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A Spatial Econometric Analysis of Alcohol Demand

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Abstract

The effects of alcohol taxation (and other price changes) have been studied extensively, and these studies have found that different types of individuals can respond quite differently to the same tax increases. Similarly, a wide range of individual and community-wide education programs and other types of interventions have been studied. Not surprisingly, it has been found that the effectiveness of an intervention is dependent on the type of drinker it is applied to.

When it comes to the control of access to alcohol, various choices include restricting access to certain ages, restricting hours of sale, and advertising restrictions. In addition, many jurisdictions restrict geographic (i.e. physical) access to alcohol by reducing the number (or density) of outlets where alcohol is available for purchase. While this type of access has been studied before, data limitations have required the use of imprecise, aggregate measures of both access and consumption. To better understand how access restrictions best fit into an overall prevention strategy, more attention should be paid both to the empirical measurement and to the underlying theory of how access affects various groups of consumers.

This paper takes several small steps forward in the study of access, employing new economic theory, techniques for measuring access, and employs spatial econometric techniques. We find that although reducing access does reduce apparent per capita consumption of liquor, alcohol-related problems are unlikely to be affected.

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1. Introduction

Although theoretical analyses of the interaction between consumer location and firm location have been common since the time of Sraffa (1926) and Hotelling (1929), very little empirical research has been done to estimate the impact that transportation costs have on consumer demand. Additionally, almost all theoretical models assume that consumers face a transportation cost for *each unit purchased*. In many cases this simplifies the analysis because it is equivalent to analyzing a change in the price of a good. However, in most consumer markets these models do not match reality.

In this paper we make several contributions to the economic analysis of consumer demand. We analyze the market for liquor in two contiguous "control"[1] states. First, making the assumption that consumers likely purchase from the closest liquor store to their residence, we create "market areas" for each of the 619 liquor stores in North Carolina and Virginia. These market areas allow us to use census data to find demographic characteristics of these consumers, and estimate the distance that consumers must travel to the nearest liquor outlet.

Second, we estimate demand functions using spatial regression techniques. These models allow for correction of spatial spillovers, as is the case when consumers purchase from a neighboring market area. Lastly, we do not interpret increasing travel cost as equivalent to an increase in price. Realizing that increasing travel costs do not affect the marginal costs, but are a fixed cost of access, we relate the results in the context of a two-part tariff model.

After reviewing the relevant literature in the next section, we describe the theoretical model in Section 3. In Section 4 we describe the data and estimation techniques, and present

[1] In a control state the distribution of liquor is largely provided by government agencies. Most often this includes sales of liquor (and only liquor) in government-run stores.

the results. The implications of the results on alcohol control policy and directions for future research are given in Section 5.

2. Background Literature

Theoretical Models

Fetter (1924) was one of the earliest economists to describe the impact of transportation costs on consumer behavior. Assuming that each unit purchased must be shipped at a freight rate that depends on distance, he describes how a firm's market area is determined based on the prices of its competitors and the freight rate. Hotelling's famous *Stability in Competition* and refinements by d'Aspremont, Gabszewicz, and Thisse (1979) furthered this research to consider the choice of location using Game Theory.

These models have been extended in many ways. For example, Salop (1979) and Prescott and Visscher (1977) use similar models to describe the extent of product differentiation and Spulber (1981) derives optimal nonlinear pricing functions for a spatial monopolist. However, all of these models either explicitly or implicitly assume that every unit purchased is subject to a transportation charge.

These per-unit transport costs models make sense in some contexts, but do not properly model the choices faced by consumers in many contexts. Most transactions involve a transportation cost which is relatively independent of the quantity of purchases made. In other words, consumers may incur costs of time, gas, and vehicle wear and tear, yet incur no marginal transportation cost for each item purchased. The cost of transportation is a hurdle that must be overcome that is then sunk, and thus irrelevant for the decision about quantity purchased.

There are very few discussions of lump-sum transportation costs in economic literature. Stahl (1982) uses a lump-sum transportation cost to explore the location of monopolistically competitive duopolists on a line, finding that lump-sum costs can provide some explanation for the agglomeration of firms. Burkey and Kurepa (2004) have recently begun to systematically solve per-unit models and compare the results to those derived in lump-sum models.

In a goods market such as that for liquor, two separate fees must be paid. First, a fixed fee of access that increases with distance must be overcome. Second, a per-unit price must be paid. A lump-sum travel cost is directly analogous to the fixed fee in a two-part tariff framework as discussed by Oi (1971) and Schmalensee (1981). In order to purchase a good, a consumer must pay a lump-sum fee. If the consumer pays the fee, then he can purchase any number of goods for a constant price. We will return to these two-part tariff models in the discussion of the empirical results in Section 4.

