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Retail Zoning and Competition

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Abstract

Previous research treats zoning as anti-competitive. Zoning can, however, increase competition by forcing sellers closer together which can decrease prices and drive out sellers. Thus, zoning can reduce prices and external costs, but decrease variety and increase travel costs for consumers traveling from outside the zoned area. Surprising predictions follow: price rises with the number of sellers, and mean distance increases with the number of sellers, both due to zoning. Using a sample of five retail types, we find evidence that mean distance rises with the number of sellers, the number of sellers rises with less restrictive zoning, and distance between sellers falls with greater product differentiation.

Keywords: zoning, agglomeration, location, retail, alcohol

JEL classification: K2, L10, L81, R12, R30

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1 Introduction

Economic research on zoning has treated it as harmful in reducing real estate competition, but valuable in averting external costs. By prescribing acceptable land uses, zoning protects home and business owners from negative external costs associated with nonconforming land uses and other unwanted intrusions. Giertz (1977) argued that "(z)oning, justified as a means of internalizing externalities, may, in fact, be a powerful tool for promoting monopoly" (p. 50).[1] By restricting the number of people that can live or work on a given parcel of land (e.g., requiring that homes be large and single family, or that retail space be single story), zoning can give land owners market power to restrict quantities and increase real estate prices (Giertz, 1977; Hamilton, 1978). Land use restrictions, such as high minimum lot sizes, increase housing prices well above supply costs in Boston (Glaeser and Ward, 2006) and Manhattan (Glaeser et al., 2003).[2]

Research on retail establishments has also found anti-competitive effects of zoning. Regulations can be anti-competitive when they limit the number of retail licenses (Ford, 1935) or restrict large retailers like Wal-Mart (Basker, 2007). Regulations intended to protect city centers can encourage the opening of stores that are smaller than both consumers and sellers would choose (Smith, 2006). Overlooked has been the effect of zoning on the proximity and resulting competition among retailers.

Zoning is not, of course, the only reason sellers cluster. Sellers also cluster by choice. Hotelling (1929) provided one of the foremost studies of agglomeration. Alternative explanations for firm agglomeration can be categorized as demand side or supply side. On the demand side, firms cluster because consumers prefer businesses in certain locations. Firms cluster to attract consumers searching for optimal product characteristics (Wolinsky, 1983;

[1]See also (Glaeser and Kahn, 2004, p.2519-2520).

[2]By restricting consumer and retail density, zoning can also exacerbate sprawl (Fischel, 1998). See Nechyba and Walsh (2004) for a discussion of the economics of sprawl.

Fischer and Harrington, 1996; Konishi, 2005), to provide a credible commitment to low prices (Dudey, 1990), to locate near consumers attracted by the marketing or reputation of rivals (Chung and Kalnins, 2001), and because consumers (residences, workplaces, or entertainment) are concentrated (Neven, 1986). On the supply side, firms cluster to decrease the costs of labor and other inputs (Marshall, 1920), to attract workers that are a better match (Helsley and Strange, 1990), to learn from other firms how to improve productivity (Glaeser et al., 1992; Shaver and Flyer, 2000; Furman et al., 2006), and because spinoffs sometimes locate near parent firms (Buenstorf and Klepper, 2005; Klepper, 2007).

Empirical analyses of agglomeration examined retail and wholesale gasoline (Pinske and Slade, 1998; Pinske et al., 2002; Netz and Taylor, 2002; Barron et al., 2004), manufacturing (Ellison and Glaeser, 1997; Marcon and Puech, 2003; Duranton and Overman, 2005; Klepper, 2007), and temporal agglomeration of scheduled flight departure times (Borenstein and Netz, 1999) and movie release dates (Corts, 2001; Einav, 2007).[3] To our knowledge, no previous empirical studies have examined agglomeration and competition while directly controlling for zoning.

We show theoretically that zoning can increase competition by forcing sellers closer together which can decrease prices and drive out some sellers. Hence, zoning can reduce prices as well as external costs, but decrease variety and increase travel costs for consumers traveling from outside the zoned area. Our theoretical analysis yields five propositions about the effects of zoning on agglomeration and competition. (1) As the area zoned for sellers increases, the number of sellers increases at a decreasing rate. (2) The distance from the nearest competitor is positively related to the number of sellers. (3) Sellers with more ability to differentiate their products cluster more. (4) More restrictive zoning increases competition and reduces prices. (5) The number of sellers is positively related to price, in contrast to the widely-accepted economics paradigm that prices fall when the number of competitors

[3]For a review of the empirical literature on agglomeration economies see Rosenthal and Strange (2004).

increases (Dranove et al., 1993). Without relying on a model of increasing search costs with the number of sellers in a market (Satterthwaite, 1979; Rosenthal, 1980), we explain that zoning can cause the relationship between prices and sellers to be positive.

We test our propositions using data on retailer locations and characteristics of the markets they serve. We use five data sources: (1) 2005 Yellow Pages; (2) alcohol licenses which provide names and addresses of licensees; (3) projections to 2005 from the 2000 U.S. Census of Population and Housing; (4) zoning ordinances from fifteen municipalities; and (5) geo-coded information on municipal and zoning boundaries. The Minneapolis-St. Paul metropolitan area is advantageous for our study because it does not have oceans or mountains which create edges and complicate agglomeration analysis. Our data set includes five types of retailers: full-service restaurants, bars, grocery stores, convenience stores/gas stations, and liquor stores.

Our empirical analysis is the first to explicitly measure retail zoning and competition. Propositions 1, 2, and 3 are tested directly. Propositions 4 and 5 are evaluated indirectly; we show entry patterns that are consistent with price competition predicted in the theoretical framework. The empirical results support the propositions. First, more lenient zoning increases distances between restaurants, bars, grocery stores, and gasoline/convenience stores. The relationship is positive until the number of sellers grows very large (well above the observational means of sellers per area). Second, the mean distance to competitors is positively related to the number of sellers for the vast majority of sellers. Third, sellers with less ability to differentiate their products are less clustered. Our estimation method controls for spatial autocorrelation.

The remainder of the paper is organized as follows. In section 2 we assume monopolistic competition to demonstrate the effects of zoning on agglomeration and price competition. In section 3 we describe the data on locations of the five retail markets in fifteen Minneapolis-St. Paul-area municipalities. In section 4 we describe the estimation of the number of sellers as a function of zoning, and the distance between sellers as a function of the number of sellers; we correct for spatial autocorrelation. In section 5 we describe the results. In section 6 we conclude.

