MAKING FRIENDS WITH YOUR NEIGHBORS? AGGLOMERATION AND TACIT
COLLUSION IN THE LODGING INDUSTRY

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Making friends with your neighbors? Agglomeration and tacit collusion in the lodging industry
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NBER Working Paper No. 16739
January 2011
JEL No. C3,L13,L4

ABSTRACT

Agglomeration is a location pattern frequently observed in service industries such as hotels. This paper empirically examines if agglomeration facilitates tacit collusion in the lodging industry using a quarterly dataset of hotels that operated in rural areas across Texas between 2003 and 2005. We jointly model a price and occupancy rate equation under a switching regression model to endogenously identify a collusive and non-collusive regime. The estimation results indicate that clustered hotels have a higher probability of being in the potential collusive regime than isolated properties in the same town. The identification of a collusive regime is also consistent with other factors considered to affect the sustainability of collusion like cluster size, seasonality and firm size, and the results are robust to alternative cluster definitions.

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1 Introduction

Agglomeration is a location pattern frequently observed in service industries such as the lodging industry. A common assumption is that hotels locate close to one another to enjoy of agglomeration effects. Fischer and Harrington (1996), for example, indicate that in industries where products are heterogeneous and need personal inspection, agglomeration results in a heightened demand. By spatially concentrating, sellers reduce consumer's search costs and attract more customers as a group relative to what they could all attract individually.[1] Helsley and Strange (1990) add that when firms are clustered, they help consumers to better evaluate their options. In the case of the lodging industry, Chung and Kalnins (2001) argue that agglomeration effects should be higher among hotels located in rural areas since most of them are overnight destinations in between days of travel, so a cluster of hotels may signal safety in an isolated area and/or indicate the availability of additional services. Other studies that have analyzed agglomeration effects in the hotel industry include Baum and Haveman (1997) and Kalnins and Chung (2004). However, not much has been said about the possibility that agglomeration may also facilitate the coordination of prices and quantities among hotels located next to each other. There is more anecdotal than empirical evidence on this matter.[2]

This paper seeks to empirically examine if agglomeration facilitates tacit collusion in the hotel industry. As revealed by Kalnins (2006), the exchange of price and occupancy information among hotels appears to be very common in the industry (e.g.

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[1] See also Stahl (1982) and Wolinsky (1983).

[2] See Kalnins (2006) for some related examples.

"call-arounds"). But agglomeration provides further opportunities for frequent firm interaction and can also facilitate the sustainability of a collusive agreement (if any) by increasing market transparency and reducing monitoring costs.[3] More specifically, on-site inspection of rates and vacancy status is costless among clustered hotels, making it easier and faster to detect deviations from any potential agreement. For example, the number of cars in the parking lot of neighboring hotels can be easily counted or employees could regularly visit the lobbies of competitors to keep record of the volume of check-ins. We examine then whether agglomeration facilitates a collusive price and quantity setting. To our knowledge, this is the first empirical study to formally test this hypothesis.

The data used for the analysis is a quarterly data set of lodging properties that operated in Non Metropolitan Statistical Areas (Non MSA) across Texas between 2003 and 2005. Using the physical address of each lodging property in the data set, we are able to determine whether a hotel is clustered and the number of nearby competitors faced by each hotel within each town. Working with geographically isolated areas also enables us to avoid any market overlapping issues and correctly identify the total number of competitors within each market, as in Bresnahan and Reiss (1991) and Mazzeo (2002).

The novelty of our methodology is that we jointly model a price and occupancy rate equation using a switching regression model to endogenously identify a collusive and non-collusive regime. In the potential collusive regime, prices are expected to be higher and quantities (occupancy rates) to be lower, as predicted by general oligopoly models

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[3] Our interviews with some hotel managers actually confirmed that hotels located close to one another exchange information on a regularly basis and adjust their rates accordingly.

where firms interact repeatedly and find it profitable to cooperate under the threat of future punishment.[4] Additionally, prices (and occupancy rates) are expected to exhibit a lower dispersion during successfully collusive periods.[5] We then analyze if agglomeration increases the probability of being in the potential collusive regime.

Other studies that use some form of mixture modeling to endogenously identify collusive and non-collusive regimes include Porter (1983), Ellison (1994) and Knittel and Stango (2003). But these studies basically focus on the pricing behavior of firms. Porter (1983) estimates a switching regression model to classify prices into collusive and non-collusive regimes during the Joint Executive Committee cartel on railroads in the late 19th century; Ellison (1994) reexamines the experience of the railroad cartel using a Markov structure on the transitions between collusive and non-collusive periods; Knittel and Stango (2003) use a mixture density model to test whether nonbinding price ceilings may serve as focal points for tacit collusion in the credit card market. Further, we examine if our identification strategy is consistent with other factors thought to affect the sustainability of colluding, as in Knittel and Stango (2003). In particular, the probability of engaging into tacit collusion is allowed to vary with cluster size, seasonality and firm size.

