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The effects of residential proximity to bars on alcohol consumption

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Abstract

A person's decision to drink alcohol is potentially influenced by both price and availability of alcohol in the local area. This study uses longitudinal data from 1985 to 2001 to empirically assess the impact of distance from place of residence to bars on alcohol consumption in four large U.S. cities from 1985 to 2001. Density of bars within 0.5 km. of a person's residence is associated with small increases in alcohol consumption as measured by: daily alcohol consumption (ml.) drinks per week, and weekly consumption of beer, wine, and liquor. When person-specific fixed effects are included, the relationship between alcohol consumption and the number of bars within a 0.5 km. radius of the person's place of residence disappears. Tests for endogeneity of the number of bars within the immediate vicinity of respondents' homes fail to reject the null hypothesis that the number of bars is exogenous. We conclude that bar density in the area surrounding the individuals' homes has at most a very small positive effect on alcohol consumption.

Keywords

Alcohol consumption; alcohol outlet proximity; geospatial data

1. Introduction

There is a long history of research into the environmental and demographic determinants of alcohol consumption (see e.g., Cook and Moore (2000)). Even before alcohol excise taxation became widespread, alcohol control policy focused on controlling consumption of alcohol by limiting its availability.

Past research has documented that a high density of alcohol sellers is associated with higher incidence of such alcohol-related outcomes as drunk driving (McCarthy 2003; Treno et al. 2007), automobile accidents (Brown and Jewell 1995), violent crime (Freisthler 2004; Gyimah-Brempong 2001), assaults (Britt et al. 2005; Gorman et al. 2001; Scribner et al. 2000; Speer et al. 1998), child abuse and neglect (Freisthler 2004), self reported injury (Treno et al. 2001), and other socially undesirable activities (Coopridge 1940; Livingston et al. 2007).

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To reduce losses from such adverse outcomes, governments have implemented various policies designed to raise the full price by means of imposing excise taxes on alcoholic beverages and decreasing the availability of sellers of alcoholic beverages by means of licensure and various zoning restrictions specifying where alcoholic beverages can be sold. The excise taxes have also been a source of revenue to states. State-run liquor stores have been established with similar goals in mind.

The most extreme example of restriction of alcohol availability in the U.S. was the enactment of Prohibition which lasted from 1920 to its repeal in 1933 (P. J. Cook 2007). Smaller scale policies to restrict or impose outright bans on alcohol sales have included county-wide bans on alcohol sales, restrictions on sales of alcoholic beverages on Sundays, and restrictions on alcohol seller entry in the form of licensure, including ceilings on the number of licenses issued, as well as zoning restrictions which specify where and where not certain types of enterprises can be sited within a locality.

Empirical research on effects of alcohol seller availability on consumption has been much more limited than has research on the money price elasticity of demand for alcoholic beverages (see e.g., P. J. Cook (2000)). Conceptually, restrictions on availability have the following potential channels of influence on alcohol consumption. Lower seller density may mean less price and non-price competition among sellers. Lack of competition may be expected to raise quality-adjusted prices of alcoholic beverages and hence reduce quantity demanded. Limiting availability is also likely to increase travel time and hence the time price and associated cost of obtaining alcoholic beverages (e.g., for gasoline). To the extent that individuals lack self control, fewer sellers may lead to fewer impulsive purchases of alcohol (Grant 2008).

Studies on the direct link between alcohol outlet density and alcohol consumption have produced mixed results with some studies finding no relationship (Pasch et al. 2009; Pollack et al. 2005), others finding a positive relationship (Chaloupka and Wechsler 1996; Gruenewald et al. 1993; Treno et al. 2003; Weitzman et al. 2003), and still others with mixed results (Schonlau et al. 2008; Scribner et al. 2000). In a cross-sectional study of 82 neighborhoods in four California cities, Pollack et al. (2005) found that alcohol sellers were the most dense in lower while heavier drinking was more prevalent in higher socio-economic status neighborhoods. With no significant direct association between neighborhood density of alcohol sellers and heavy drinking behavior. Scribner et al. (2000), in a cross-sectional study of 24 Census Tracts in New Orleans, found that individual distance to the closest alcohol outlet was not associated with alcohol consumption but that higher mean distances at the neighborhood level predicted lower alcohol consumption. Schonlau et al. (2008) measured numbers of such sellers within 0.1, 0.25, 0.5, and 1.0 mile buffers relative to place of residence as well as by Census Tract of residence in two locations, Los Angeles County (N=1,578) and southern Louisiana (N=1,303). They found no relationship between alcohol outlet density and the percentage of persons who were drinkers at either site, but found an association between density and alcohol consumption in Louisiana. Chaloupka and Wechsler (1996) found that alcohol outlet density within a mile of a college campus was positively related to binge drinking among college students while Weitzman et al. (2003) found similar results for heavy and frequent drinking using a two-mile radius around college campuses. However, many of these studies are cross-sectional (e.g., (Chaloupka and Wechsler 1996; Pollack et al. 2005; Schonlau et al. 2008; Scribner et al. 2000; Weitzman et al. 2003)).

If individuals consider availability of alcohol when deciding where to live or if alcohol sellers locate in areas of higher alcohol demand, then density of alcohol outlets is endogenous to consumption (Godfrey 1988). With one exception, no previous study has

accounted for possible endogeneity of alcohol seller location. In the exception (Gruenewald et al. 1993), two-stage least squares (TSLS) was used to account for endogeneity of alcohol outlet density; however, density was measured at the state level, which is too large a geographic area for this product. Several other studies have used such large administrative units as the state (Trolldal 2005) or city (Treno et al. 2003). Some studies have employed only small local samples, e.g., data from a city (Pasch et al. 2009; Pollack et al. 2005; Schonlau et al. 2008; Scribner et al. 2000; Weitzman et al. 2003). Such results may not generalize.