Empirical Models

In the arena of non-market goods, Hotelling (1947) is also credited with suggesting a method of estimating the value of national parks by the Travel Cost Method (TCM). The TCM is a method of estimating the willingness to pay for a non-market good by using the opportunity cost of time spent at a park as the marginal cost the consumer pays, and the travel costs incurred (fixed fee) is used as a lower bound on the consumers' surplus for each visit. Collecting this data through surveys allows estimations of the market demand curve for a site.

A drawback to the TCM is that the goal is not to estimate how the transportation cost affects demand. Rather, the transportation cost is not estimated, but normally assumed to be some fixed proportion of wages[2].

[2] See Cesario(1976) for a discussion of this issue.

Empirical models of transportation costs in product markets are rare. Davis (2001) includes customer locations in a model of spatial competition among movie theaters. Several studies have been done measuring the effects of geographic access to various medical services, including abortion (Kane and Staiger, 1996) and physician services (Newhouse et al., 1982). However, the most active research in this area focuses on the market for alcoholic beverages.

Beard et al. (1997) explicitly model a consumer's decision to drive across state lines in order to take advantage of price differences. They correctly realize the difference between the fixed transportation cost and the price paid. Using a model incorporating state prices, incomes, race, tourism, and sales, they estimate the amount of border-crossing behavior in northeastern alcohol markets. They find substantial amounts of border-crossing in the New York, Vermont, New Hampshire, and District of Columbia markets.

However, most research regarding geographic access to alcohol mistakenly equates the effects of restricting access to a price increase. While the effect of price increases on various types of drinkers is well understood (Manning et al, 1995, Cook and Tauchen, 1982), the effects of access are not. Most research on access finds that while apparent per capita consumption decreases when access costs increase, they find that alcohol-related problems do not.

The findings appear to depend greatly on how access is defined, and whether the outcome measure correlates more to acute or chronic alcohol consumption. For example, one is certain to find that a neighborhood with many bars (high "access") will have high rates of drunk and disorderly conduct. However, one must use care to avoid confusing the factors that determine the location of drinking with those that may affect the frequency of consumption or volume consumed per occasion.

For example, Scribner et al. (1998) found a positive relationship between alcohol availability and gonorrhea rates. Gyimah-Brempong (2001) finds statistically significant relationships between access and a variety of crime measures. However, Markowitz (2000) and Gorman et al.(1998) both fail to find any relationship between measures of access and spousal abuse.

Gruenewald and Millar (1996) find that although availability does not have a relationship with self-reported driving under the influence, there is a relationship with Single Vehicle, Nighttime (SVN) crashes[3]. Focusing on vehicle fatalities of young men, Kelleher et al. (1996) found that availability played no role. Brown and Jewell (1996) find a small, statistically significant relationship between availability and cirrhosis mortality, but Xie, Mann and Smart (2000) find no relationship. Tatlow, Clapp, and Hohman (2000) find that increased access has a positive relationship with alcohol-related hospital admissions. Lester (1995) found that measures of access to alcohol were not related to suicide nor homicide rates. However, Scribner et al. (1999) found that access was statistically significantly related to homicide rates in New Orleans. We will reconcile these apparent contradictions in the next section.

A Theory of Demand with Access Costs

In order to purchase a good, a consumer must incur a lump-sum travel cost (T). If the consumer pays the fee, then he can purchase any quantity for a constant price per unit (p). T will be a function of distance to a store, commuting patterns near stores, the number of stores, and the distribution of stores. The main difference between a two-part tariff model and the current framework is that the fixed fee is not collected by the firm, but has a similar effect of

[3] "SVN" crashes are often used as a proxy for alcohol-related crashes.

causing consumers to "disconnect" from the market when the fixed fee is sufficiently large[4]. We also include a taste parameter for alcohol that can be partially explained by demographic characteristics, *a*.

Let us construct a demand function for good *q*. Since the expenditure share for any one good is typically small, any income effects will be small.[5] Therefore, we will not dwell on the income effects in this analysis.

A consumer will choose to purchase the good if the consumer's surplus from the transaction is greater than the travel cost (given income *y*):

$$(1)\quad CS = \int_{P}^{\infty} q(a, y - T, p)dp > T$$

For a given $T = \overline{T}$, we could in principle find the minimum level of the taste parameter (a_m) and income (y_m) at which a consumer is indifferent between purchasing and disconnecting from the market. The transportation cost only affects the choice of *whether* to purchase the good, while it is the price that affects *how much* is purchased (as well as whether to purchase).

In a dynamic model the Economic Order Quantity model[6] becomes relevant, where consumers may purchase or consume more on each trip as access costs increase in order to economize on the travel costs themselves. In addition to having no decreasing effect on the consumption of high demanders, there is the possibility of increased consumption per episode (particularly at on-premise outlets) as access is decreased.