The estimation results suggest that agglomeration facilitates tacit collusion. Clustered hotels show a higher probability of being in the suspected collusive regime than isolated properties in the same town. Further, our identification of a collusive regime

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[4] See Tirole (1988).

[5] Recent studies suggesting that prices are more stable under collusion include Athey, Bagwell and Sanchirico (2004), Connor (2005) and Abrantes-Metz et al. (2006). For a general discussion on different behavioral patterns under collusion, refer to Harrington (2005).

is also consistent with other factors considered to affect the sustainability of colluding, and the results are robust to alternative cluster definitions. Moreover, hotels without any competitors in a town (i.e. monopolists), whom behavior is similar to perfect collusion, also show a higher likelihood of being in the collusive regime.

The reminder of the paper is organized as follows. Section 2 further discusses how agglomeration can facilitate tacit collusion. Section 3 describes the data and certain empirical regularities of the lodging industry in rural areas across Texas. The empirical model is presented in Section 4. Section 5 reports the estimation results while Section 6 concludes.

2 Agglomeration and tacit collusion

This section briefly discusses the economics of tacit collusion and how agglomeration can facilitate the sustainability of a cooperative agreement among clustered firms. It is well established that tacit collusion can arise when firms interact repeatedly in the same market. Firms can achieve higher profits by tacitly agreeing to raise prices (and restrict quantity) above (below) the static Nash equilibrium level. Since cheating or deviating from the collusive agreement increases current profits, firms can only be deterred from deviating if they are penalized in the future. For example, if a firm deviates from the collusive or cooperative outcome at a particular time period, the other firms may respond by reverting to the non-cooperative outcome for a certain number of subsequent periods (or forever). The collusive equilibrium condition or incentive compatibility (IC)

constraint requires then that the present value of foregone future profits is greater than or equal to the current profits from deviating.

Consider N firms each producing a differentiated product and competing in prices in an infinitely repeated game. All firms share the same unit cost of production. Let $p_i^s, i = 1,...,N$, be the price that maximizes firm i's profits (π_i^s) in the static version of the game. If firms agree to cooperate by charging $p_i^c > p_i^s$ and obtaining profits π_i^c in each period, then the IC constraint requires that,

$$\sum_{t=1}^{T} \delta^t (\pi_i^c - \pi_i^s) \geq \pi_i^d - \pi_i^c \tag{1}$$

where $\delta \in (0,1)$ is the discount factor equal across firms, π_i^d are firm i's profits when deviating from the collusive agreement and choosing best-response price p_i^d given all other firms' prices p_{-i}^c, and T are the number of periods of reversion to the non-collusive outcome. Note that $\pi_i^d > \pi_i^c > \pi_i^s$. From the condition above, it follows that the collusive outcome is more likely to be an equilibrium the higher the discount factor δ or when T is sufficiently high.

To see how agglomeration can facilitate collusion, assume that firms compete f times in a given time period. The discount factor can then be defined as $\delta = \dfrac{1}{1 + r/f}$, where r is the interest rate in a given period (Cabral, 2000). Since clustered hotels are likely to interact more frequently than isolated properties and δ is increasing in the frequency of interaction among firms, it is clear that agglomeration can facilitate the

sustainability of a collusive agreement.[6] Intuitively, when firms interact more often, they

can react more quickly if one of the firms deviates from the agreement, so collusion is

easier to maintain. A similar idea applies if we consider that clustered hotels adjust their

prices more frequently than isolated ones.

Additionally, agglomeration increases the transparency of the market and reduces

monitoring costs. On-site inspections of both rates and vacancy status (parking lots) are

costless among clustered hotels, making it easier and faster to detect deviations from any

agreement. This, in turn, limits the potential profits from deviating or short term profits

π_i^d, making collusion more easier to sustain among hotels in a cluster.[7]

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[6] Alternatively, we can let $T = \infty$ and assume that firms only compete every k periods, so the higher the

frequency of interaction among firms the lower the value of k. It can be shown then that the critical

threshold for the weight firms put on their future profits, i.e. the value of δ that makes equation (1) hold

with equality, decreases with a lower k (Ivaldi et al., 2003).