There is likely to be considerable heterogeneity in seller density within larger administrative units. Consumers plausibly do not consider alternative sources of supply over an area as large as a county or city, when deciding to purchase beer, wine, or liquor products.

While there has long been a presumption among practitioners and policymakers that distance to an alcohol seller is an important determinant of alcohol consumption, empirical evidence on this relationship, especially using administrative areas as small as those surrounding individual addresses (e.g., Treno et al. (2007)), and based on applications of newer techniques of geo-coding to these issues (e.g., (Pasch et al. 2009; Schonlau et al. 2008; Weitzman et al. 2003)), are still rare.

In this study, we examine the relationship between bar density and consumption of beer, wine, and liquor in four interview waves from 1985 to 2001 in four U.S. cities, considering three distance ranges of two kilometers or less from individuals' residences. We account for endogeneity of bar location using TSLS. To our knowledge this is the first longitudinal study that uses geospatial techniques to examine the effects of bar density around individual residences on alcohol consumption in four geographically dispersed U.S. cities. Since data on alcohol prices are lacking below the level of the city, we do not investigate effects of changes in such prices on amounts of alcohol consumed.

2. Data and Methods

2.1. Data

Our primary data source is Coronary Artery Risk Development in Young Adults (CARDIA), a prospective epidemiologic study designed to assess antecedents of cardiovascular disease risk factors in 5,115 black and white men and women aged 18-30 years at their initial interviews in 1985-6. CARDIA collected on a variety of risk factors including the traditional cardiovascular risk factors (smoking, blood pressure and cholesterol), as well as dietary and exercise patterns, behavioral and psychological variables, medical and family history, and licit and illicit drug use.

CARDIA has been previously used in research on substance abuse. Most studies based on CARDIA data used the first few sets of CARDIA interviews (Braun et al. 1996; Braun et al. 1997; Dyer et al. 1990; Greenfield and Weisner 1995; Hoegerman et al. 1995; Kiefe et al. 2001; Sidney et al. 1993; Slattery et al. 1992; Son et al. 1997; Wagenknecht et al. 1992a; Wagenknecht et al. 1998; Wagenknecht et al. 1990; Wagenknecht et al. 1992b).

The sample was recruited in Birmingham, AL; Chicago, IL; Minneapolis, MN; and Oakland, CA. All of the cities are highly urbanized. We analyze data from interviews conducted in 1985-6, 1990-1, 1995-6, and 2000-1. Retention rates were: 81% (1992-3), 79% (1995-6), and 74% (2000-1). Retention rates did not differ according to use of alcohol or illicit substances (Hoegerman et al. 1995).

We restrict our analysis sample to individuals who reported consuming alcohol in at least one wave. We exclude observations with missing values on dependent and explanatory

variables. The variable with the most missing values is household income, 16.6% missing at baseline. We also exclude observations of persons after they moved if they moved outside of a CARDIA city since CARDIA did not follow sample persons after they moved from a CARDIA city. Of the 2,325 individuals who moved during the study period, only 49 individuals moved from one CARDIA city to another; data on those persons who moved to a non-CARDIA city are excluded from our analysis after they moved. Analysis sample sizes for the three subsequent waves are: 4,086 (19985-6); 3,165 (1992-3); 2,657 (1995-6); and 1,901 (2000-1); 11,810 pooled.

We merge data from *Yellow Pages* with individual records from CARDIA. Data from this source were coded from hard copies for purposes of this study. Terms used for bars differed in *Yellow Pages* by city. In Birmingham, they were listed under the heading “bars.” In Chicago, they were “bars,” “nightclubs,” and “taverns.” In Minneapolis, they were “bars,” “beer parlors,” nightclubs,” saloons,” and “taverns.” In Oakland, they were “bars,” “lounges,” nightclubs,” “saloons,” sports bars,” and “taverns.” Machine-readable data are unavailable for the earlier study years. Furthermore, electronic versions of *Yellow Pages* seem to include only some of the sellers included in the printed versions.

We identify alcohol sellers in each of the four CARDIA cities in each of the years we include in our empirical analysis. We coded the exact address of establishment as given in *Yellow Pages*. Locations of alcohol establishments were geocoded-- a process of mapping street addresses to latitude and longitude coordinates. Using this dataset, we calculate bar density within fixed radii of individuals’ residence, limiting the sample to sellers with an alcohol license.

Addresses of residences of CARDIA respondents were also geocoded, using ArcView¹ v9. Based on the geocoded information, we calculate bar density within fixed radii of individuals’ residences.

We also coded data on liquor stores, gas stations, and grocery stores from *Yellow Pages*. Preliminary analysis with corresponding measures of liquor store density yields no statistically significant findings on alcohol consumption. Hence, we do not pursue that analysis further. However, we use data on liquor store, gas station, and population density to compare results for effects of zoning and other factors on bar density with those for the other sellers and for population density (see Appendix).

2.2. Empirical Specification

Dependent Variables—At each interview, respondents were asked, “How many drinks of (beer/wine/liquor) do you usually have per week?” One drink was defined for the respondent as: a 5ounce (oz)/148 milliliter (ml.) glass of wine, a 12 oz./355 ml. glass/can/bottle of beer, or a 1.5 oz./44 ml. shot of liquor. CARDIA constructed a fourth variable, ml. of alcohol consumed per day using a weighted combination of the amounts of each of the three types of alcohol consumed weekly by the individual which was then divided by seven for a daily average (Dyer et al. 1990).

We analyze five dependent variables with the person/year as the observational unit: amount of alcohol consumed per day (in ml.); total number of drinks per week; number of beers per week; number of drinks of liquor (distilled spirits) per week; and number of glasses of wine per week.