2 Theory

One neighborhood is zoned residential (consumers but no sellers) while the other is zoned for mixed use (consumers and sellers). It is costly for consumers to move from the neighborhood without sellers to the neighborhood with sellers. We model the neighborhoods as circles (or equivalently infinite lines) so we can focus on interesting competitive effects and avoid technical problems associated with endpoints (Salop, 1979). We model the industry as monopolistically competitive, so there are no regulatory limits on how many sellers can enter, although there are limits on where they can locate.

Formally, $L > 0$ consumers per unit of distance are located on two circles. The circle zoned for mixed use has circumference z and the circle zoned residential has circumference $1 - z$ where $z \in (0, 1)$. Each consumer purchases one unit of a retailer's product according to preferences, prices, and location.[4]

A consumer located on the circle without sellers travels to the circle with sellers at cost $\alpha = |(1 - 2z)/2\pi|$ which is the difference in radii between the two circles.[5] The consumer then arrives at a random location on the circle with sellers. A consumer located on the circle with sellers at l^* (or who travels to l^* from the circle without sellers) travels to retailer l_i at a cost of $t|l_i - l^*|$. The consumer's utility is $v - p_i - t|l_i - l^*| - a$ where a depends on whether the consumer and retailer are on the same circle. If the retailer is on the same circle as the

[4] We focus on the competitive region, because Salop (1979) shows that the monopoly and super-competitive regions occur only under very restrictive conditions.

[5] Solve for α by taking the circumferences $z = 2\pi r$ and $1 - z = 2\pi\hat{r}$ and solving for the difference in radii $\hat{r} - r$.

consumer, then $a = e$ is the negative external cost[6] associated with proximity to a retailer. If the retailer is on the circle without sellers then $a = \alpha$.

The number of sellers N is endogenous. Zoning restricts on which circle sellers can locate, but the total number of sellers is limited only by profitability. All (infinitely many) potential competitors have the same technology. Fixed costs of entry are $F > F_m > 0$. Sellers enter until economic profits $(p_i - c)q_i - F$ are zero.

Seller i charges price p_i and its nearest competitor located distance z/N away charges p_j. A consumer located at $\hat{x}$, or who travels to $\hat{x}$ from an area of town without sellers, is indifferent between purchasing from 2 firms located z/N apart. In Figure 1, $z < 1/2$ (consistent with Table 1 which reports that on average zoning permits sellers in only about 10 percent of the space) but the theory requires only $z < 1$. A consumer is indifferent when $v - p_i - t\hat{x} - a = v - p_j - t(z/N) - \hat{x}) - a$. The distance from the indifferent consumer to i is $\hat{x} = (p_j - p_i)/2t + z/2N$.

Demand is $q^c = 2L\hat{x}/z$. The distance $\hat{x}$ is doubled because there are indifferent consumers on each side of the seller, multiplied by L consumers per unit distance, and multiplied by $1/z$ to account for consumers coming from all areas, not just the area zoned for sellers. Substituting for $\hat{x}$ in q^c gives $q^c = L((p_j - p_i)/(tz) + 1/N)$. The best response function is then $p_i(p_j) = ((p_j + c)N + tz)/(2N)$. Assuming that sellers are symmetric, the profit maximizing price is $c + tz/N$.

Sellers enter until economic profit is zero; the equilibrium number of sellers is

$$N^e = \sqrt{\frac{Ltz}{F}} \tag{1}$$

Given the equilibrium number of sellers, the equilibrium price is

[6]Presumably consumers would want to be closer to sellers but sellers can be noisy, smelly, or provide a bad view.

$$p^e = c + \frac{Ltz}{N^e} = c + \sqrt{\frac{Ftz}{L}} \tag{2}$$

When $z = 1$ the equilibrium price and number of sellers (equations 1 and 2) are the same as the competitive equilibria from Salop (1997, 148).

The equilibrium distance from a seller's nearest competitor is

$$\Delta^e = \frac{z}{N^e} = \sqrt{\frac{Fz}{Lt}} \tag{3}$$

Increases in fixed costs lead to less entry (equation 1) and greater distances between competitors (equation 3). Furthermore, more permissive zoning (z) increases the distance between competitors. But greater transportation costs allow competitors to locate closer without intense price competition.

Consider an example in which there are two sellers in equilibrium, because zoning is $\tilde{z} = 4F/(Lt)$. If zoning is relaxed so the mixed-use area expands by 9/4, then the equilibrium number of sellers will increase from two to three (equation 1). The equilibrium distance increases by 50 percent, as does the equilibrium mark-up over marginal cost ($p^e - c$). The number of consumers (total circumference of the residential plus mixed-use circles) is the same before and after the relaxation of zoning (see Figure 1). When zoning expands, the number of sellers increases in a smaller proportion, because consumer population is fixed. Hence distances increase and prices increase, though unit sales per firm fall, so economic profit remains at zero.

Proposition 1 *As the area zoned for sellers increases, the number of sellers increases at a decreasing rate.*

Differentiating the equilibrium number of sellers (from equation 1) with respect to zoning yields $\partial N^e/\partial z = (\sqrt{Lt})/(2\sqrt{Fz}) > 0$ and $\partial^2 N^e/\partial z^2 = -(\sqrt{Lt})/(4z\sqrt{Fz}) < 0$.

Similarly, as the area zoned for sellers increases, the distance from a retailer's nearest competitor increases at a decreasing rate. Differentiating the equilibrium distance between sellers (Δ^e in equation 3) with respect to zoning yields $\partial\Delta^e/\partial z = \sqrt{F}/(2\sqrt{Ltz})$ which is positive and $\partial^2\Delta^e/\partial z^2 = -\sqrt{F}/(4z\sqrt{Ltz})$ which is negative.

Solving equations 1 and 3 for z and then setting them equal,

$$\Delta = \frac{FN^e}{Lt} \tag{4}$$

Hence, distance between sellers is increasing in fixed costs and the number of sellers, and decreasing in the number of consumers and transportation costs. Equation 4 leads to a proposition that might be surprising, at least at first glance.

Proposition 2 *The distance from the nearest competitor is positively related to the number of sellers.*

This might seem counter-intuitive, but it results from the effect of zoning (and similar constraints on location). An increase in the fraction of the area zoned for sellers encourages more sellers to enter because they can disperse which in turn decreases price competition. Both the number of sellers and the distance from the nearest competitor depend on zoning. The derivative of equation 4 with respect to N is positive, so the relationship between the number of sellers and the distance to the nearest competitor is positive.

Distance $\Delta = (FN^e)/(Lt)$ (from equation 4) is a nexus of equilibria for various values of zoning. The lower bound is $\Delta_m = (F_m N^e)/(Lt)$ where F_m represents the minimum fixed costs. Fixed costs must be positive; otherwise an infinite number of firms would enter with non-negative profit.