The brief exposition above uses several basic economic results to derive important new implications for the study of alcohol demand. For any given access cost, only those with

[4] That is, larger than consumer's surplus.
[5] See Vives(1987).
[6] If T is a fixed ordering cost, C is a per-item inventory cost, and D is annual demand, then the quantity purchased per trip is $Q* = \sqrt{\frac{2TD}{C}}$, and the frequency of orders per year is $N* = \sqrt{\frac{DC}{2T}}$

sufficiently strong demand will continue to purchase the good. As policies to reduce geographic access are strengthened, those with lower taste parameters will drop out of the market first. In the absence of income effects, because the price of the good has not changed, consumption for those with sufficiently high demand will be unaffected, but *per capita* consumption will go down as those with lower demand drop out of the market.

These realizations help to explain the apparent inconsistency in the alcohol literature regarding the effect of access on outcomes associated with heavy chronic drinking. Many of the studies finding relationships between access and crime measures are likely to be finding that high concentrations of on-premise outlets are loci of criminal and drunken behavior, rather than the concentration of outlets causing the behaviors themselves.

3. Data

Context

With the above theory in mind, we now describe a data set that will be used to empirically describe some of the implications of the model. Sadly, a direct test of the model is not possible with any available data. In order to verify the predictions that those with lower demand for alcohol drop out of the market while those with higher demand are unaffected would require a micro data set on alcohol consumption that contains a meaningful measure of geographic access. At this point, no such data set exists.

Because the basic elements of the theory are well-understood, we will instead use available data to perform two tasks. First, we will estimate parameters for a demand function that can be interpreted using the theory presented in Section 2. Second, we will perform some indirect tests of the theory. Namely, we will see if access is negatively related to per-capita consumption measures, but unrelated to common effects of heavy, chronic alcohol use.

We construct our data set using retail liquor outlets in North Carolina and Virginia. We use these contiguous states because in these control states, only liquor is sold in these outlets.[7] This creates a situation where a special stop (if not a special trip) must be made in order to purchase liquor in these states. Additionally, advertising, pricing, and selection are all regulated and fairly homogenous both within and between these states. Table 1 provides important statistics on state characteristics for comparison. Table 2 provides a comparison of the pricing formulas in each state.

We see that these two states are almost identical in most respects, except that while North Carolina has a larger area, it appears to have much higher access to alcohol. Two common measure of access are shown, Stores/Capita and Stores/Square Mile. Using these simple methods, one may wonder why the per capita sales are almost identical. How access is measured should be carefully considered.

Measuring Access

Consider two square counties which have five liquor stores each. County A has one store located in each corner, and one in the center of the county. County B's five stores are located on top of one another in the center of the county. Previous measures of access would treat these two counties in the same way. However, because access should be a proxy for a transaction cost associated with purchasing alcohol, this is unacceptable.

We use the individual outlet as the initial level of observation for this study. Once the locations and sales volumes are determined, the characteristics of those living in the vicinity of

[7] A small amount of wine is sold at liquor stores in each state. In North Carolina, it is only for special orders for products not imported into the state by a wholesaler. In Virginia, products produced by Virginia vintners are sold in ABC stores. The amount of wine sold is small, typically far less than 1% of total sales in each state. In addition, a small variety of "mixers" are sold at stores in both states. However, these mixers must contain at least 1% alcohol derived from liquor.

the stores will be determined from census data at the block group level. Characteristics including incomes, income inequality, racial characteristics, employment in the tourism industry, commuting patterns, and unemployment rates will be compiled.

In order to match consumers to stores, we create market areas with *Thiessen Polygons* (Figure 1) around each outlet. These polygons simply define all areas that are closer to a particular store than any other store, where the liquor outlet is represented by a point roughly in the center. All block groups whose center (centroid) is located in a given outlet's polygon will be matched to that store for analysis.

This method makes the rather strong assumption that consumers patronize the store closest to where they live. We will attempt to correct for violations in this assumption with the econometric techniques employed. The measure of access we use here is defined as the weighted average distance of a consumer distance to the closest store. This distance is computed as follows:

$$(2) \qquad \overline{T} = \frac{\sum_n P_n D_n}{\sum_n P_n}$$

where P is the number of consumers in block group *n*, and D is the distance from the center of the block group to the closest store. The summation is over the number of block groups closer to a particular store. There are 10,663 block groups and 619 stores in this study, for an average of 17.2 block groups associated with each store. The natural log of the distance is used, so that the parameter estimate will represent an elasticity.