¹ArcView – Version 9 © Environmental Systems Research Institute, Inc.

Explanatory Variables—The key explanatory variables are counts of bars within ranges of three fixed radii from the person's residential location: bars within less than 0.5 km., bars within 0.5 to 1 km.; and bars within 1-2 km. Bars within a kilometer or so of one home's are plausibly within walking distance. The more distant bars are probably mostly reached by some other transportation form.

Other explanatory variables are: respondent household income and demographic characteristics—age, gender, race, marital status, and educational attainment. Age is specified as a continuous variable based on the age recorded by CARDIA in 1985-6. We also include a covariate for age-squared to account for non-linear age effects on alcohol consumption. Gender and race are defined as binary variables with female and Black equal to 1. All sample persons are either White or Black. CARDIA did not survey persons of other races/ethnicities. Marital status categories are: married; widowed; divorced; and separated; with never married, the omitted reference group. Educational attainment is measured as years of schooling completed, which has a range from 1-20. CARDIA provides annual household income data in mutually-exclusive categories. We use these categories to define binary variables: 0-\$15,999; \$16,000-\$24,999; \$25,000-\$49,999; \$50,000-\$74,999; and over \$75,000 with income below \$16,000 omitted.

We include binary variables for fixed year and city effects. Omitted reference groups are 2000-1 and Chicago, respectively.

2.3. Estimation

We initially model alcohol consumption using a reduced form equation as follows:

$$A_{it} = \beta_0 + \beta_2 W_{it} + \beta_1 X_{it} + e_{it} \quad (1)$$

A_{it} is a measure of alcohol consumption for individual i at year t . W_{it} is a vector of the number of bars in three distance ranges from an individual's residence. X_{it} is a vector of predetermined variables for individual i at year t . The error term is e_{it} .

Milliliters of alcohol consumed contains a high percentage of zeros (45%). We use Tobit to estimate eq. (1) with this dependent variable. The other dependent variables are count measures. For these, we use negative binomial regression.

Bar density may be endogenous if heavier drinkers disproportionately locate where bars are nearby, bars locate in neighborhoods with such drinkers, and/or both bar location and alcohol consumption are correlated with an omitted third factor not included in the analysis. We include person-fixed effects in one variant to account for omitted third factors.

To address endogeneity, we use TSLS with the zoning mix in each Census Tract in the four CARDIA cities as instrumental variables (IVs). Zoning ordinances affect location decisions of businesses, private and public institution, and residences. However, there is no conceptual reason to expect that zoning ordinances directly affect alcohol consumption. Furthermore, zoning ordinances change very slowly.

The zoning variables were created by overlaying city Census Tracts with zoning maps in ArcGIS and calculating the percent of land area in each Tract that had each of the seven zoning designations: commercial; residential; mixed-use office; institutional; industrial; other; and unincorporated. The omitted reference group in our analysis is residential. Zoning maps were obtained from the planning department in each city and reflect zoning ordinances as of 2005. Thus, the zoning variables are time invariant. We only allow for bars within a 0.5 km. radius of the person's place of residence to be endogenous.

3. Results

3.1. Sample Characteristics

Sample persons consumed an average of 11.5 ml. of alcohol per day and 4.7 drinks per week distributed as 62% beer, 18% wine, and 20% liquor consumption (Table 1). On average, respondents have more than one bar in a 0-0.5 km. radius of their residences; on average, there are four bars within 0.5-1 km., and 13 bars within 1-2 km.

3.2. Basic Results

Without considering the possibility of endogeneity of bars and using Tobit analysis, the number of bars within a 0.5 km. radius is positively related to alcohol consumption in all specifications (Table 2). The marginal effect of adding a bar within this radius is an increase of 0.32 ml. of alcohol consumed daily--2.8% percent of the sample mean. The marginal effect on the number of weekly drinks is somewhat lower, 0.072--1.5% of the sample mean. Although statistically significant at the 0.001 level, the marginal effects of adding a single bar are small.

Among the three alcoholic beverage types, the largest marginal effect is for liquor, 0.017--1.8% of the sample mean. Marginal effects on both beer and wine consumption are equal to 1.3% of their respective means.

The number of bars within a 0.5-1 km. radius only has a positive and statistically significant effect on daily alcohol consumption (ml.) with a marginal effect about half of its counterpart for the 0-0.5 km. radius. For weekly drinks, the corresponding effect is not statistically significant. Similarly, bar density within 1-2 km. has no statistically significant effects on either dependent variable. Similarly, bars from 0.5 to 1 km. and 1 to 2 km. have no statistically significant effects in the analysis of the number of beers, glasses of wine, or drinks of liquor consumed per week.

Overall, in terms of signs and significance levels, results for alcohol consumption (ml.) and number of drinks per year are generally similar. For alcohol consumption (ml.), consumption rises with age but at a decreasing rate, reaching a peak at an age of 37.9 years. Females, Blacks, currently married individuals, more highly educated persons, and generally those with household incomes in the \$16,000 to \$74,999 range consume less alcohol than do men, whites, never married and less highly educated individuals, and those with household incomes under \$16,000). Separated individuals, and persons with household incomes over \$75,000 consume more alcohol on average, although persons in the most affluent group tend to consume less beer. People who moved after 1985-86 consumed more liquor before their move, but otherwise none of the marginal effects are statistically significant.

Minneapolis residents consume higher amounts of alcohol, measured in milliliters, than do residents of Chicago, the omitted reference group. The difference is attributable to higher consumption of liquor in Minneapolis. Alcohol consumption is relatively high in the first survey year (1985-6).