The function $\Delta = z/N$ illustrates the inverse relationship between number and distance when zoning is fixed. As more sellers are added to a given area, the distance from the nearest competitor decreases. The upper bound is z_u/N because zoning cannot be greater than 1 (i.e., 100 percent of area allowed for sellers).

The shaded area in Figure 2 contains equilibrium combinations of number and distance bounded above by z_u/N where $z_u \leq 1$, and by $(F_m N)/(Lt)$ (recall F_m is the lowest value for fixed costs). When fixed cost falls, the equilibrium moves from A to B, because profit rises which encourages entry by additional sellers which are closer together. When zoning becomes more lenient, the equilibrium moves from B to C, because more sellers enter and the distance from the nearest neighbor increases (Figure 2).

Proposition 3 *Sellers with more ability to differentiate their products cluster more.*

Let the distance from the marginal consumer to the retailer be the product of the endogenous geographic distance and the exogenous product differentiation which varies by product market. For example, exogenous ability to differentiate products is smaller for liquor stores than for full-service restaurants. To maintain the equilibrium, if exogenous product differentiation increases, endogenous geographic distance must decrease. Hence, geographic distance is inversely related to product differentiation. This result is well established in the theoretical literature (Irmen and Thisse, 1998).

Restrictive zoning and geographic boundaries force firms into a smaller location choice set which decreases distance between them. When firms locate closer together, they engage in more intense price competition. With lower prices, fewer firms enter the market. Hence, zoning can lead to lower prices and lower external costs associated with living near sellers, but fewer firms (and thus less variety) and higher travel distances from consumers to sellers.

Proposition 4 *More restrictive zoning reduces prices.*

The derivative of equation 2 with respect to zoning z is positive; thus a decrease in z (less space for locations) reduces price. This result follows logically from the model, but contrasts with previous research on real estate zoning (Giertz, 1977; Hamilton, 1978). Restrictive zoning leads to shorter distances between sellers which causes more intense price competition.

Proposition 5 *The number of sellers is positively related to price.*

To derive Proposition 5 we solve for z from equation 1, then substitute z into equation 2 to get $p^e = c + FN^e/L$. As zoning increases, more sellers enter, but the distance between sellers also increases. Since distances increase, equilibrium prices increase. Each retailer earns a higher price, but a lower market share since there are more sellers serving the same number of consumers.

This theory implies that increases in price are positively related to increases in the number of sellers, but this runs counter to standard economic intuition that more sellers will drive down prices. Satterthwaite (1979) posited that this could occur due to increasing search costs. We offer an alternative, but not mutually exclusive, explanation: that the positive relationship between prices and number of sellers results from zoning.

We have measured distance to the nearest competitor as z/N. Instead we could measure average distance to all competitors: $\nu z/(4(\nu - 1))$ where $\nu = N$ if N is even or $\nu = N + 1$ if N is odd. Measuring distance using nearest competitor is equivalent to using average of all competitors because in both cases distance is increasing in z and decreasing in N. In the theoretical section, we use distance to the nearest competitor because it is more tractable and consistent with previous literature. In our empirical analysis, we use mean distance to all competitors within the market.

3 Data

We use 2005 data from 15 municipalities in the Minneapolis-St. Paul area (Bloomington, Brooklyn Park, Burnsville, Coon Rapids, Eagan, Eden Prairie, Edina, Golden Valley, Hopkins, Maple Grove, Minneapolis, Plymouth, Richfield, St. Louis Park, and St. Paul). We examine location patterns in five retail markets: full-service restaurants, bars, grocery, gasoline/convenience, and liquor stores. We study alcohol markets because of the historical relationship to zoning regulation. The rationale for zoning regulations in alcohol markets is two-fold: (1) alcohol sellers might create negative externalities for people in surrounding areas, and (2) distance from consumers to sellers discourages consumption.[7]

We use five data sources: (1) 2005 Yellow Pages which we coded for this research; (2) alcohol licenses which provide names and addresses of licensees; (3) projections to 2005 from the 2000 U.S. Census of Population and Housing; (4) zoning ordinances from 15 municipalities; and (5) GIS data on municipality and zoning boundaries, the University of Minnesota boundary, and street networks.

First, Yellow Pages data provide addresses and market types for full-service restaurants, grocery stores, and gasoline/convenience stores. Establishments choose Yellow Pages headings. We then geocode the sellers based on street address information. There is an overlap of 60 sellers which advertised in the Yellow Pages as both bars and full-service restaurants. Otherwise, retailers advertised in only one category. We combine convenience stores and gasoline stations, since nearly all gasoline stations sell convenience store items.

Second, alcohol license data give addresses for bars and liquor stores, as well as license numbers, issue and expiration dates, and types of licenses. In addition, we use ABC data for a product differentiating characteristic for restaurants, grocery stores, and gasoline/convenience stores.

Third, projections to 2005 from the 2000 U.S. Census of Population and Housing were purchased from GeoLytics. Data elements include total population, fraction of population ages 20-34, fraction of population renting, and median household income. GeoLytics data

[7]For a comprehensive review of the literature on alcohol regulation and consumption see Cook and Moore (2000).

are specific to a Census block group. We compute weighted averages of block group data to derive characteristics of the area within a half mile and one mile of each retailer.

Fourth, local governmental agencies supplied the zoning data. We exclude some small municipalities in the Minneapolis-St. Paul area which did not provide zoning information. Fifth, we employ GIS data to construct variables for each seller's circular market area.

The final sample includes 2499 full-service restaurants, 288 bars, 265 liquor stores, 1386 grocery stores, and 762 gas/convenience stores.

4 Empirical Analysis

4.1 Equation Specification

Standard economic theory predicts that adding sellers will decrease prices and distance between sellers will not rise. Our theoretical model, however, indicates that the relationship could be the opposite when accounting for zoning. Hence, we estimate the effect of zoning rules, other impediments to entry and location, and demand factors on the number of sellers. We then estimate the effect of the number of sellers on distance between sellers.

We define markets by drawing circles of radius a half mile or one mile around a given seller. We focus on a radius of a half mile from the seller, because a half mile can be traversed on foot in about 10 minutes or in a motor vehicle traveling 30 miles per hour in a minute. To account for the ease with which consumers can travel greater distances, we control for whether the seller is on a major road and whether the seller is driving to the area because it is near the university.

By defining markets around each seller, the number of markets equals the number of sellers. Defining markets in this way gives greater weight to areas with more sellers.