Other Data

Data on sales and location for each store in North Carolina are based on my own research in cooperation with the North Carolina ABC Commission for the year 1994. The data on sales and location for each store in Virginia came from the Virginia ABC Commission. Data on religious affiliation was taken from *Churches and Church Membership in the United States, 1990*[8]. The source for all other socioeconomic data is the 1990 census. All of the socioeconomic variables were measured by block group, and weighted averages over the consumers of a given store were computed for use in the regressions.

Religion is represented by the percentage of residents of a county who are affiliated with a church which is associated with the Southern Baptist Convention. This choice was made for two reasons. The Southern Baptists represent a large portion of the church-going population in Virginia and North Carolina, and as much as 60% of the general population in some areas. For this reason, the percentage of residents in this category is highly correlated with the total percentage of residents with a religious affiliation. Southern Baptists were also chosen because of their historical, decidedly anti-liquor position (Rosenberg, 1989). Since this data was available only at the county level, the percentage of Southern Baptists in the county in which a liquor store is located is used.

Sales is the dollar amount[9] sold per store retail, not including the sales these stores make to restaurants. This figure is divided by the number of potential consumers patronizing a store, and the natural logarithm of this per capita figure is used in regressions. The number of potential consumers was defined as follows: First, the number of people 18 and over was computed. Of course, the *legal* drinking age is 21 in all states; however, failing to include those 18 to 20 as demanders would ignore the importance of this segment of the market. In all, approximately 10 million Americans under the age of 21 reported having had at least one drink

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[8] Bradley et al. (1990)

[9] Ideally one would use the *quantity* of alcohol sold, however, this data is not recorded for individual stores. Sales will tend to overestimate quantity in affluent areas, because through product selection the average price per unit is higher in these areas. The income variable should control for this effect somewhat.

in the previous month (NIDA, 1995). Although many people under the age of 18 also drink alcohol, 18 appeared to be an empirically valid cutoff point. The percentages of 16-17 year olds who both use alcohol or binge drink are roughly half that of the 18-20 year old and 21 and over rates (NIDA 1995).

From this number of potential consumers, institutionalized persons and military personnel were removed. Institutionalized persons will undoubtedly face large obstacles when attempting to obtain liquor, thus removing nursing home and prison populations is in order. Any consumption by these persons will increase the apparent consumption of those living near such an institution, but such effects will surely be very small. Military personnel were also removed because they can purchase liquor on military bases at a much lower price than in a civilian liquor store, since these stores are controlled by neither North Carolina nor Virginia, and they do not charge state taxes.

The natural log of the weighted average per capita **income** is used, calculated in a fashion similar to Equation (2). This elasticity is expected to be positive, since an increase in income is likely to increase both the quality and quantity of liquor purchased.

Race variables from census data are included. We include the percentage of inhabitants of a market area that are other than white, non-Hispanic. Typically, nonwhites drink less than whites do. Whites have a usage rate of 56%, compared with 45% and 41% for Hispanics and Blacks (NIDA, 1995). Thus, the expected sign of the coefficient on this variable is negative.

A dummy variable intended to capture any effects that **Virginia**'s system may have on sales is used. This may capture such factors as the 3% price difference, minor differences in selection, or other factors.[10]

Border Effect Dummies: The stores that are in counties in North Carolina or Virginia that border another state have a dummy variable indicating which state they border. Virginia borders Maryland, Washington DC, West Virginia, Kentucky, and Tennessee. North Carolina borders South Carolina, Georgia, and Tennessee. These variables are included to account for any border-crossing that may occur due to price differences. While it is not possible to make categorical statements comparing prices in different states due to differences in taxes, competition, and other factors, Maryland, D.C., West Virginia, South Carolina, and Kentucky have generally lower price levels than North Carolina and Virginia, while Tennessee and Georgia's prices are generally higher.[11]

Areas which have large numbers of **tourists** or business travelers will tend to have sales made to these individuals increase the apparent consumption of those living in the area. Census data which measures the percentage of those over 16 years of age employed in entertainment or recreation was used as an indicator of the amount of tourism in an area.

The **unemployment rate** for each group of consumers is calculated from the census data. The number of those unemployed is recorded for each block group. This number is divided by the total number of persons minus those identified as non-labor-force participants. This variable is expected to have a positive relationship with alcohol sales for two reasons. First, unemployed people have more leisure time to consume alcohol, and may be likely to use

[10] For example, only Virginia allows the use of "cents off" coupons.
[11] Only Kentucky and Washington, DC appeared to have an effect on the results. Therefore, only these two dummy variables are used in the analysis which follows.

alcohol more as a drug. Secondly, these people do not commute and will likely buy their alcohol from the store closest to their home.