[7] It is worth to mention that the discussion above (and the posterior empirical analysis) on how

agglomeration may facilitate tacit collusion takes geographic location as given. Friedman and Thisse

(1991) have also shown that agglomeration is the only equilibrium outcome when collusion on price

follows competition on location. Locating at the same point implies that firms' ability to punish one another

for defection is maximized once the equilibrium locations are selected. The authors develop a spatial

duopoly model in which firms simultaneously select their locations at the beginning of time (once and

forever) and choose prices in each of a countable infinite succession of time periods. The critical

assumption in their model is that firms have the ability, at the beginning of the game, to determine the set

of price outcomes that are admissible in the subsequent repeated subgames. The authors also briefly discuss

some model extensions. In particular, they argue that when location is chosen sequentially and collusion on

prices takes place after entry, the second firm will locate at the same place as the first one, eliminating any

first-mover advantage observed in the one-shot price game. But if location is chosen simultaneously and

As noted, in the analysis we also control for factors, other than agglomeration, that can affect the sustainability of collusion.[8] These other factors include number of competitors (cluster size), seasonality and firm size. We discuss later how these other variables can make a collusive agreement easier or more difficult to sustain. Next, we describe the data used for the study and some empirical regularities of the hotel industry in rural areas across Texas.

3 Data

The main data source of this paper is the Texas Hotel Performance Factbook, published every quarter by Source Strategies Inc.. This is a unique data set that contains information on room counts, average daily rates (ADR), and occupancy rates for all lodging properties in Texas exceeding 18,000 dollars per quarter in gross revenues.[9] The data set also provides the hotel name and address, and indicates whether each property is

there are more than two firms, they sustain that firms' location will be affected by collusive pricing although it is not obvious that all firms will choose to locate together.

[8] For an extensive description of factors relevant for collusion see Ivaldi et al. (2003).

[9] See Table A.1 for a more detailed description of these variables. According to SSI, properties below 18,000 dollars per quarter result in approximately 1.5% of the total state revenues being excluded from this database. To our knowledge, this is one of the few datasets that provide detailed financial information of each lodging property in a whole state. Smith Travel Research (STR), a leading private research firm in the lodging industry, gets full financial reports from hotels/motels accounting for 80% of the market but only publishes aggregate results. They also maintain a Lodging Census Database which does not include financial information.

affiliated to a "Top 50+" chain.[10] Hotels are ordered by MSA/Non MSA, city/town and zip code. In this study, we focus on lodging properties that operated in Non MSA across the state between 2003 and 2005. This allows us to work with a comparable and geographically isolated set of oligopoly markets. Similar to Bresnahan and Reiss (1991) and Mazzeo (2002), by working with isolated markets we avoid any inter-market competition issues and correctly identify the number of competitors on each market.[11] Overall, we have an unbalanced panel of 9,148 observations corresponding to 845 properties operating in 250 markets between the first quarter of 2003 and the fourth quarter of 2005.[12]

The data set was supplemented with quality ratings from the American Automobile Association's (AAA) online hotel directory (www.aaa-texas.com). In this directory, lodging properties are rated from one to five "diamonds", ranging from simple to luxurious.[13] Following Mazzeo (2002), for those "Top 50+" chain-affiliated hotels not listed in the directory, we assigned the modal category of other chain-affiliated members that were in fact rated. Since AAA has minimum quality standards for inclusion of hotels

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[10] The "Top 50+" chains are determined and tracked by Source Strategies Inc., and may vary across time.

[11] Bresnahan and Reiss (1991) study the relationship between the number of firms, market size and competition using a sample of 202 isolated local markets (county seats) in the western United States. Mazzeo (2002), in turn, analyzes the effect of market concentration and product differentiation on market outcomes using a cross section of 492 isolated motel markets located adjacent to small, rural exits along one of the 30 longest U.S. interstate highways.

[12] The unbalanced panel results from the fact that the information for certain hotels and markets is not fully reported by SSI across all periods, and due to a small number of entries/exits in some markets.

[13] Refer to Table A.2 for details of AAA Diamond rating. Hotels range from 1 to 4 diamonds in our sample.

in their directory, we assigned the lowest category for independent properties and other minor chains not listed. These ratings allow us to control for quality in the estimations.

The data set was finally complemented with several control variables to account for different cost and demand conditions across markets. These variables include population, per capita personal income, number of gas stations at each location, value of rural land per acre, weekly wage on leisure and hospitality, distance to a MSA and regional dummies.[14] Table A.3 describes the sources of information consulted to construct these variables.