We determine the fraction of the market zoned for a particular seller type using geo-coded zoning maps. We define market characteristics as weighted averages of population characteristics for areas that overlap the circular market.

The first regression tests Proposition 1. The dependent variable is N_{mi}, the number of sellers of type $m \in (1, 5)$ in a circular market in which seller i is at the center. We estimate the parameters of the following equation:

$$N_{mi} = \beta_0 + \beta_1 Z_{mi} + \beta_2 R_i + \beta_3 D_{mi} + \epsilon_{mi} \tag{5}$$

where i is the seller, and each seller is at the center of a geographic market with a fixed radius (of half or one mile); Z_{mi} is the share of i's area zoned for m-type retailers; R_i are other restrictions on location besides zoning; D_{mi} are demand characteristics for retailer i and its rivals in market type m; and ϵ_{mi} is the error term.

Zoning (Z_{mi}) is the fraction of the area of the circle that is zoned for a m type retailer. Hence, high values for zoning indicate that sellers can locate in more of the area. We obtained geo-coded zoning maps from each of the 15 municipalities indicating the type of establishment allowed in a particular space (e.g., residential, commercial, industrial) and zoning requirements specific to alcohol vendors.

Formal zoning regulations do not fully capture impediments to entry (Siegan, 1972; Fischel, 1985). Grandfathering provisions might allow older establishments to operate in areas otherwise prohibited by zoning. Also, it is possible for establishments to obtain a zoning variance when political opposition is low. On the other hand, neighborhoods can block entry of undesirable sellers without formal zoning. Neighborhoods with high populations might crowd out retail space.[8]

For these reasons we include both population and proxies for political opposition to relaxing zoning. Opposition might be greater in neighborhoods with higher median income or fewer renters. Renters can, however, also capture demand characteristics if, for example,

[8]Most college students are not counted as residents at their school location by the U.S. Census. We include a binary variable for proximity to the University of Minnesota-Twin Cities.

renters are more likely to dine out. Higher income areas might have fewer retailers, because higher income people have greater political power and willingness to pay to avoid negative externalities associated with sellers (e.g., noise, congestion, and odor). Yet the number of sellers might increase with median income, because higher median income could decrease price elasticity and increase the opportunity cost of travel (t).

Demand characteristics (D_{mi}) include whether the retailer is within 500 feet of a major road, whether the retailer is within a quarter of a mile of the University of Minnesota-Twin Cities campus (with a student enrollment of about 50,000), and the fraction of people ages 20 to 34. Conceptually, many of these demand-side control variables have ambiguous signs. Proximity to a major road increases the effective consumer population, though without the crowding out effect that residential population has. Proximity to major roads also decreases travel costs. Convenience to travelers on a major road is most important to gasoline/convenience stores.

The second regression tests Proposition 2. The dependent variable is Δ_{mi}, the mean Euclidean distance between a retailer at the center of a circular market and each of its rivals within a given radius. The measurement of distance between sellers in our empirical analysis is the mean distance for sellers within the radius, while in the theoretical model distance is measured to the nearest competitor. As we show in section 2, the measures of distance are roughly equivalent in theory. Going from circumference in theory to area in the empirical analysis is consistent with previous research (Netz and Taylor, 2002).

We hypothesize that the relationship between the number of sellers and distance is positive because of how sellers respond strategically to zoning (and similar location restrictions), rather than simply due to geometry. In the absence of strategic behavior and zoning (and similar location restrictions), if sellers located randomly then the number of sellers should be uncorrelated with their mean distance apart. Imagine randomly throwing darts at a map and calculating the mean distance from the darts to the center of the map. The mean distance should not depend on the number of darts. For a circular map of radius one-half mile, the mean distance should be 0.35 regardless of the number of darts thrown.[9] Given that zoning forces other sellers in the area to be near the focal seller at the center, the mean distance between sellers will likely be less than 0.35 in a half-mile market.

The number of rival sellers (N_{mi}) measures the degree of competition because sellers enter until profit is zero. The number squared allows for a nonlinear relationship between spatial differentiation and the number of sellers.

If a seller has no competitors in a given radius (half or one mile) then distance is set at 0.5 or 1. The share of sellers that are "monopolists" varies from 20 percent for liquor stores to one percent for full-service restaurants in the half-mile market, and from 18 percent to less than one percent in the one-mile market. To account for the concentration of sellers at the outer limit of the circle we use a Tobit estimator which accounts for spatial autocorrelation. We also conduct regressions without local monopolists; the results, not shown here, are similar.

We test Proposition 3 by comparing the magnitudes of the different marginal effects depending on the ability of sellers to differentiate various types of products. The five types of products (m) have substantially different abilities to differentiate. This is our primary differentiating characteristic. We also include two variables for retailer i's attributes. In the analysis of restaurants and bars, we include a binary variable indicating whether the retailer advertised in the Yellow Pages as both a bar and restaurant. In the analysis of the other types of sellers, we include a binary variable indicating whether the retailer had a license to sell alcohol. A restaurant which also advertises as a bar is likely to be more oriented toward alcohol sales. Likewise, a bar which also advertises as a restaurant is likely to have broader food offerings than a typical bar.

[9] Set 0.5 $\pi r_a^2 = \pi r_b^2$ and solve for r_a.

4.2 Econometric Issues

Our observations might be subject to two types of spatial effects. The first type is a spatial error effect; the error terms for sellers within a certain distance are correlated. This spatial error effect might arise from similarities in market characteristics not explicitly captured by the explanatory variables. The existence of spatial errors leads to biased standard errors (Anselin, 1988). The second type is the spatial lag effect; the degree of spatial differentiation at one location is correlated with the degree of differentiation at another location within a certain distance. This spatial lag effect might be introduced by procedures used to construct explanatory variables at the area level. Alternatively, because market areas of nearby sellers overlap, unless corrected the spatial lag leads to biased parameter estimates.

To control for the spatial lag effect, rewrite equation 5 as

$$N_{mi} = \beta_0 + \beta_1 Z_{mi} + \beta_2 R_i + \beta_3 D_{mi} + \rho W_{lag} N + \epsilon_{mi}, \tag{6}$$

where ρ is the parameter indicating the existence and magnitude of the spatial lag effect and W_{lag} is the spatial lag weight matrix. In the weight matrix, each entry for seller i is equal to 1 divided by the number of i's rivals if seller $j \neq i$ is in i's market and is a center of the market, and each entry for seller i is equal to 0 if seller j is either not in i's market or if j is not a center seller.