Because the amount of liquor purchased at retail may be related to the availability of **Liquor by the Drink** in restaurants, I include a dummy variable to pick up these effects. As a rough measure of availability of liquor by the drink, I set the dummy variable to one if liquor by the drink is available anywhere in the county in which a liquor store is located. This variable should roughly determine if liquor by the drink and retail liquor are substitutes, compliments, or unrelated in consumption.

4. Empirical Estimation and results

We begin with the basic log-log OLS equation:

(3) $\ln Q_i = a \ln T_i + b \ln Y_i + cD_i + \varepsilon_i$

where Q_i is the dollar amount of apparent per capita consumption, T_i is a measure of access, Y_i is a measure of income, and D_i are other demographic and explanatory variables. The one variable that is conspicuous in its absence in equation (3) is price. Price is not included as a variable because within these two states, the price of liquor is determined by a formula (see Table 2). The resulting prices are very similar in the two states. As shown previously in Table 1, the pricing difference is small, on the order of 3%. The Virginia dummy variable will capture any effects of this price difference.

The residuals from these regressions will be tested for spatial dependence. Because these data are explicitly spatially related, omitting this information can cause omitted variable bias and/or inefficiency. There is a potential for spatial spillover effects as customers of one area purchase in neighboring market areas.

Spatial Econometric Models: Lag vs. Error

Because neighboring areas are related, the first task is to define in what manner areas are to be considered neighbors. This can be done in several ways, including areas that share a common boundary or areas that are within (say,) 15 miles of one another. In this paper we define areas as neighbors using *queen contiguity*; that is, areas are considered neighbors if they share a common boundary or meet at a corner. Then, a contiguity (i.e. spatial weights) matrix is constructed which mathematically represents these neighbor relationships. Using these spatial weights matrices, we perform diagnostic tests[12] to determine whether any spatial dependence is present in the data under study. The two basic classes of spatial models are spatial *error* and spatial *lag* models.

A spatial ***lag*** model is appropriate when activity in one location both affects, and is affected by, activity in neighboring locations, or when there is spatial contagion of a disease or a trend over space and through time. Spatial ***error*** models are often employed when data on important variables involving the spatial structure of an activity are unobserved. Alternatively, one can interpret these models as incorporating the fact that unobserved influences are correlated across space. In these cases, the error terms in a regression will tend to be spatially correlated. In this case, ignoring this "spatial nuisance" will not bias coefficient estimates, but will cause inefficiency. Econometrically, the spatial lag model is estimated via a "spatial autoregressive model" (Anselin 1998, p.35).

(4) $y = \rho W y + X\beta + \varepsilon$

Simply stated, this formula tests the hypothesis that per capita consumption (y) is a both a function of explanatory variables ($X\beta$) as well as a function of the per capita consumption of

[12] Specifically, these are Lagrange Multiplier tests implemented in the **spdep** package in R (by Roger Bivand and Andrew Bernat).

neighboring areas (ρWy). Here, ρ is constrained to be less than one, and describes the "strength" of the spatial dependence.

In a similar fashion, the spatial error model assumes a spatial correlation among the error terms:

(5) $y = XB + \varepsilon, \varepsilon = \rho W\varepsilon + u$, where $u \sim i.i.d.$

The failure to estimate a spatial lag model (when called for) will lead to inconsistent and biased estimates. However, in the case of a spatial error model OLS estimates are unbiased, but inefficient.

OLS Results and Specification Tests

Results of an OLS estimation are shown in Table 3. Using these results as a starting point, we calculate Lagrange Multiplier tests for the two classes of models described above[13]. Because each LM test can result in a false positive for the other type of model, a robust form of each test is also used. The LM Tests (Table 4) for both models are statistically significant, however, only the Robust LM statistic for the error model is significant. Therefore, the spatial error model indicated. We include results of both the lag and error models for comparison (Tables 6 and 7). As the two are similar, we will focus on the results of the error model for discussion purposes.

Discussion of Results

The income elasticity of 0.38 is close to estimates found in previous studies.[14] The coefficient on the percentage of workers in the entertainment and recreation industry is statistically significant and large. The coefficient implies a 15% increase in per capita sales for each 1% increase in entertainment workers. The large sign on the entertainment and recreation

[13] See Anselin(1988) and Anselin, Bera, Florax, Yoon (1996) for details about these tests.
[14] For example Cook and Tauchen(1982)'s estimate of 0.43.

variable is understandable, since a change of one percent of the work force employed in these fields represents a large change in tourism. The maximum observed in the data for this variable was slightly over 5.9%, with the average being close to .66%. Similarly, the unemployment rate has a large, positive coefficient.

The dummy variables for Kentucky and Washington, DC are negative, consistent with the fact that they have much lower prices than Virginia. Per capita sales are roughly 60% lower in counties bordering these regions, indicating border-crossing sales. The Virginia dummy variable is also marginally statistically significant, with the point estimate suggesting a 10% lower sales figure per capita, *ceteris paribus*.

