year heterogeneous cross-section estimates, all of the coefficients of lagged and future consumption are significant and positive rejecting the myopic model in favor of the rational addiction model. The Pesaran and Smith [20] average pooled estimator over time is reported in Table 1, panel A. The implied short- and long-run liquor price elasticity estimates at the mean of the data are \( -0.28 \) and \( -1.45 \), respectively, and the implied interest rate for the mean estimates is \( 1.4\% \). If we apply 2SLS using two period lagged and forward exogenous variables which include price, neighboring price and income, the results yield 24 years with real roots for the second difference equation. For these year by year heterogeneous cross-section estimates, all of the coefficients of lagged and future consumption are positive and the majority are significant. This evidence is in favor of the rational addiction model and against the myopic model. The implied interest rate for the mean estimates is \( 1.8\% \) and the implied short- and long-run liquor price elasticity estimates at the mean are \( 0.31 \) and \( 0.62 \), respectively.

### Homogeneous rational addiction model estimates

Assuming the coefficients of equation (4) do not vary over time or states, one can pool the data and run 2SLS with fixed effects for states and years.

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**Table 1. Estimates of rational models of addiction: dependent variable = \( C_t \)** (Asymptotic \( t \)-statistics are in parentheses)

<table>
<thead>
<tr>
<th>Model</th>
<th>( C_{t-1} )</th>
<th>( C_{t+1} )</th>
<th>( P_t )</th>
<th>( P_{nt} )</th>
<th>( Y_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Heterogeneous estimates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average OLS (by State)</td>
<td>0.442</td>
<td>0.472</td>
<td>(-2.680)</td>
<td>2.595</td>
<td>0.001</td>
</tr>
<tr>
<td>&amp;</td>
<td>(5.03)</td>
<td>(5.53)</td>
<td>((-4.85))</td>
<td>(4.44)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Average 2SLS (by State)</td>
<td>0.428</td>
<td>0.508</td>
<td>(-1.986)</td>
<td>1.882</td>
<td>0.001</td>
</tr>
<tr>
<td>&amp;</td>
<td>(4.01)</td>
<td>(4.97)</td>
<td>((-3.50))</td>
<td>(3.17)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Average OLS (by Year)</td>
<td>0.486</td>
<td>0.493</td>
<td>(-0.697)</td>
<td>0.081</td>
<td>0.001</td>
</tr>
<tr>
<td>&amp;</td>
<td>(7.76)</td>
<td>(7.87)</td>
<td>((-2.26))</td>
<td>(0.24)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Average 2SLS (by Year)</td>
<td>0.493</td>
<td>0.484</td>
<td>(-0.866)</td>
<td>(-0.068)</td>
<td>0.001</td>
</tr>
<tr>
<td>&amp;</td>
<td>(6.30)</td>
<td>(6.11)</td>
<td>((-2.69))</td>
<td>((-0.20))</td>
<td>(0.09)</td>
</tr>
<tr>
<td><strong>B. Homogeneous estimates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE2SLS(^a)</td>
<td>0.687</td>
<td>0.274</td>
<td>(-1.067)</td>
<td>(-0.169)</td>
<td>(-0.0002)</td>
</tr>
<tr>
<td>&amp;</td>
<td>(9.68)</td>
<td>(3.32)</td>
<td>((-1.77))</td>
<td>((-0.30))</td>
<td>((-0.31))</td>
</tr>
</tbody>
</table>

\(^a\)Time and state dummies are included but their estimates are not reported to save space. These dummies were jointly significant. The instruments used are \( P_t \), \( P_{nt} \), \( Y_t \) and their lagged and future values. All first-stage regressions on the instruments yield significant joint \( F \)-tests and exhibited high \( R^2 \). Hausman’s test for over-identification based on FE2SLS was insignificant.
This is the estimation method suggested by Becker et al. [8] for cigarette smoking. Table 1, panel B shows the fixed effects 2SLS estimates using $P$, $P_{nt}$ and $Y_t$ and their lagged and future values as instruments. Gruber and Kőszegi [5] recommend using state taxes as instruments rather than prices for their cigarette study. However, this data is harder to get for liquor. The coefficients of $C_{t-1}$ and $C_{t+1}$ are significant and positive rejecting the myopic model in favor of the forward looking rational addiction model. The implied short- and long-run liquor price elasticity estimates at the mean of the data are $-0.10$ and $-1.24$, respectively. The implied interest rate estimate is $150\%$. Note that the range of short- and long-run liquor price elasticity estimates are not that sensitive to the homogeneity versus heterogeneity assumption, but the estimates of the interest rate are very sensitive to this assumption. Reliable estimates of the interest rate was also a problem for the cigarette study by Becker et al. [8] and the liquor study by Grossman et al. [11]. In those studies, as well as the study on caffeine by Olekalns and Bardsley [10], prior estimates of the discount rates were imposed to check the sensitivity of the results to a reasonable range of interest rates. Overall, these results support the rational addiction theory for liquor consumption. The empirical evidence against the rational addiction theory are: (i) The finding of complex roots for the second difference equation for 20 states out of 42 for the heterogeneous state by state model and 12 years out of 34 for the heterogeneous year by year model. (ii) The unreasonable estimates of the discount rate. The implied interest rates were negative for the heterogeneous state by state model, small and positive for the 2SLS heterogeneous year by year model and large and positive for the homogeneous model. However, it should be emphasized that none of these interest rates were significant. The empirical evidence in favor of the rational addiction theory are: (i) The significance of future as well as lagged consumption for both heterogeneous and homogeneous rational addiction models. Also, (ii) the persistent and robust evidence of smaller short-run rather than long-run liquor price elasticities for both homogeneous and heterogeneous models. The policy implications from the latter results is that there is scope for raising revenues from increasing liquor taxes in the short-run. However, these gains in tax revenue are short lived since the long-run elasticity is larger than one. This also means that taxes are an effective weapon as a social control device to reduce consumption of alcohol in the long-run. We have also checked the sensitivity of our results to alternative price measures rather than Seagram 7. In fact, we used a Laspeyres and a Paasche indexes of nine brands of liquor to control for multibrand and changes in quality. Although the magnitudes of the short- and long-run price elasticities and that of the discount rate change, the main conclusions are still the same. One can also first-difference the model in (4) and apply the GMM methods described in [5,14] for cigarettes to check the robustness of the rational addiction specification for liquor. However, we think that a more promising approach is to use micropanel data like that of Grossman et al. [11] but with better measures of consumption and price.

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