3.1 The Lodging Industry in Non MSA across Texas

The total number of properties in Non MSA across the state increased at an annual growth rate of 2.9% between 1995 and 2005, totaling 790 hotels and motels by the end of 2005.[15] The continuous upward trend in the supply of lodging units is reflected in the increase of room nights available, as shown in Figure 1. The number of rooms sold and, consequently, the occupancy rate did not follow a similar pattern. The latter showed a downward trend at the beginning of the present decade probably due to the recession of the economy and the 9/11 events, but recovered recently. The average occupancy rate in

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[14] Distance to a MSA is measured as the mileage between the town and the nearest MSA.

[15] In the same time period, lodging properties in MSA report an annual growth rate of 4.7%, totaling 3,194 hotels by the end 2005.

2005 was around 52%, similar to the levels shown in the late 90's.[16] The total room revenues, on the contrary, showed a steady increase (explained in part by the increase in the ADR), reaching almost 200 million dollars in 2005. The ADR increased two dollars in real terms, or sixteen dollars in nominal terms, across the period.

As noted, we focus on the period 2003-2005.[17] The whole list of locations in our sample, by region, is reported in Table A.4. Our unit of observation is a hotel-quarter pair. Table 1 presents the distribution of markets by number of operating firms at each point in time.[18] It follows that our sample basically consists of small oligopolies. In four of every five markets observed, there are five or less hotels operating. More specifically, 37% of the markets are monopolies, 18% are duopolies and another 26% have between three and five competitors.

Table 2 indicates that more than 68% of the operating properties do not have more than 50 rooms and an additional 20% have between 51 and 75 rooms. The small capacity of these properties is consistent with the small size of the markets in our sample. In terms of the distribution of hotels by chain affiliation and quality type, Table 3 shows that

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[16] As noted by Kalnins (2006), the nationwide occupancy rate of an average hotel is roughly 60% while the break-even occupancy (i.e. percentage of rooms that must be sold on average for a hotel to show positive pretax income) is estimated at around 53% since 2000.

[17] The second semester of 2005 may be an atypical period because of the sudden increase in the demand for hotel rooms after Katrina and Rita. However, according to a list of hotels/motels that participated in the Federal Emergency Management Agency's (FEMA) temporary housing program, provided by the same agency, most of the evacuees in Texas relocated in urban areas. In any case, we include time-period dummies in our estimates.

[18] Considering that we have data for 12 quarters, each market can be observed up to 12 times.

independent hotels and small franchises remain quite common across rural areas. Two thirds of the properties are either independent or not affiliated to any of the "Top 50+" chains. Among the properties that represent a top chain, 26% are affiliated to Best Western, 13% to Holiday Inn Express or Holiday Inn, 12% to Days Inn, 10% to Comfort Inn or Comfort Suites and 10% to Super 8.

There is a strong correlation between large franchises and quality type. Overall, 36% of the hotels in our sample are of high-quality, i.e. are rated with two or more "diamonds" according to AAA, and 88% of them represent a top chain. Since both chain affiliation and quality type are sources of product differentiation, we account for both of them in the estimations as well as for hotel size.

With respect to the geographical location of properties, relative to their nearby competitors, we find that 35% of them have at least one competitor in a radius of 0.2 miles. This fraction decreases to 24% if we reduce the ratio to 0.1 miles and increases to 52% if we extend the ratio to half a mile. Since the exact extent of a cluster is an empirical issue, we limit the cluster radius to 0.2 miles and compare our estimation results to those obtained under the other two alternative measures.[19] These conservative measures are also in line with the idea that for agglomeration to facilitate the sustainability of a collusive agreement, hotels should be located sufficiently close to each other to interact (and adjust prices) frequently, increase market transparency and reduce monitoring costs, so any potential deviation can be easily and promptly detected.

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[19] This empirical issue is similar to the problem that arises when establishing geographical boundaries to identify a firm's close competitors. Netz and Taylor (2002), for example, use market radii of half a mile, one mile and two miles in their study about gas stations' location patterns in Los Angeles. As indicated, we avoid any market definition issues because we work with rural areas which are generally isolated.

In Table 4 we segment our sample of hotels into four groups: clustered hotels, isolated hotels with a cluster of hotels in town, monopolists (i.e. hotels without any competitors in town), and isolated hotels without any cluster in town. As can be seen, clustered hotels seem to be larger and of higher quality than the other groups of hotels. Monopolists, on the contrary, are much smaller and of lower quality while isolated hotels, with and without a cluster in town, are in between. In particular, among clustered hotels, 43% have more than 50 rooms and almost 50% are of high quality. Among isolated properties with a cluster of hotels in town, 33% have more than 50 rooms and 41% are of high quality while among those without a cluster in town, the figures are 25% and 28%, respectively. Finally, only 10% of the monopolists have more than 50 rooms and 91% are of low quality, probably due to the fact that monopolists are basically located in small markets.