3.3. Fixed Effects and Two-Stage Least Squares Results

3.3.1. First-Stage Estimates—The first stage has the number of bars within a 0.5 km. radius of the respondent's place of residence in a year as the dependent variable (Table 3). The same first-stage equation applies to analysis of both alcohol consumption measured in milliliters as for the number of drinks. Holding other factors constant, several parameter estimates on the zoning variables which are excluded from the second-stage equations have statistically significant parameter estimates. Relative to the fraction of the Census Tract in

which the respondent lived, the omitted reference group, Tracts with larger fractions zoned for commercial, office, mixed use, and other establishments have larger numbers of bars. The largest parameter estimate is for commercially-zoned Tracts, which is plausible. To determine whether or not our IVs are weak, we perform an F-test on the IVs excluded from the second-stage equation. The F-statistic on the excluded instruments in the first stage regression is 82.9 with a partial R^2 of 0.073, implying that the requirement that IVs be substantially correlated with the endogenous variable is satisfied.

Other explanatory variables positively associated with the number of bars within a 0.5 km. radius of the respondent's home are the number of bars within 0.5 to 1 km. and within 1 to 2 km of the home, especially the former variable, female gender, educational attainment of the respondent, and residents of Chicago, the omitted reference group for cities. Age has a positive effect at young adult ages, but the effect diminishes with age and eventually becomes negative. Among the income variables, only the binary variable for the highest income category is positive and statistically significant at conventional levels. Relative to never married persons, the omitted reference group, currently married persons live in areas with fewer bars in the immediate vicinities of their homes.

3.1.2. Ordinary Least Squares and Fixed Effects Results for Alcohol

Consumption—For purposes of comparison with the Tobit and negative binomial results presented above, we reestimate the equations for alcohol consumption with ordinary least squares (OLS). The implied marginal effects for the bar density variables from OLS are quite close to their Tobit and negative binomial counterparts, slightly lower than the Tobit marginal effects and almost identical to the negative binomial marginal effects, respectively (Table 4). However, when we add person-specific fixed effects, the positive and statistically significant effects for bar density in the < 0.5 km. radius disappear. This result suggests that individual-specific changes in bar density are too small to identify a longitudinal relationship between alcohol consumption and bar density. These individual fixed effects should account for time-invariant differences in tastes for alcohol among individuals which otherwise may appear in e_{it} . In the Appendix, we compare results for bars with other measures of seller density for other seller types obtained from *Yellow Pages*.

3.1.3. Second-Stage Results for Alcohol Consumption—Durbin-Wu-Hausman tests of the null hypothesis that the number of bars within a 0.5 km. radius of respondents' homes is exogenous accept the null hypothesis by a large margin. Over-identification test chi-square statistics are 8.5 ($p=0.20$) for daily ml. of alcohol and 8.9 for drinks per week ($p=0.17$); we thus accept the null hypothesis that the zoning IVs are exogenous. The TSLS parameter estimates on the number of bars within a 0.5 km. radius, like their counterparts from fixed effects, are not statistically significant.

In sensitivity analysis, we include individuals who did not report consuming alcohol in any of the survey waves. The results are similar to those presented. Without accounting for endogeneity, we still observe an effect for bar location within 0.5 km. of an individual's residence. As in the analysis presented above, the null hypothesis of no effect of bar density on alcohol consumption is accepted in the fixed effects and TSLS specifications with the reduced sample.

Given the Durbin-Wu-Hausman test results, which accept the null hypothesis of exogeneity of bar density within 0.5 km., we conclude that adding bars in the immediate vicinity of individuals' homes raises alcohol consumption, but by very small amounts. The fixed effects and TSLS results further add support to our conclusion that bar availability effects on consumption are zero or at most small.

3.1.4. A Further Look at the Endogeneity Issue—Above, we attribute lack of findings on bar density on alcohol consumption when person-specific fixed effects are included to the lack of change in bar density with 0.5 km. of respondents' residences over time. Although not inconsistent with this statement, in fact, among persons who participated in both the first and the last set of interviews, the mean number of bars within 0.5 km. declined by about 60% on average between 1985-6 and 2000-1. Only 3.1% of persons in both first and last sets of interviews did not change Census Tracts over this period; however, 95.5% changed Census Tract but remained in the same CARDIA city; only 1.4% remained in the same CARDIA city, but changed Census Tracts.

There are two mechanisms underlying changes in bar density in the immediate vicinity of place of residence: (1) moving to a different Census Tract, which has a different bar density; and (2) an increase in density for those individuals who did not move due entry/exit of sellers. The second mechanism only applies to a few CARDIA respondents.

To determine the extent to which alcohol consumption at baseline is associated with future changes in bar density, we estimate an equation with the difference in number of bars within 0.5 km. of the person's home between 2000-1 and 1985-6 as the dependent variable. The key explanatory variables are the person's alcohol consumption in ml. in 1985-6, binary variables for movers within the same CARDIA city and for movers from one CARDIA city to another and interaction terms between the binary variables for movers and alcohol consumption in 1985-6. We also include the other covariates included in the above analysis of alcohol consumption, all defined for 1985-6.

Holding other factors constant, alcohol consumption at baseline is positively related to the change in bar density between 1985-6 and 2000-1 (Table 5). This result implies that heavier drinkers at baseline tend to move to neighborhoods with more bars. However, these persons constitute only a very small fraction of persons in this sample. In the analysis sample used for Tables 1-4, non-movers constitute 22% of the sample. However, this is often for a considerably shorter time period than 1985-6 to 2000-1. Thus, in the full analysis sample, non-movers are also in the minority.

Judging from the parameter estimate on the binary variable, the change in bar density is not different between persons who moved to another CARDIA city and non-movers. The interaction term parameter estimate is almost statistically significant at the 0.05 level and is negative implying that heavier drinkers at baseline tend to move to neighborhoods with fewer bars. The much larger group consists of those persons who stayed within the same CARDIA city but moved to a different Census Tract during the 15-year period. For these persons, there is both a tendency for bar density to decline and for heavier drinkers at baseline to locate in neighborhoods with fewer bars. This result is not quite statistically significant at conventional levels.