To control for spatially autocorrelated errors, we rewrite equation 5 as

$$N_{mi} = \beta_0 + \beta_1 Z_{mi} + \beta_2 R_i + \beta_3 D_{mi} + \lambda W_{error} \epsilon_{mi} + \mu_{mi}, \tag{7}$$

where ϵ_{mi} is the vector of errors for all sellers, λ is the coefficient indicating the level of spatial error, μ is an independently and normally distributed error term with constant variable, and W_{error} is the spatial error weight matrix; W_{error} is an inverse function of the Euclidean distance between any two markets so that closer sellers are more weighted for spatial correlation. In the matrix, the off-diagonal entries are the negative exponential of the distance between sellers i and j and the diagonal entries are zero. We estimate equations 6 and 7 for the number of sellers (N_{mi}) and the mean distance between sellers (Δ_{mi}) using maximum likelihood.

5 Results

Sellers with less ability to differentiate their products are more likely to be local monopolists (Table 1). The fraction of local monopolists rises monotonically from full-service restaurants to liquor stores in the half-mile market and nearly monotonically (except for grocery stores) in the one-mile market. Likewise, mean distance to competitors rises monotonically (except for grocery stores) from restaurants to liquor stores. Liquor stores are not only distinct in their lack of ability to differentiate, they also have the smallest fraction zoned for them, which is consistent with liquor stores having larger negative externalities. Likewise, where liquor stores locate, a higher percentage of the population are renters and have lower median household income.

Correlations indicate that higher income neighborhoods tend to have fewer renters, fewer young adults, and more restrictive zoning for all retail types except restaurants (Table 2). While short travel distances are useful, higher income people might prefer to avoid external costs (e.g., aesthetic and traffic costs) associated with liquor stores, gas stations, and grocery stores near their homes. The fraction of renters is a good proxy for zoning. The correlation between fraction zoned and fraction renters varies from 0.37 (for full-service restaurants at half-mile radius) to 0.25 (for bars and liquor stores at half-mile and one-mile radii). We include both fraction zoning and fraction renters in the first regression because the fraction zoned might not fully reflect the ease with which potential entrants can obtain zoning variances from local governments.

Consistent with Proposition 1, the fraction of the area zoned for a given seller type has a positive relationship with the number of restaurants, bars, grocery stores, and liquor stores in the half-mile market (Table 3). Results for the one-mile market are similar and not shown. The implication is that zoning regulations tend to be binding in the case of these seller types. For a 0.1 increase in the fraction zoned for restaurants, an additional 15 restaurants enter. For the same magnitude change in zoning, there are 11 additional bars and 0.6 additional liquor stores. The latter, though smaller, is nevertheless consequential because adding a liquor store might considerably increase competition. For the grocery and gas/convenience stores, the fraction zoned is inconsequential.

In addition to zoning, proxies for lenient location restrictions, such as the fraction of renters, tend to have a positive relationship with the number of sellers (Table 3). Whereas in the case of grocery and gas/convenience stores, formal zoning has an insignificant effect, the effect of the fraction of renters appears both economically and statistically significant. The number of grocery and gas/convenience stores increases with population in a market, indicating that the demand effect dominates the crowding out of stores by residences. The effect of median household income of residents in the market varies by product type, plausibly because it picks up demand-side influences other than zoning.

The spatial autocorrelation parameter estimate for ρ is not statistically significant for any product market, and the parameter estimate for λ is statistically significant only for restaurants and grocery stores. Not surprisingly, results without controlling for spatial autocorrelation (not shown) are similar.

Consistent with Proposition 2, the number of sellers has a positive relationship with mean distance for the vast majority of sellers (Table 4). The two terms are jointly significant at better than the 0.001 level. The exception is in the analysis of bars in the one-mile market where the coefficients have the expected sign but are not statistically significant. The positive relationship between sellers and distance is plausibly driven by zoning and other location restrictions. As zoning loosens, we expect the number of sellers to increase and their distance apart to increase (Figure 1).

The scatter plots (Figure 3) for the half-mile market area also demonstrate a positive relationship between the number of sellers and the mean distance between sellers until the number of sellers grows large (well above the observational means of sellers per market) and values eventually converge to about 0.25 (on the Y-axis). The scatter plots (Figure 3) have a similar shape to Figure 2 for most of the product markets.[10] For liquor stores, however, a pattern is less evident probably because there are few points. There are few points for liquor stores in the scatter plot because liquor stores have a high proportion of local monopolists. There are 53 local liquor-store monopolists represented by a single point at coordinates (1,0.5). All of the bars in markets with more than 100 bars advertise themselves as both bars and restaurants.

Table 5 shows the marginal effects on distance of adding sellers. Using parameter estimates from Table 4 and sample means from Table 1, we calculate the marginal effects on distance of adding sellers ($\beta_1 + 2\beta_2 N$). At the observational means, adding a liquor store increases mean distance between competitors by 0.036 miles (Table 5, Panel A). If the number of sellers increases from the mean of 2.71 to 3.71, and the incumbents do not move, then the marginal entrant must locate 0.134 miles away, i.e. one and a half city blocks. Given our definition of the market as a half mile, liquor stores cannot locate more than 6 blocks apart, and zoning further restricts their location choices. For liquor stores in the one-mile market, the results are virtually identical (0.132 miles).

Adding another restaurant causes the marginal entrant to locate 0.054 miles away in the half-mile market, or 0.108 miles away in the one-mile market. The distances are shorter for restaurants even though on average there are more than 12 times as many restaurants as

[10]There are different scales for the horizontal axes in Figure 3, because of the differences in sample sizes across sellers.

liquor stores. Likewise, adding another bar causes the marginal entrant to locate 0.050 miles away in the half-mile market, or 0.031 miles away in the one-mile market.

Consistent with Proposition 3, sellers with more ability to differentiate their products cluster more (Table 5, Panel A). Restaurants and bars have the greatest ability to differentiate and have the smallest marginal effects on distance. Liquor stores have less ability to differentiate and have the greatest marginal effects. Grocery and gasoline/convenience stores are in between.

Comparing these results with those from Table 1 and Figure 3, Panel B shows the critical values of retailer numbers at which the marginal effects become negative. For each retail type, the vast majority are in the positively sloped region which supports Proposition 2.

Propositions 4 and 5 are tested indirectly because we do not observe prices for individual sellers. Previous research established that price competition can be inferred from entry (Bresnahan and Reiss, 1991). When entry slows it is plausibly due to intense price competition. [11] Results from Table 3 indicate that restrictive zoning is associated with fewer sellers. Results from Table 4 indicate that fewer sellers are associated with shorter distances. These are consistent with our theoretical framework predicting that restrictive zoning decreases distances between sellers, increases price competition, and drives out some sellers. Hence, we include Propositions 4 and 5 because they can be tested indirectly, and because they introduce important alternative theories for the effect of zoning and for the relationship between price and the number of sellers which were examined in previous theoretical research (Satterthwaite, 1979).