For the present study, we are particularly interested in examining the price and occupancy rate behavior of clustered hotels relative to isolated ones in the same town. A preliminary look at the data reveals that clustered hotels seem to behave in a different manner than isolated properties. Figures 2 and 3 indicate that clustered hotels charge, on average, lower prices and have higher occupancy rates, regardless of the season of the year. Overall, the average daily rate of a room in clustered hotels is 52.8 dollars versus 57.6 dollars in isolated hotels with a cluster in town (see Table 5). The average occupancy rate among clustered properties is 51.3% and 49.8% among isolated properties. In terms of dispersion, clustered hotels exhibit a much lower dispersion in prices and a slightly lower dispersion in occupancy rates across the year.

This initial look at the data provides mixed support regarding the hypothesis that agglomeration facilitates tacit collusion. If agglomeration increases the probability of colluding and if there are not any deviations from the collusive agreement, we would then expect a lower dispersion in prices and occupancy rates among clustered properties, relative to isolated ones, as observed. However, we would also expect clustered hotels to charge higher prices than isolated hotels and exhibit lower occupancy rates, but not the inverse.[20]

Next, we formally examine whether agglomeration facilitates tacit collusion. We propose a switching regression model to endogenously classify prices and occupancy rates into collusive and non-collusive regimes, while controlling for several factors at the property and market level that may affect a firm's competitive behavior. We then examine whether agglomerated hotels exhibit a higher probability of colluding than isolated hotels in the same town.

4 The Empirical Model

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[20] Alternatively, the differences in prices and occupancy rates between clustered and isolated hotels in a town could be explained in the context of the spatial competition literature, which considers a market power and a market share effect when clustering (e.g. Fujita and Thisse, 1996; Pinske and Slade, 1998; and Netz and Taylor, 2002). The market power effect predicts that, other things equal, firms will compete more intensively on prices when locating closer to each other (i.e. lower prices). But if the products between firms are differentiated enough, price competition may be weakened (Irmen and Thisse, 1998). The market share effect, in turn, predicts that firms will capture more customers when clustering (i.e. higher occupancy rates).

This section develops a switching regime model to analyze if clustered hotels are more likely to engage in collusive behavior than isolated properties in the same town. We jointly model a price and occupancy rate equation under a mixture modeling to endogenously identify a collusive and non-collusive regime. We then analyze if agglomeration increases the probability of colluding. As in Knittel and Stango (2003), we also test whether our identification of the collusive regime is consistent with other factors thought to affect the sustainability of collusion.[21]

Let a firm's log-linear price (p) and occupancy rate (q) equations be given by,

$$\ln p_{imt} = \delta_1^s + \delta_2^s MktStructure_{mt} + X_{imt}\gamma^s + \varepsilon_{imt}^s \text{ and} \tag{2}$$

$$\ln q_{imt} = \alpha_1^s + \alpha_2^s MktStructure_{mt} + X_{imt}\beta^s + u_{imt}^s, \tag{3}$$

where the subscript i refers to a firm, m to the market, and t to the time period, and the superscript s indicates one of two possible regimes, a collusive regime (C) and a non-collusive one (NC). The variable $MktStructure_{mt}$ measures the level concentration in the market through the Herfindahl-Hirshman Index (HHI), which is based on each firm's share of rooms sold, and the vector X_{imt} includes several property- and market-specific variables. The summary statistics of all variables used in the estimations are presented in Table 6.

The property-specific variables include dummy variables for the geographic location of hotels relative to their nearby competitors (i.e. clustered, isolated with a

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[21] These authors point out that an omitted variable or misspecification of the functional form might lead to the spurious identification of two regimes, a collusive and a non-collusive one. They suggest then examining whether the probability of being in the identified collusive regime varies with factors thought to affect the sustainability of collusion.

cluster of hotels in town, monopolist, isolated with no cluster in town), cluster size, a

dummy variable if the hotel is of medium or large size (i.e. if the hotel has more than 50

rooms) and dummy variables for high-quality and affiliations to major chains in our

sample.[22] The market-specific variables include population, per capita personal income,

number of gas stations, value of rural land per acre, wage on leisure and hospitality,

distance to a MSA and regional dummies. These firm- and market-specific variables are

intended to account for cost and demand factors that may affect a firm's competitive

behavior, besides market concentration.