Overall, the results suggest the following: First, there are relatively few persons who stay in one location for a 15-year period, during the time span from early adulthood to mid life. Second, on average, the change is to living in neighborhoods with fewer bars rather than more bars. Third, a few heavy drinkers remain in place, but in general, even heavier drinkers while in young adulthood move to areas in which there are comparatively fewer bars. Presumably other neighborhood attributes like having a place for children to play have a higher priority than does bar density in a person's choice of neighborhood as the person transitions from young adulthood to middle age.

The negative relationship between alcohol consumption at baseline and subsequent change in bar density introduces the possibility that OLS estimates are biased in the negative

direction. Although this is a possibility, it seems unlikely given the results of our Durbin-Wu-Hausman tests.

4. Discussion and Conclusions

This paper empirically assesses the impact of distance of bars from locations of adults in four large U.S. cities. We find that density of bars within a 0.5 km. radius of a person's home raises alcohol consumption as measured by: daily alcohol consumption (ml.), drinks per week, and weekly consumption of beer, wine, and liquor. The marginal effects of changing the number of bars, however, are small. Adding a bar within a 0.5 km. radius only increases consumption by 0.32 milliliters per day. According to the National Institute on Alcohol Abuse and Alcoholism, a standard drink of alcohol is any drink that contains 0.6 fluid ounce or 17.7 milliliters of pure alcohol.² Hence, the marginal effect estimate implies an increase of 0.018 of a drink daily or 0.13 drinks per week. The estimate of the marginal effect of adding a bar from our analysis of number of drinks per week implies an even smaller impact, 0.072 drinks weekly. Estimates derived from the analysis including individual fixed effects imply no relationship as do those from two-stage least squares although our tests of endogeneity fail to reject the null hypothesis that the number of bars within a 0.5 km. radius of individuals' homes is exogenous. From the vantage point of public policy, it makes very little difference if the marginal effect is very small or zero. Density of liquor stores, in analysis not reported here, has no statistically significant effects on alcohol consumption.

Given these results, should public policy makers worry about the effects of changes in availability of alcohol sellers on alcohol consumption? From the above results, the answer seems to be "no." A further consideration, moreover, is that people tend to move as they age, and that movement generally appears to be away from bars. For the non-mover group, while there was an increase in bar density between 1985-6 and 2000-1, which amounted to a mean increase of 52% within 0.5 km. of a person's place of residence. Even taking our highest estimated marginal effect for the effect of bar density on drinking, this change would generate an increase of only 0.13 in the number of drinks per week.

The strengths of this study include the use of data on number of alcohol sellers for very small areas, collected specifically for purposes of this research, which plausibly correspond to areas over which people obtain much of the alcohol they consume on site, the link between these data and data on individual alcohol consumption and other pertinent individual characteristics, and the longitudinal feature. Further, the data encompass individuals' life experiences from young adulthood to mid life, a period during which relatively many persons visit bars. This is often a fairly dynamic period as regards alcohol consumption, starting with relatively high consumption in the twenties with appreciable decreases in consumption by the forties (Costanzo et al. 2007; Fillmore et al. 1991).

We acknowledge several limitations. First, CARDIA is limited to four U.S. cities. This means that once an individual moves to a non-CARDIA city, s/he is lost to the survey. For this reason, a high proportion of mobile persons are lost, leaving persons who moved within the CARDIA cities as a disproportionate share of the sample. Second, zoning is time invariant in our study and pertains to the Census Tract in which the person lived, not to a specific radius around the person's home. Fortunately, Census Tracts tend to be quite small and numerous (97 within the city limits of Birmingham AL in 2008, <http://www.census.gov/geo/www/tiger/ning>, accessed 10/7/10), especially in large cities, but there remains some non-correspondence between Tracts and the radii as defined in our study, which is a source

²NIAAA, National Institute on Alcohol Abuse and Alcoholism, *NIH Publication No. 07-3769*, revised January 2007.

of measurement error. Third, alcohol consumption reflects variation in the money price of the good. No small area measures of prices of drinks in bars are available for areas corresponding to our radii.

In sum, although there is a conceptual relationship between the number of sellers within small areas and individuals' alcohol consumption, the relationship is small at most. Policymakers concerned with regulating alcohol consumption levels should consider other options than limiting the numbers of sellers.

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Appendix

Results for Determinants of Liquor Store, Gas Station, and Population Density

To ascertain whether or not results for the number of bars generalize to other alcohol sellers and to establishments that may more clearly generate negative externalities in the immediate vicinity of individuals' places of residences, we perform an identical analysis for the number of liquor stores and gas stations (Table A1). Liquor stores, like bars, are extremely dependent on alcohol sales; all gas stations in our sample have alcohol licenses. Like bars, our data on liquor stores and gas stations come from *Yellow Pages* in the four CARDIA cities and have been geocoded in the same way as bars have.

For liquor stores, the most striking differences with results for bars are that annual income over \$75,000 and educational attainment have positive impacts on the number of bars and negative impacts on the number of liquor stores. Also, liquor store density is likely to be higher in the immediate vicinity of a Black individual's residence, while bar density tends to be lower in such cases. For both seller types, bar density at 0.5 to 1 km. and 1 to 2 km. is positively associated with seller density at under 0.5 km. For both, Census Tracts with a higher proportion zoned commercial have more sellers. However, there are differences in signs of parameter estimates for other types of zoning. While the effect of age is positive at lower ages and negative at higher ages, the switch from positive to negative occurs at a much later age for liquor stores than for bars and the age density relationship is much flatter for liquor stores.