[11] In our model the relationship between the number of sellers and price can be positive if zoning varies, but if zoning is constant the relationship between the number of sellers and price is negative.

6 Discussion and Conclusions

Zoning and natural boundaries force firms into a smaller location choice set which decreases distances and thus lowers prices. Lower prices induce sellers to exit so the remaining sellers each serve more consumers (because of a fixed number of consumers). Seller exit also increases prices somewhat, but does not fully offset the price decline from greater proximity, so the net effect on price is negative. Hence, zoning can lead to lower prices and lower external costs associated with living near sellers, but fewer firms (less variety) and higher travel distances from consumers to sellers.

Three theoretical implications might be initially surprising. First, one might expect zoning to confer market power by restricting locations of competitors, but zoning can actually increase competition by forcing firms to locate closer together. Hence, an unintended consequence of zoning is greater price competition which might be socially beneficial in many markets, though not necessarily in alcohol markets. Second, one might expect a negative relationship between the number of sellers and their distance apart, but we show that the relationship is positive over the relevant range due to zoning. Third, one might expect a negative relationship between the number of sellers and price but we show that when zoning is added to the model, the relationship can instead be positive.

Three empirical findings are particularly important. First, permissive zoning (measured directly as the fraction of area allowed for seller types, and indirectly as the fraction of renters in the area) increases the number of sellers. The additional sellers can spread out which can decrease price and non-price competition. Second, the number of sellers is positively related to the mean distance between competitors for the vast majority of sellers of each type. Third, spatial distance decreases with increases in the ability to differentiate products.

Our results suggest that businesses should not necessarily advocate restrictive zoning, because rather than keeping out competitors, it might force competitors to locate closer thus intensifying competition. If, however, firms can differentiate their products, they can diminish the competitive intensity.

Despite the policy importance of zoning, there have been few theoretical and empirical economic studies of zoning. To our knowledge, this is the first study to explicitly measure zoning and how it affects business locations and competition.

There are several possible extensions. First, the analysis could usefully be extended to other cities, including Houston which is the only large U.S. city that does not have formal zoning(Siegan, 1972), and some European cities which have highly restrictive zoning. Second, future analysis could explicitly test our theoretical model's predictions about the effects of zoning on prices. This study, like much of the industrial organization literature, infers price competition from the market structure (Bresnahan and Reiss, 1991; Berry, 1992). Third, future analysis could model optimal zoning by comparing the social benefit (lower prices, externalities, and total fixed costs) to the social harm (higher transportation costs and less variety). Fourth, future studies could investigate the political economy driving zoning, including how race and income relate to restrictive zoning.

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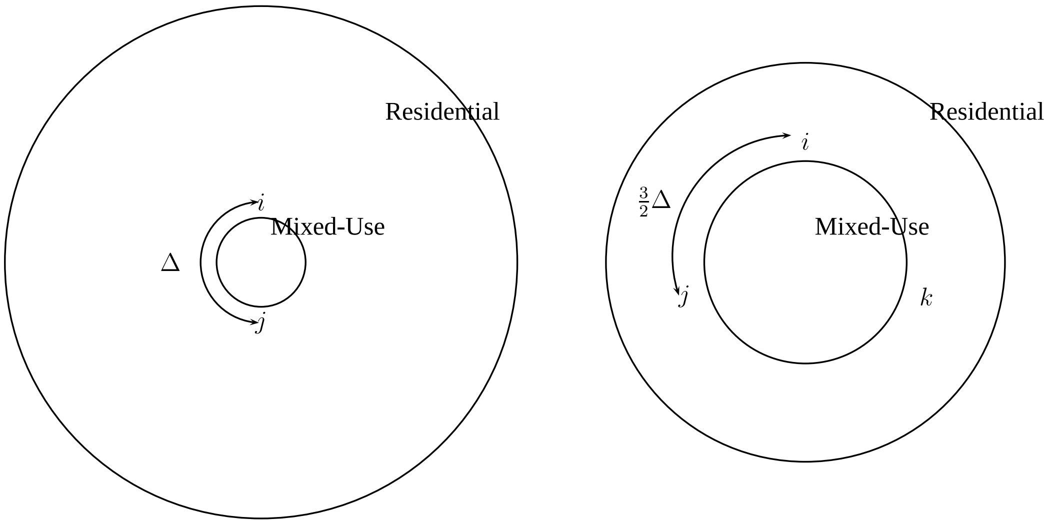

Figure 1: Effect of relaxing zoning restrictions on the number of sellers and their distance apart.

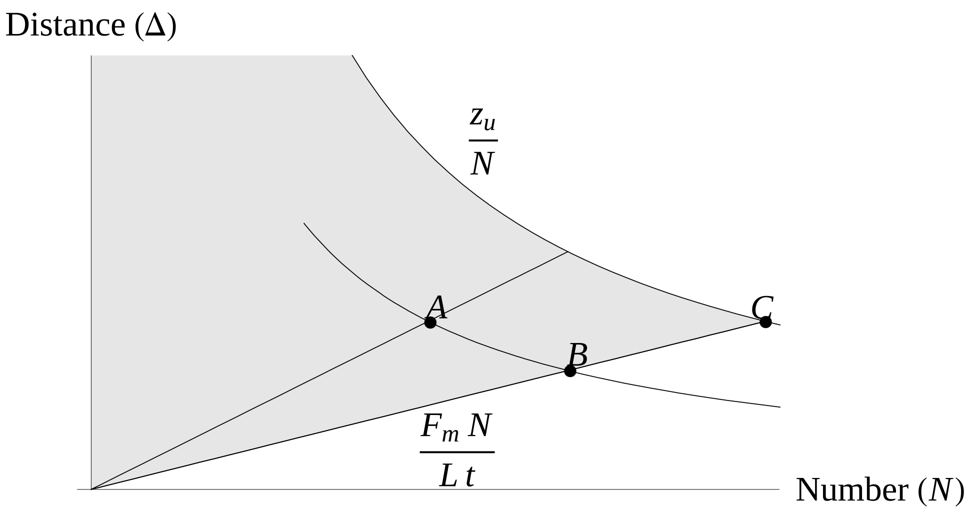

Figure 2: Relationship between the number of sellers and the distance to the nearest competitor.