Interestingly, religion, race, and the availability of liquor by the drink were not statistically significant. The latter suggests that liquor by the drink is neither a substitute nor a complement for retail purchases of liquor, on the whole.

The Interpretation of Access

As expected, the coefficient on the access measure is negative and significant. This can be interpreted as an elasticity: As the distance doubles the per capita amount purchased drops by approximately 19%. Thus, we can see that this relationship is very inelastic. However, this is in sharp contrast to consensus estimates of the price elasticity of demand for liquor -1.5 (NIAAA, 2001), reinforcing the theoretical differences mentioned in Section 2.

Thus, when the average travel distance for a store's market area increases, one would expect total sales to increase as more customers are included in the market area. However, one would expect fewer of these customers to connect because of higher travel costs. Thus, we have a measure of an "apparent"[15] per capita elasticity. We can write this elasticity as follows:

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[15] "Apparent", because this elasticity does not describe how individuals respond, but rather how the aggregate sales respond.

(6) $$\varepsilon_{tc} = \frac{\partial(\frac{P*Q}{\tilde{N}})}{\partial T} * \frac{T}{\frac{P*Q}{\tilde{N}}}$$

where $\tilde{N}$ is the total population in a market area. Given that P is assumed to be fixed, we can write $\partial(P*Q/\tilde{N}) = P*\partial(Q/\tilde{N})$, and the price will cancel out of the elasticity. The elasticity now involves only quantity, not dollar value of sales. In addition, if we assume that the quantity sold is a linear function of $\tilde{N}$ (ceteris paribus), then we can also bring out the $1/\tilde{N}$ from the derivative, and it, too, cancels out. This gives:

(7) $$\varepsilon_{tc} = \frac{\partial Q}{\partial T} * \frac{T}{Q}$$

Recall that in section 2 it was argued that consumers will respond to increases in travel costs just as they would to an increase in a fixed fee in a two part tariff. Schmalensee(1981) derives some useful relationships describing how consumers will behave in such a model. Let $\hat{q}$ be the quantity demanded by a marginal consumer, and subscripts denote partial derivatives. In a model assuming that income effects are zero:

(8) $$N_P = \hat{q}N_T = Q_T$$

Here N reflects the number of consumers who actually connect to the market. Equation (8) states that a price increase of ΔP has the same disconnection effect as a $\hat{q}\Delta T$ increase in travel costs. The last equality simply states that the change in the quantity sold in the market as transportation costs increase must equal $\hat{q} * N_T$. In this context, T must be in dollar units rather than miles. As a very rough estimate, let us assume that the IRS figure of 36 cents per mile is an accurate reflection of marginal (rather than average) travel costs.

Converting miles into a travel cost in dollar units will not change the point estimate of the elasticity, because this will change both the measure of T and the magnitude of ∂T by identical amounts. However, in order to isolate Q_T from the elasticity, we should multiply by the average value of Q/T from the data. The average Q (in bottles) per store was around 81,800, and average travel cost was $2.67 per trip. This gives a measure of –5,818 for Q_T, which should also equal N_P for the average store. The major problem with the calculation of Q_T above is that the $2.67 figure is *per trip*, using yearly figures. Given that more than one trip per year is probably taken by those who connect, –5,818 is certainly an upper bound on $|Q_T|$. In addition, $0.36 per mile is probably a fairly low estimate of average cost per mile, especially since there are costs of time, including a cost of purchasing associated with the consumer's time *once inside the store*. Both of these problems reinforce the fact that Q_T is probably less than calculated.

Even so, around –6,000 is not a wholly unreasonable value for Q_T and N_P. Suppose that this value would hold for a $1 change in Travel Cost or Price. Given that the average number of potential customers per store is around 15,000, N_P would indicate that increasing the price of liquor $1 (about 15%) would cause 6,000 marginal customers to disconnect. While this does seem drastic, it is not out of line with Cook and Tauchen's (1982) price elasticity estimate of -1.8. The above price increase would cause a decrease in total quantity demanded of 27%, which would represent a large percentage of consumers (the low demanders) dropping out of the market and purchasing a substitute.

Q_T would tell us that the average number of bottles sold per store (82,000) will drop by about 6,000 if travel costs are increased by $1. This number also seems to be within the bounds of reasonability. If we had data on $\hat{q}$, the quantity consumed by a marginal consumer per year, we could estimate $N_T = \frac{6000}{\hat{q}}$. Supposing that $\hat{q}$ is 2 or 3 bottles per year would lead us to conclude that N_T is between 2,000 and 3,000 for an average store.