Fewer parameter estimates are statistically significant in the gas station than in the liquor store analysis, but overall the results are more similar between gas stations and liquor stores than between gas stations and bars.

Overall, it appears that there is an important distinction to be made between sellers of products for on-site consumption, such as bars, and sellers of products for consumption elsewhere, such as liquor stores and gas stations.

The final regression in the table is for population density within 0.5 km. of the respondent's home. Commercial, office, and institutional zoning tends to be in Census Tracts with higher population density. While industrial, unincorporated, and other zoning tends to be in areas with less dense population. Blacks in the four CARDIA cities tended to live in more population dense areas and more highly educated persons in less dense areas. There are no statistically significant relationships between population density and household income.

Appendix A

First stage regressions using liquor stores, gas stations, and population density as dependent variables

<i>Variables</i>	<i>No. liquor stores within less than 0.5 km</i>	<i>No. gas stations within less than 0.5 km</i>	<i>Population density in Census Tract</i>
Zoning Ordinances			
Fraction of Census Tract zoned "Commercial"	1.43 *** (0.086)	2.74 *** (0.16)	5.08 *** (0.31)
Fraction of Census Tract zoned "Industrial"	-0.0063 (0.034)	-0.39 *** (0.064)	-2.94 *** (0.12)
Fraction of Census Tract zoned "Mixed Use"	-0.075 (0.078)	1.74 *** (0.15)	-0.024 (0.29)
Fraction of Census Tract zoned "Office"	1.55 *** (0.52)	2.11 ** (0.97)	11.1 *** (1.84)
Fraction of Census Tract zoned "Institutional"	0.93 *** (0.33)	1.17 * (0.63)	2.92 ** (1.17)
Fraction of Census Tract zoned "Unincorporated"	1.08 ** (0.50)	2.28 ** (0.94)	-7.90 *** (1.76)
Fraction of Census Tract zoned "Other"	-0.13 *** (0.046)	-0.54 *** (0.087)	-2.24 *** (0.17)
Other exogenous variables			
Alcohol availability			
No. bars within 0.5 to 1 km.	0.0013 (0.0013)	0.0086 *** (0.0025)	0.0072 (0.0046)
No. bars within 1 to 2 km.	0.0030 *** (0.00053)	0.0065 *** (0.0010)	0.0031 * (0.0019)
Income and demographic characteristics			
Age	0.020 * (0.011)	0.035 * (0.020)	0.032 (0.038)
Age ²	-0.00023 (0.00017)	-0.00056 * (0.00032)	-0.00052 (0.00061)
Female	-0.020 (0.015)	-0.043 (0.028)	-0.13 ** (0.055)
Black	0.030 * (0.017)	0.42 *** (0.033)	0.35 *** (0.064)
Married	-0.040 ** (0.019)	-0.019 (0.035)	-0.018 (0.068)
Widowed	-0.0062 (0.11)	0.076 (0.20)	0.063 (0.40)
Divorced	-0.0040 (0.026)	-0.038 (0.050)	0.025 (0.096)
Separated	0.011 (0.039)	0.10 (0.073)	0.031 (0.14)
Years of education	0.0013 (0.0037)	-0.021 *** (0.0070)	-0.034 ** (0.014)
Annual income \$16,000-\$24,999	0.0035 (0.025)	-0.016 (0.048)	0.013 (0.091)
Annual income \$25,000-\$49,000	0.028 (0.022)	-0.047 (0.041)	-0.0085 (0.079)
Annual income \$50,000-\$74,999	-0.034 (0.028)	-0.11 ** (0.053)	0.13 (0.10)
Annual income over \$75,000	-0.016 (0.032)	-0.27 *** (0.060)	-0.12 (0.12)
Time and city effects			
1985-6	0.33 *** (0.039)	0.059 (0.074)	-0.16 (0.14)
1992-3	0.082 ** (0.034)	0.36 *** (0.063)	-0.81 *** (0.12)
1995-6	0.079 *** (0.030)	-0.018 (0.057)	-0.63 *** (0.11)

<i>Variables</i>	No. liquor stores within less than 0.5 km	No. gas stations within less than 0.5 km	Population density in Census Tract
Birmingham	0.42 *** (0.029)	-1.61 *** (0.055)	-1.18 *** (0.11)
Oakland	0.97 *** (0.026)	-0.60 *** (0.050)	1.77 *** (0.094)
Minneapolis	0.19 *** (0.031)	-1.48 *** (0.058)	0.22 ** (0.11)
Constant	-0.86 *** (0.17)	1.13 *** (0.32)	2.55 *** (0.60)
Observations	7,397	7,397	6,916
R ²	0.29	0.41	0.36

Standard errors in parentheses

***

p<0.01,

**

p<0.05,

*

p<0.1

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Table 1

Descriptive statistics

	Mean	Std. dev
<i>Dependent variables</i>		
Alcohol consumed/day (ml.)	11.5	(23.1)
No. of drinks/ week	4.7	(9.4)
No. of beers/ week	2.9	(7.1)
No. of glasses of wine/week	0.83	(2.6)
No. of drinks of liquor/week	0.94	(3.2)
<i>Explanatory Variables</i>		
Alcohol availability		
No. of bars within < 0.5 km.	1.42	(3.83)
No. of bars within 0.5 to 1 km.	3.97	(8.94)
No. of bars within 1 to 2 km.	12.9	(22.8)
Income and demographic characteristics		
Age	31.5	(6.6)
Female	0.55	(0.50)
Black	0.52	(0.50)
Married	0.37	(0.48)
Widowed	0.0043	(0.066)
Divorced	0.10	(0.30)
Separated	0.040	(0.20)
Years of education	14.2	(2.4)
Annual income < \$16,000	0.20	(0.40)
Annual income \$16,000-\$24,999	0.14	(0.34)
Annual income \$25,000-\$49,000	0.36	(0.48)
Annual income \$50,000-\$74,999	0.17	(0.38)
Annual income > \$75,000	0.13	(0.34)
Time and city effects		
1985-6	0.35	(0.48)
1992-3	0.27	(0.44)
1995-6	0.22	(0.42)
2000-1	0.16	(0.37)
Birmingham	0.25	(0.43)
Oakland	0.26	(0.44)
Chicago	0.19	(0.39)
Minneapolis	0.30	(0.46)
Population density (per 10,000 square ft. in Census Tract) ^b	2.63	(0.033)