Further assume that the error terms in each regime s, $s = \{C, NC\}$, are bivariate

normally distributed such that $(\varepsilon_{imt}^s, u_{imt}^s) \sim N_2(0,0,\sigma_\varepsilon^{s2},\sigma_u^{s2},\rho_s)$ where $\rho_s = \dfrac{\sigma_{\varepsilon u}^s}{\sigma_\varepsilon^s \sigma_u^s}$.

Then, the log likelihood for the jth firm-quarter period can be modeled as,

$$\ln l_j = \ln\left(h \frac{1}{2\pi\sigma_\varepsilon^C \sigma_u^C \sqrt{1-\rho_C^2}} \exp\left(\frac{-z_j^C}{2(1-\rho_C^2)}\right) \right.$$
$$\left. + (1-h)\frac{1}{2\pi\sigma_\varepsilon^{NC} \sigma_u^{NC} \sqrt{1-\rho_{NC}^2}} \exp\left(\frac{-z_j^{NC}}{2(1-\rho_{NC}^2)}\right) \right) \tag{4}$$

where $z_j^s = \dfrac{\varepsilon_j^{s2}}{\sigma_\varepsilon^{s2}} + \dfrac{u_j^{s2}}{\sigma_u^{s2}} - \dfrac{2\rho^s \varepsilon_j^s u_j^s}{\sigma_\varepsilon^s \sigma_u^s}$ and the mixing parameter h, $h \in [0,1]$, is defined as

the probability that a firm will collude.

In the collusive regime, firms are expected to charge higher prices and exhibit

lower occupancy rates (restrict output) than in the non-collusive regime. Additionally,

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[22] Recall that a hotel is considered of high quality if it is rated with two or more "diamonds" according to

AAA. The major chains include Best Western, Best Value, Comfort, Days, Econolodge, Holiday, Motel 6,

Super 8 and Ramada.

during successfully collusive periods we expect a lower dispersion in prices and occupancy rates. Consequently, identifying a potential collusive regime requires to test if $\delta_1^C > \delta_1^{NC}$, $\alpha_1^C < \alpha_1^{NC}$, $\sigma_\varepsilon^C < \alpha_\varepsilon^{NC}$, and $\sigma_u^C < \alpha_u^{NC}$.

The mixing parameter h or probability of engaging into tacit collusion is modeled as a constant and as a function of the geographical location of a hotel relative to its nearby competitors. In the former case, $h = G(\kappa)$ where κ is a constant and $G(\cdot)$ is approximated with a logistic CDF; in the latter case,

$h_j = G(\kappa_1 + \kappa_2 Clustered_j + \kappa_3 Monop_j + \kappa_4 Isolated\_no\_cluster_j)$ where *Clustered* equals to one if the hotel has a nearby competitor in a radius of 0.2 miles, *Monop* equals to one if the hotel is the only one operating in the town, and *Isolated_no_cluster* equals to one if the hotel does not have a nearby competitor in a radius of 0.2 miles and there is not a cluster of hotels in town .[23] The first specification assumes that the probability of tacit collusion is constant across all hotels (and time periods) while the second specification allows us to evaluate whether the probability of being in a potential collusive regime varies with the relative location of the hotel within the town. Examining then if agglomeration facilitates collusion is equivalent to testing if $\kappa_2 > 0$.

Provided that our identification strategy of a collusive and non-collusive regime may be subject to an omitted variable or misspecification of the functional form, we also model h as a function of other factors typically correlated with the sustainability of tacit collusion. These other factors include cluster size, seasonality and firm size. Tacit collusion is easier to maintain among fewer firms so the probability of being in a potential collusive regime should decrease with the number of firms in the cluster.

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[23] The dummy variable for isolated properties with a cluster of hotels in town is the base variable.

Similarly, collusion is less likely during high season periods because the gain from cheating during a peak-demand period is higher than the future punishment (Rotemberg and Saloner, 1986).[24] Finally, the probability of colluding should also increase with firm size since deviations from any collusive agreement are typically more profitable for smaller than for larger firms.[25]

In the estimation of the price and occupancy rate equations specified in (2) and (3), some of the right-hand side variables are likely to be endogenous. In particular, the market-level HHI is presumably endogenous because there might be unobserved cost or demand characteristics in a market that not only influence prices (and occupancy rates) but also the underlying market structure. For example, markets with unobserved high costs are likely to have higher prices but these markets are also likely to exhibit fewer firm entries. We instrument the HHI with the HHI of the closest urban area to the town, obtained also from the Texas Hotel Performance Factbook. This instrument is valid under the assumption that market structure of the closest city, which is also affected by unobserved cost or demand characteristics in the area, is not influenced by prices (or occupancy rates) in a particular town.