Negative Outcomes and Access

Preliminary regressions show little relationship between access and many negative outcomes associated with alcohol. However, more data needs to be incorporated before confidence in these regressions can be earned. Because almost all of this data is only reported at the county level, characteristics of those living in a county (including distance to the closest outlet) were aggregated to the county level. Data from the *County alcohol problem indicators, 1986-1990* on alcohol-related deaths and data from the *FBI Uniform Crime Reports* have been collected. An example regression using readily-available data on *total alcohol-related death rate* is shown in Table 8. The coefficient on average distance is small and statistically insignificant. However, without careful consideration of the explanatory variables involved, the results at present could be a result of omitted variable bias.

5. Conclusion

While it has often been argued that consumers will react to increases in travel costs as an increase in price, theoretically, increases in travel costs should have no marginal effects on a consumer’s purchases. From this viewpoint, this paper indirectly contains an argument for dismantling state-run retail liquor enterprises. Perhaps a “better” social policy would be to sell liquor in grocery stores and increase taxes. Selling liquor in this way would lower travel costs (arguably to zero), because the average consumer goes to a grocery store more than 2 times per week (Pearcy, 1998). Because travel costs are simply a loss of consumer’s surplus, this is one example of efficiency gains. Secondly, more people will connect with the retail liquor market, increasing efficiency. Because these additional consumers will be those with low demand, there is a lower chance of possible negative externalities from these demanders. Increasing taxes on liquor will better serve to decrease the quantity consumed by high demanders than will increasing travel costs. A third source of increased efficiency would be the lack of overhead associated with operating state-run liquor stores. In North Carolina, overhead costs were one-sixth of total sales. While this overhead expense is on the same order as those incurred by grocery stores, the cost of selling a non-refrigerated, nonperishable good would certainly be lower than for the average food product.

Thus, it is probable that with increased connection and increased taxes that total consumer's surplus would rise, total sales could remain relatively constant, sales per consumer would drop, tax revenues would increase, and negative externalities from high demanders would drop. Although this may paint the policy picture with colors that are a little too rosy, there is no obvious reason to think that these goals could not be simultaneously achieved.

In the future, the analysis presented in this paper could be significantly improved in several ways. Almost all of these ways involve the costly acquisition of data. For example, it would be extremely useful to have data from store transaction records. This data would allow the exact quantity of liquor sold at each store, as well as the quantity purchased per transaction. In addition, survey data identifying the amounts consumed by various types of individuals, and number of trips taken to the stores per year would be useful. Knowing estimates of and the underlying rates of disconnection would allow empirical estimates of travel costs to be derived. Empirically estimating how consumers perceive and react to travel costs, rather than conjecturing their magnitude, would be a significant contribution in and of itself.

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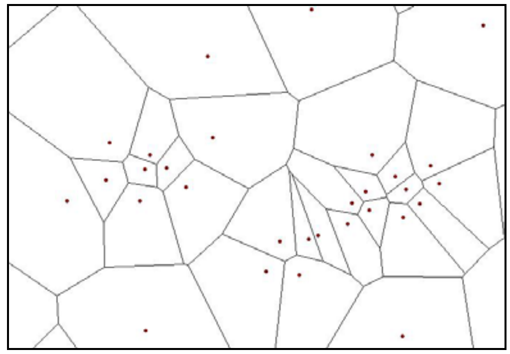

Figure 1: Thiessen Polygons for liquor stores

Table 1. Basic Statistics for Virginia and North Carolina

	Virginia	North Carolina
Population	6,394,493	6,836,338
Area (Square Mi.)	40,815	52,712
Annual Sales	$291,395,139	$312,085,985
Annual Total Profit + State Taxes	$77,086,713	$109,186,015
Number of Stores	243	386
(Profit + Tax) Per Store	$317,229	$282,865
Stores/100,000 Population	3.80	5.65
Stores/1000 Square Miles	5.95	7.32
Sales Per Person	$45.57	$45.65

Table 2. Breakdown of $3 (distiller's price) bottles of liquor in each state

	Virginia	North Carolina
Distiller's price	$3.00	$3.00
Federal tax	2.24	2.24
Markup[16]	2.50	2.38
State excise tax	1.60	2.02
Warehouse charge	.11	.14
Total:	$9.45	$9.75

[16] In North Carolina, this corresponds to "local markup", or the revenue the local board keeps.