	Mean	Std. dev
Zoning ordinances		
Fraction of Census Tract zoned "Commercial" ^a	0.076	(0.001)
Fraction of Census Tract zoned "Industrial" ^a	0.11	(0.00)
Fraction of Census Tract zoned "Mixed Use" ^a	0.021	(0.001)
Fraction of Census Tract zoned "Office" ^a	0.0054	(0.0002)
Fraction of Census Tract zoned "Institutional" ^a	0.0045	(0.0003)
Fraction of Census Tract zoned "Unincorporated" ^a	0.0019	(0.0002)
Fraction of Census Tract zoned "Other" ^a	0.074	(0.002)
Fraction of Census Tract zoned "Residential" ^a	0.71	(0.00)
Observations	11,810	

^a Observation count lower due to missing data (N=7,397)

^b Observation count lower due to missing data (N=6,916)

Table 2

Effects of proximity to bars on alcohol consumption with marginal effects from Tobit and negative binomial regressions

Variables	Alcohol consumed/day	No. of drinks/week	No. of beers/week	No. of glasses of wine/week	No. of drinks of liquor/week
	Tobit	Negative binomial	Negative binomial	Negative binomial	Negative binomial
Alcohol availability					
No. bars within < 0.5 km.	0.32 *** (0.11)	0.072 *** (0.023)	0.037 ** (0.015)	0.011 * (0.0059)	0.017 ** (0.0068)
No. bars within 0.5 to 1 km.	0.15 ** (0.064)	0.017 (0.012)	0.012 (0.0083)	0.0047 (0.0032)	-0.0013 (0.0037)
No. bars within 1 to 2 km.	-0.024 (0.026)	-0.0026 (0.0055)	-0.0034 (0.0037)	0.00053 (0.0014)	0.00014 (0.0016)
Income and demographic characteristics					
Age	3.73 *** (0.54)	0.61 *** (0.11)	0.42 *** (0.070)	0.096 *** (0.028)	0.087 *** (0.033)
Age ²	-0.050 *** (0.0085)	-0.0072 *** (0.0017)	-0.0057 *** (0.0011)	-0.00083 * (0.00043)	-0.00084 * (0.00051)
Female	-19.5 *** (0.69)	-4.23 *** (0.18)	-3.39 *** (0.14)	-0.075 ** (0.035)	-0.69 *** (0.050)
Black	-5.68 *** (0.76)	-1.26 *** (0.16)	-0.71 *** (0.10)	-0.34 *** (0.043)	-0.019 (0.046)
Married	-8.87 *** (0.86)	-1.60 *** (0.15)	-0.81 *** (0.10)	-0.28 *** (0.041)	-0.50 *** (0.046)
Widowed	-2.78 (5.25)	-0.82 (0.79)	-0.23 (0.58)	-0.35 ** (0.14)	-0.18 (0.24)
Divorced	1.44 (1.22)	0.15 (0.24)	0.12 (0.16)	0.0044 (0.061)	-0.0088 (0.070)
Separated	8.11 *** (1.74)	2.24 *** (0.52)	1.16 *** (0.34)	0.42 *** (0.14)	0.48 *** (0.16)
Years of education	-1.31 *** (0.17)	-0.30 *** (0.033)	-0.23 *** (0.022)	0.024 *** (0.0084)	-0.078 *** (0.010)
Annual income \$16,000-\$24,999	-5.23 *** (1.20)	-0.89 *** (0.19)	-0.56 *** (0.12)	-0.032 (0.059)	-0.14 ** (0.062)
Annual income \$25,000-\$49,000	-5.30 *** (1.02)	-1.21 *** (0.18)	-0.76 *** (0.12)	-0.14 *** (0.050)	-0.19 *** (0.057)
Annual income \$50,000-\$74,999	-3.25 ** (1.27)	-1.01 *** (0.21)	-0.79 *** (0.13)	0.00084 (0.065)	-0.066 (0.073)
Annual income over \$75,000	2.79 * (1.45)	-0.058 (0.29)	-0.57 *** (0.16)	0.29 *** (0.097)	0.18 * (0.11)
City and year effects					
1985-6	8.28 *** (1.84)	1.50 *** (0.41)	0.46 * (0.25)	0.54 *** (0.12)	0.40 *** (0.13)
1992-3	0.44 (1.53)	0.14 (0.30)	-0.0088 (0.20)	0.015 (0.080)	0.10 (0.096)
1995-6	-0.27 (1.36)	-0.0073 (0.26)	-0.061 (0.17)	-0.024 (0.068)	0.033 (0.083)
Birmingham	-2.07 (1.34)	-0.12 (0.25)	-0.020 (0.17)	-0.057 (0.065)	-0.019 (0.077)

<i>Variables</i>	Alcohol consumed/day	No. of drinks/week	No. of beers/week	No. of glasses of wine/week	No. of drinks of liquor/week
	Tobit	Negative binomial	Negative binomial	Negative binomial	Negative binomial
Oakland	1.83 (1.23)	0.16 (0.24)	-0.39*** (0.14)	0.44*** (0.082)	-0.072 (0.070)
Minneapolis	3.41*** (1.29)	0.36 (0.26)	0.15 (0.17)	-0.044 (0.063)	0.14* (0.081)
Observations	11,810	11,810	11,810	11,810	11,810