Other potential endogenous variables include hotel size, quality type and location, although we treat them as predetermined. As indicated by Fernandez and Marin (1998),

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[24] Alternatively, if both current demand and firms' expectations on future demand are allowed to change over time, it will be more difficult for firms to collude when demand is falling (i.e. during low seasons) since the foregone profits from inducing a price war are relatively low (Haltiwanger and Harrington, 1991).

[25] Smaller firms, however, may also have less to gain from undercutting their rivals because of their higher capacity constraints relative to larger firms. But hotels in rural areas (at least in Texas) seem to operate well below their capacity, as previously shown.

the behavior of firms in the hotel industry can be represented as a sequential process. Initially, firms decide if they want to open an establishment in a particular location and simultaneously choose their capacity and quality. So these variables could be regarded as long-run decision variables. Firms compete then in prices (quantities) and take the establishments' capacity, quality and location as given. It is also important to note that in our working sample the number of entries and exits are very small, as well as the number of hotels that changed their affiliations (and possibly their capacity and/or quality level).

5 Results

We now turn to our estimation results. As noted, we instrument HHI with the HHI of the closest urban area to the town. Kleibergen and Paap's (2006) LM under-identification test and Wald weak-identification test indicate that the market-level HHI and HHI squared of the closest urban area are not weakly correlated with the market-level HHI of a particular town in our sample.[26] Hansen's J statistic for overidentifying restrictions also indicates that with a five percent level of significance we cannot reject the null hypothesis that these instruments are valid instruments (i.e. uncorrelated with the error term in the price and occupancy rate equations). A semiparametric partially linear version of this first-stage regression, where the HHI of the closest city is modeled nonparametrically and all other exogenous variables are modeled linearly, further increases the R-squared from

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[26] Results are available upon request. The LM and Wald versions of the Kleibergen and Paap (2006) rk statistic are a generalization of the well-known Anderson LM test of canonical correlations and Cragg and Donald Wald test for weak identification to the case of non-i.i.d. errors.

0.450 to 0.563. So the HHI in equations (2) and (3) is replaced with the corresponding fitted values from the semiparametric partially linear regression.[27]

For comparison purposes, we first do not allow for the possibility of different regimes and separately estimate the price and occupancy rate equations by least squares. The results are reported in Table 7. Several of the coefficients of the explanatory variables have the expected signs and are statistically significant, particularly in the price equation. Regarding the property-specific characteristics, high-quality hotels charge, on average, 31.4% higher prices than low-quality ones, reflecting the higher costs associated with providing additional quality. These hotels report at the same time a 12.9% higher occupancy rate. Besides, medium and large hotels charge 5.6% lower prices than small hotels and exhibit an 8.5% lower occupancy rate.

As in the preliminary analysis, clustered hotels seem to charge lower prices and exhibit higher occupancy rates than isolated hotels in the same town (base group in the regressions), although these effects are attenuated by the number of hotels in the cluster. Since we do not allow for two-regime periods, this result is probably only reflecting spatial competition and/or agglomeration effects.[28] Monopolists and isolated hotels

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[27] The estimation results presented in this section are very similar to those when using the lagged value of the market-level HHI as an alternative instrument for it (but we lose observations for one period).

[28] Recall that the spatial competition literature predicts a lower price among clustered (and homogeneous) hotels, relative to isolated properties, due to a price competition effect, and a higher occupancy rate due to a market share effect. The agglomeration literature predicts, in turn, a higher price and occupancy rate among clustered hotels because of a higher matching quality and matching probability effect. Testing for these effects is beyond the scope of the present study.

without a cluster in town also face higher occupancy rates than isolated properties with a cluster in town, but do not report significant differences in prices.