Table 3. Descriptive Statistics

Variable	Mean	Units	St. Dev.
Per Capita Sales	78.80669	Dollars	113.43
Log Per Capita Sales	4.1458	Log Dollars	0.57
Average Distance	3.74694	Miles	2.18
Per Capita Income	13,175.49	Dollars	4645.71
Religion	18.07	Percent	10.59
% Unemployment	3.52974	Percent	1.46
% Long Commute	55.34865	Percent	8.57
% Entertainment Empl.	0.67083	Percent	0.52
Per Capita Income	13,175.49	Dollars	4645.71

Table 4. OLS Results

Variables	Coefficient	Std. error	*t*	*p* value	
(Intercept)	0.700208	1.232681	0.568	0.57022	
LAVDIST	-0.16716	0.044589	-3.749	0.000195	***
PNONWHITE	0.001908	0.001526	1.25	0.211603	
LOGPCI	0.338465	0.123146	2.748	0.006165	**
PUNEMP	0.098324	0.031603	3.111	0.00195	**
PENTREC	0.176485	0.057414	3.074	0.002208	**
KY	-0.58806	0.254701	-2.309	0.021287	*
DC	-0.59623	0.160487	-3.715	0.000222	***
VA	-0.10072	0.047522	-2.12	0.034451	*
REL	0.001165	0.002313	0.504	0.61461	
LBD	0.061086	0.06236	0.98	0.327684	
Residual standard error	0.527 on 608 degrees of freedom				
Multiple R-Squared	0.1683				
Adjusted R-squared	0.1546				
F-statistic	12.3 on 10 and 608 DF				
p-value	< 2.2e-16				
Sample size	619				

Table 5. 1^{st} order Queen Lag Specification Diagnostics
Lagrange Multiplier Diagnostics for Spatial Dependence

Variables	LM	df	*p* value
LM Error	9.4823	1	0.002075
RLM Error	2.8073	1	0.09384
LM Lag	7.2795	1	0.006975
RLM Lag	0.6044	1	0.4369

Table 6. Spatial Error Model

Variables	Coefficient	Std. error	*z*	*p* value
(Intercept)	0.359527	1.277032	0.2815	0.778302
LAVDIST	-0.19109	0.047569	-4.0171	5.89E-05
PNONWHITE	0.00178	0.001652	1.0775	0.281259
LOGPCI	0.384373	0.127693	3.0101	0.002611
PENTREC	0.14585	0.059244	2.4619	0.013822
PUNEMP	0.090872	0.03204	2.8362	0.004565
KY	-0.59141	0.279285	-2.1176	0.034211
DC	-0.60472	0.178175	-3.394	0.000689
VA	-0.10774	0.056378	-1.911	0.055999
REL	0.001059	0.00259	0.4088	0.682702
LBD	0.043001	0.063886	0.6731	0.500895
Lambda	0.19894			
LR test value	9.2691			
p-value	0.0023305			
Asymptotic standard error	0.061939			
Wald statistic	10.317			
p-value	0.0013184			
Log likelihood	-471.624 for error model			
Number of observations	619			
AIC	969.25, (AIC for lm: 976.52)			

Table 7. Spatial Lag Model

Variables	Coefficient	Std. error	*z*	*p* value
(Intercept)	0.222803	1.220217	0.1826	0.855118
LAVDIST	-0.15749	0.044504	-3.5388	0.000402
PNONWHITE	0.001515	0.001506	1.0063	0.314256
LOGPCI	0.325278	0.121743	2.6718	0.007544
PENTREC	0.153917	0.056682	2.7154	0.006619
PUNEMP	0.093355	0.031105	3.0013	0.002688
KY	-0.52992	0.251478	-2.1072	0.035097
DC	-0.55613	0.159125	-3.4949	0.000474
VA	-0.0909	0.047065	-1.9313	0.053448
REL	0.001068	0.002275	0.4693	0.638852
LBD	0.050684	0.061379	0.8258	0.408936
Rho	0.15454			
LR test value	6.5715			
p-value	0.010362			
Asymptotic standard error:	0.060517			
Wald statistic	6.5209			
p-value	0.010662			
Log likelihood	-472.9728 for lag model			
ML residual variance (sigma squared)	0.26875, (sigma: 0.51841)			
AIC	971.95 (AIC for lm: 976.52)			
Test value	1.0898			
p-value	0.29653			

Table 8. Negative Outcomes of Alcohol Abuse: Alcohol-Related Deaths

Variables	Coefficient	Std. error	*t*	*p* value
(Intercept)	162.02	28.93452	5.6	6.15E-08
LAVDIST	0.0607	0.76625	0.079	0.937
PNONWHITE	0.34647	0.03599	9.627	< 2e-16
LOGPCINC	-13.435	2.92246	-4.597	7.10E-06
PUNEMP	0.0988	0.55868	0.177	0.86
PENTREC	-0.05867	0.05543	-1.059	0.291
VADUMMY	-2.44455	1.01666	-2.404	0.017
Residual standard error	7.413 on 228 degrees of freedom			
Multiple R-Squared	0.5307			
Adjusted R-squared	0.5183 on 6 and 228 DF			
F-statistic	42.97			
p-value	< 2.2e-16			