Standard errors in parentheses

*** p<0.01,
** p<0.05,
* p<0.1

Table 3

First stage results for two-stage least squares analysis of effects of proximity to bars on alcohol consumption

Zoning ordinances	
Fraction of Census Tract zoned "Commercial"	6.25*** (0.43)
Fraction of Census Tract zoned "Industrial"	0.97*** (0.17)
Fraction of Census Tract zoned "Mixed Use"	3.43*** (0.39)
Fraction of Census Tract zoned "Office"	-3.16 (2.61)
Fraction of Census Tract zoned "Institutional"	-1.09 (1.68)
Fraction of Census Tract zoned "Unincorporated"	0.98 (2.52)
Fraction of Census Tract zoned "Other"	5.10*** (0.23)
Other exogenous variables	
Alcohol availability	
No. bars within 0.5 to 1 km	0.12*** (0.0066)
No. bars within 1 to 2 km	0.015*** (0.0027)
Income and demographic characteristics	
Age	0.21*** (0.054)
Age ²	-0.0029*** (0.00086)
Female	0.15* (0.076)
Black	-0.50*** (0.087)
Married	-0.47*** (0.095)
Widowed	0.21 (0.55)
Divorced	0.019 (0.13)
Separated	-0.048 (0.20)
Years of education	0.083*** (0.019)
Annual income \$16,000-\$24,999	-0.025 (0.13)
Annual income \$25,000-\$49,000	0.18 (0.11)
Annual income \$50,000-\$74,999	0.24 (0.14)
Annual income over \$75,000	0.77*** (0.16)
Time and city effects	
1985-6	0.98*** (0.20)
1992-3	0.087 (0.17)
1995-6	-0.13 (0.15)
Birmingham	-2.09*** (0.15)
Oakland	-2.07*** (0.13)
Minneapolis	-1.97*** (0.15)
Constant	-3.26*** (0.86)

Zoning ordinances	
Observations	7,397
R ²	0.491
Partial R ²	0.076
F-statistic on excluded instruments	86.2
Degrees of freedom	(7,7368)

Standard errors in parentheses

***
p<0.001,

**
p<0.01,

*
p<0.05

Table 4

Effects of proximity to bars on consumption using ordinary least squares, OLS with fixed effects, and two-stage least squares^a

Variables	OLS			Fixed effects			TSLS	
	Alcohol consumed/day (ml.)	Drinks/week	Alcohol consumed/day (ml.)	Drinks/week	Alcohol consumed/day (ml.)	Drinks/week	Alcohol consumed/day (ml.)	Drinks/week
No. bars within < 0.5 km.	0.21 *** (0.059)	0.084 *** (0.024)	-0.053 (0.17)	-0.020 (0.070)	0.071 (0.29)		0.025 (0.12)	
No. bars within 0.5 to 1 km.	0.049 (0.037)	0.020 (0.015)	0.053 (0.071)	0.022 (0.029)	0.077 (0.064)		0.031 (0.026)	
No. bars within 1 to 2 km.	-0.010 (0.012)	-0.0041 (0.0049)	-0.0090 (0.024)	-0.0037 (0.0095)	-0.010 (0.020)		-0.0040 (0.0080)	
Observations	11,810	11,810	11,810	11,810	7,397		7,397	
R ²	0.085	0.086	0.007	0.006			0.089	
Durbin-Wu-Hausman chi-sq.					0.25			0.29
Durbin-Wu-Hausman chi-sq. (p-value)					0.62			0.59
Hansen J-statistic					8.71			9.15
Hansen J-statistic (p-value)					0.19			0.17

Standard errors in parentheses

*** p<0.001,

** p<0.01,

* p<0.05

Table 5

Analysis of changes in bar density within 0.5 km of residence

Panel A. Descriptive statistics		
<i>Variable</i>	Mean	Std. Dev.
Change in bar density within 0.5 km (1985-6 to 2001-1)	-0.58	2.60
Bar density within 0.5 km in 1985-6	0.95	2.70
Alcohol consumed/day (ml) in 1985-6	11.93	21.9
Moved to a different city	0.014	0.12
Moved to a different city*Alcohol consumed/day (ml)	0.17	2.53
Moved to a different Census Tract within city	0.96	0.21
Moved to a different Census Tract within city*Alcohol consumed/day (ml)	11.36	21.5
Birmingham (1985-6)	0.30	0.46
Oakland (1985-6)	0.27	0.44
Minneapolis (1985-6)	0.38	0.49
Observations	1685	
Panel B. Determinants of the change in bar density within 0.5 km of residence on alcohol consumption and mobility^a		
<i>Variables</i>	Change in bar density within 0.5 km (1985-6 to 2001-1)	
Alcohol consumed/day (ml.) in 1985-6	0.0045* (0.0019)	
Moved to a different CARDIA city	0.84 (0.96)	
Moved to a different CARDIA city*Alcohol consumed/day (ml)	-0.092 (0.050)	
Moved to a different Census Tract within city	-0.28* (0.12)	
Moved to a different Census Tract within city*Alcohol consumed/day (ml.)	-0.0041 (0.0025)	
Birmingham (1985-6)	5.49*** (0.86)	
Oakland (1985-6)	5.30*** (0.87)	
Minneapolis (1985-6)	5.38*** (0.86)	
Constant	-0.68 (2.78)	
Observations	1,685	
R ²	0.243	

Robust standard errors in parentheses

***
p<0.001,**
p<0.01,*
p<0.05^aBaseline explanatory variables included but not shown: age, age2, female, black, married, widowed, divorced, separated, years of education, and income