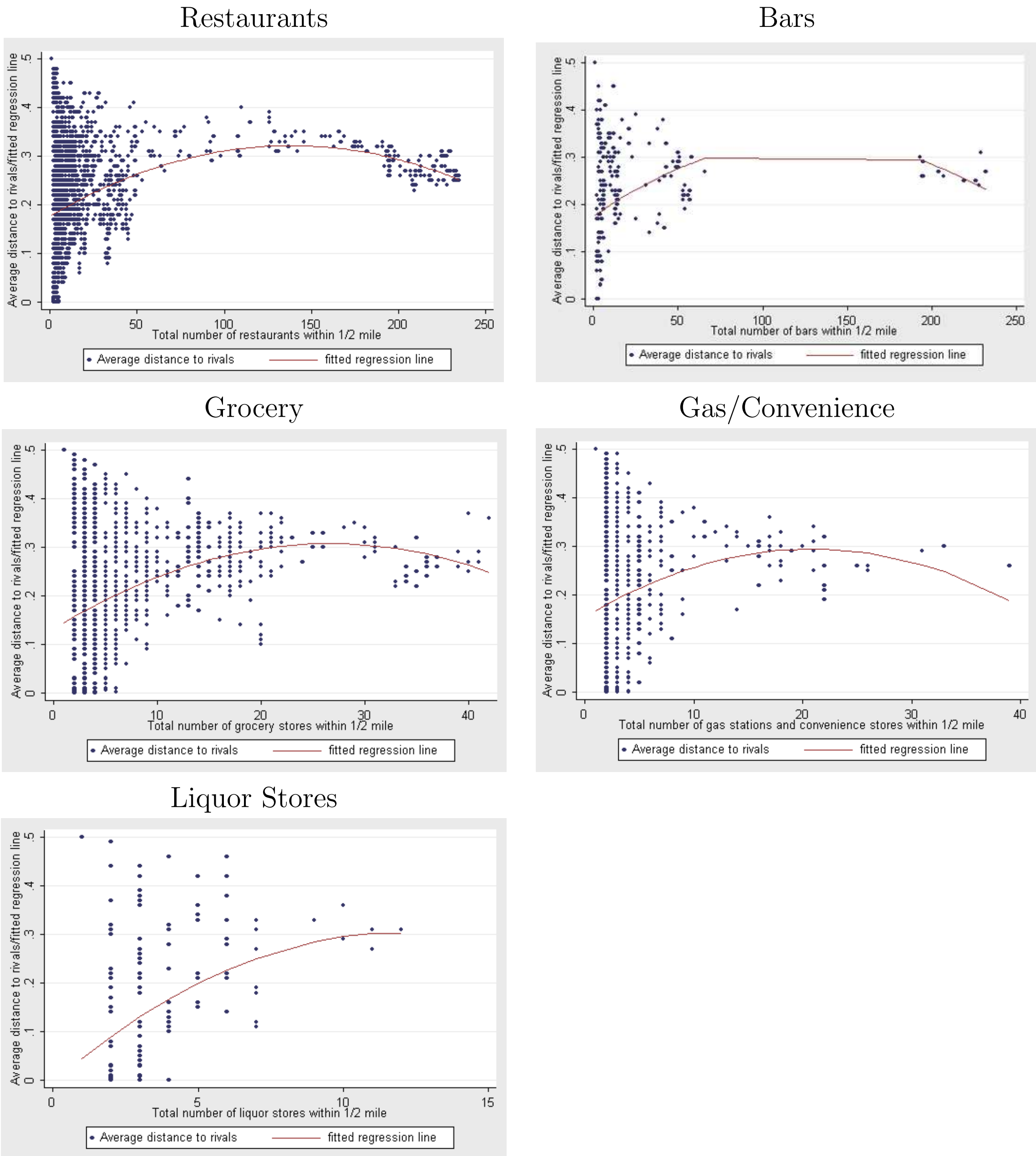

Figure 3: Relationship between the number of sellers and mean distance to competitors in half-mile markets.

Table 1: Summary Statistics

A. Half-mile market	Restaurants (N=2499)		Bars (N=288)		Grocery (N=1386)		Gas/Convenience (N=762)		Liquor Stores (N=265)	
	Mean	StdDev	Mean	StdDev	Mean	StdDev	Mean	StdDev	Mean	StdDev
Distance (1/1000 mile)	219.56	104.5	229.84	117.89	228.62	131.84	237.34	152.84	261.88	174.06
Number of sellers	32.91	56.97	24.22	45.68	7.69	8.31	3.54	4.94	2.71	2.09
Fraction monopoly sellers	0.01		0.01		0.03		0.06		0.20	
Fraction zoned for	0.20	0.28	0.24	0.19	0.10	0.12	0.17	0.13	0.07	0.11
Fraction renters	0.32	0.11	0.33	0.11	0.29	0.12	0.25	0.12	0.56	0.17
Median income (000)	47.29	27.32	43.28	26.34	46.32	32.48	37.11	26.34	39.34	25.83
Population (000)	3.05	2.34	3.53	2.29	3.49	2.67	2.48	1.91	2.39	1.99
Both bar & restaurant	0.02	0.15	0.21	0.38						
With alcohol license	0.88	0.33	1	0	0.80	0.40	0.65	0.48	1	0
On major roads (500 ft)	0.43	0.41	0.40	0.39	0.36	0.40	0.42	0.44	0.39	0.43
Fraction ages 20-34	0.40	0.15	0.43	0.13	0.39	0.13	0.36	0.11	0.35	0.11
Within 1/4 mile univer	0.02	0.05	0.03	0.05	0.01	0.04	0.05	0.07	0.14	0.35

B. One-mile market	Restaurants (N=2499)		Bars (N=288)		Grocery (N=1386)		Gas/Convenience (N=762)		Liquor Stores (N=265)	
	Mean	StdDev	Mean	StdDev	Mean	StdDev	Mean	StdDev	Mean	StdDev
Distance (1/1000 mile)	492.35	178.99	499.06	198.59	546.13	183.21	536.8	238.01	549.36	277.71
Number of sellers	66.38	96.65	43.36	71.41	20.15	22.3	7.44	11.9	4.75	4.68
Fraction monopoly sellers	0.00		0.01		0.01		0.03		0.18	
Fraction zoned for	0.17	0.26	0.06	0.13	0.1	0.23	0.12	0.14	0.08	0.14
Fraction renters	0.3	0.13	0.33	0.12	0.27	0.13	0.24	0.12	0.76	0.13
Median income (000)	54.81	28.62	50.89	27.72	50.7	30.1	39.43	27.19	38.24	22.14
Population (000)	12.08	8.52	14.5	8.31	12.95	9.27	9.49	6.87	9.15	6.91
Both bar	0.02	0.15	0.21	0.38						
With alcohol license	0.94	0.24	1	0	0.83	0.38	0.76	0.43	1	0
On major roads (500 ft)	0.35	0.48	0.29	0.45	0.32	0.46	0.76	0.43	0.29	0.46
Fraction ages 20-34	0.40	0.13	0.43	0.12	0.39	0.12	0.36	0.10	0.35	0.11
Within 1/4 mile univer	0.06	0.08	0.07	0.09	0.02	0.05	0.02	0.06	0.03	0.05

Table 2: Correlations

A. Half-mile market	Fraction renters	Fraction ages 20-34	Median income (000)
Fraction renters			
Fraction ages 20-34	0.57**		
Median income (000)	−0.35**	−0.55**	
Fraction zoned for restaurants	0.37**	0.48**	0.24**
Fraction zoned for bars	0.25**	−0.26**	−0.26**
Fraction zoned for liquor stores	0.25**	0.16**	−0.24**
Fraction zoned for grocery stores	0.38**	−0.47**	−0.24**
Fraction zoned for gas & convenience	0.32**	−0.54**	−0.16**

B. One-mile market	Fraction renters	Fraction ages 20-34	Median income (000)
Fraction renters			
Fraction ages 20-34	0.42**		
Median income (000)	−0.48**	−0.57**	
Fraction zoned for restaurants	0.36**	0.56**	0.23**
Fraction zoned for bars	0.25**	−0.22**	−0.22**
Fraction zoned for liquor stores	0.25**	0.18**	−0.20**
Fraction zoned for grocery stores	0.33**	−0.50**	−0.20**
Fraction zoned for gas & convenience	0.29**	−0.58**	−0.11**

** $p < 0.01$

Table 3: Results: Number of Sellers within Half-Mile Radius

	Restaurants (N=2499)		Bars (N=288)		Grocery (N=1386)		Gas/Convenience (N=762)		Liquor Stores (N=265)	
Fraction zoned for	147.63**	(2.36)	104.86**	(6.97)	3.30*	(1.33)	0.10	(0.23)	6.43**	(0.85)
Fraction renters	50.50**	(10.74)	36.71	(32.79)	20.99**	(2.42)	23.88**	(3.89)	5.36*	(2.47)
Median income (000)	0.10**	(0.01)	0.09*	(0.05)	−0.01**	(0.00)	0.02**	(0.01)	0.001	(0.005)
Population (000)	−1.41**	(0.51)	−1.39	(1.51)	2.43**	(0.12)	0.60*	(0.24)	0.04	(0.14)
Fraction ages 20-34	−30.80**	(6.97)	50.87*	(24.15)	−12.72**	(2.29)	−6.75	(2.59)	1.18	(2.37)
Within $\frac{1}{4}$ mile univ	2.01	(5.13)	−13.33	(13.60)	1.03	(1.51)	3.95*	(1.54)	0.14	(0.54)
On major roads	7.19**	(1.83)	10.31	(5.66)	−1.30**	(0.46)	−2.11	(1.10)	0.31	(0.46)
Both bar & restaurant	−1.86	(4.37)	49.19**	(4.40)						
With alcohol license	10.27**	(2.25)			0.13	(0.45)	−0.71	(0.72)		
Constant	−16.86**	(3.58)	−50.27	(10.70)	1.48	(1.75)	−7.47**	(1.70)	−0.35	(0.73)
χ^2 test	2785.50**		277.05**		1023.78**		163.07**		89.96**	
ρ (lag)	0.06	(0.04)	0.05	(0.03)	0.06	(0.04)	0.02	(0.02)	0.06	(0.05)
λ (error)	0.10**	(0.04)	0.05	(0.03)	0.05**	(0.02)	0.05**	(0.02)	0.03	(0.02)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$

Table 4: Results: Mean Distance (1/1000 mile) between Retailers within Given Radius

A. Half-mile market	Restaurants		Bars		Grocery		Gas/Convenience		Liquor Stores	
	(N=2499)		(N=288)		(N=1386)		(N=762)		(N=265)	
Number of sellers	2.06**	(0.16)	2.48**	(0.54)	12.75**	(1.24)	12.70**	(3.48)	47.67**	(15.71)
Number squared	−0.008**	(0.00)	−0.01*	(0.00)	−0.25**	(0.04)	−0.32*	(0.14)	−2.20	(1.63)
Constant	179.18**	(3.06)	177.92**	(10.05)	144.70**	(6.49)	168.35**	(9.94)	4.18	(27.72)
χ^2 test	268.98*		24.95*		165.06*		39.33*		50.53*	
Joint significance	0.00		0.00		0.00		0.00		0.00	
ρ (lag)	0.09	(0.06)	0.07	(0.05)	0.04	(0.03)	0.05*	(0.02)	0.06	(0.04)
λ (error)	0.06	(0.05)	0.08	(0.05)	0.05**	(0.02)	0.08*	(0.03)	0.07*	(0.02)

B. One-mile market	Restaurants		Bars		Grocery		Gas/Convenience		Liquor Stores	
	(N=2499)		(N=288)		(N=1386)		(N=762)		(N=265)	
Number of sellers	2.71**	(0.16)	1.03	(0.59)	6.57**	(0.72)	7.90**	(1.84)	33.20**	(11.52)
Number squared	−0.008**	(0.00)	−0.003	(0.00)	−0.06**	(0.01)	−0.09*	(0.03)	−1.08	(0.56)
Constant	421.48**	(5.45)	469.49**	(18.24)	463.10**	(8.73)	480.74**	(12.33)	348.21	(35.73)
χ^2 test	267.21*		3.14		121.06*		23.60*		15.76*	
Joint significance	0.00		Not sig		0.00		0.00		0.00	
ρ (lag)	0.08	(0.05)	0.07*	(0.02)	0.03	(0.03)	0.06*	(0.02)	0.03	(0.02)
λ (error)	0.06	(0.04)	0.08*	(0.02)	0.01	(0.01)	0.07*	(0.02)	0.04	(0.02)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$

Table 5: Marginal Effects of Adding Sellers

A. Marginal effects at observational means (miles)	Restaurants	Bars	Grocery	Gas/Convenience	Liquor Stores
Half-mile market area	0.0016	0.0020	0.0089	0.0065	0.0357
One-mile market area	0.0016	0.0007	0.0042	0.0066	0.0229

B. Number of sellers at zero marginal effects	Restaurants	Bars	Grocery	Gas/Convenience	Liquor Stores
Half-mile market area	134	128	26	20	11
One-mile market area	167	151	55	44	15