With respect to the market-specific variables, market concentration has a negative effect on prices but it does not significantly affect occupancy rates. A one standard deviation increase in the HHI (0.28) results in a 3.1% decrease in prices.[29] Prices are also positively correlated with the per capita income in the area. This is in line with the fact that wealthier locations usually have more businesses and places to visit, so we expect a higher number of visitors and higher prices. Hotels located in areas with higher wages and a higher value of land naturally charge higher prices because of the higher costs they face (but they also show lower occupancy rates). Additionally, the further away a hotel is from an urban area the higher the price it charges probably due to its higher market power in the vicinity of the area. A 10% increase in the distance to a MSA result in a 1.2% increase in prices. Curiously, population has a negative (although economically small) effect on both prices and occupancy rates. Finally, a higher number of gas stations in the area, which may approximate potential demand for hotel rooms, have a positive effect on occupancy rates but a negative impact on prices.[30]

We now turn to the MLE results of the switching regression model which endogenously classifies prices and occupancy rates into two regimes. As noted above, we jointly model a price and occupancy rate equation under each regime. The results are

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[29] This result might seem counterintuitive but recall that for several oligopolistic competition models prices fall with market concentration (Sutton, 1991).

[30] Gas stations exist to serve both residents of and travelers passing through and visiting a market. As indicated by Chung and Kalnins (2001), a higher number of gas stations in a market might also indicate that the area is well located as an intermediate point from one major destination to another.

presented in Table 8. Regime 1 is the potential collusive regime provided that hotels

charge significantly higher prices than in regime 2 and face lower occupancy rates.[31]

Prices and occupancy rates also show a lower dispersion during regime 1. In Model 1, the

mixing parameter *h* or probability of being in the suspected collusive regime is modeled

as a constant while in Model 2 we allow this probability to vary depending on the relative

location of the hotel within the town. In Model 3, we control for additional factors

considered to affect the sustainability of tacit collusion.

As can be seen, all three specifications provide very similar results regarding the

impact of firm- and market-specific variables on prices and occupancy rates. It follows

that when allowing for two regimes, the magnitude and direction of the effect of several

of the control variables are not necessarily similar to those obtained under the least-

squares approach and may vary by regime.[32] For example, quality type has a higher

positive impact during the suspected collusive regime. In Model 3, during the collusive

period, high-quality hotels charge almost 48% higher prices than low-quality hotels and

report a 13.4% higher occupancy rate; during the non-collusive period, the price and

occupancy rate difference between high- and low-quality hotels is not significantly

different. Medium and large lodging properties exhibit lower occupancy rates than small

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[31] This follows from the magnitude and significance of the constant terms under each regime. We also infer

from these results that the switching regression model is not just distinguishing between high- and low-

demand seasons since in high seasons we expect both a high price and occupancy rate. Later we show that

there is a lower probability of being in regime 1 (high prices, lower occupancy rates) during high seasons,

i.e. second and third quarter of the year.

[32] Note that we allow for different coefficients of the control variables under each regime in order to have a

more flexible model.

properties during both regimes (as in the least-squares approach), but they only charge

lower prices during non-collusive periods; during potential collusive periods they charge

around 3% higher prices. Further, clustered hotels only seem to charge lower prices than

isolated properties with a cluster in town during the non-collusive regime (60.6% lower

prices) while during the suspected collusive regime they charge higher prices (11.4%

higher prices) as well as monopolists and isolated properties without a cluster in town. In

terms of occupancy rates, the results are less clear since clustered hotels report a higher

occupancy rate during regime 1 and a lower occupancy rate during regime 2. Monopolists

and isolated hotels without a cluster in town only report higher occupancy rates (as in the

least-squares approach) during regime 2. Besides, market concentration only has a

negative effect on prices during the non-collusive regime (as well as a negative effect on

occupancy rates); during the collusive regime, a one standard deviation increase in the

HHI results in a 5.5% increase in prices. Other market controls that show significant

opposite effects across regimes include per capita income, wages, proximity to a MSA

and number of gas stations.[33]

Moving to the likelihood of being in regime 1, the potential collusive regime, in

Model 1 we observe that the sample-wide probability is equal to 68.3%.[34] When we

allow in Model 2 for the probability to vary with the geographical location of hotels,

relative to their local competitors, we find that clustered hotels have a higher probability

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[33] Although examining the impact of different control variables on hotels' prices and occupancy rates is not

the main objective of the present study, these results reflect the importance of allowing for different

regimes if we want to analyze the marginal effects of firm- and market-specific characteristics on hotels'

competitive behavior.

[34] In the regression, we estimate $\kappa = 0.769$ and $h = \exp(0.769) / (1+\exp(0.769)) = 0.683$.

of engaging into tacit collusion than isolated properties with a cluster in town (base group). In particular, having a competitor in a radius of 0.2 miles increases the probability by more than twelve percentage points, from 64.8 to 76.9%. Similarly, monopolists, whom behavior should be close to perfect collusion, also show a higher likelihood of being in the potential collusive regime. The probability increases in this case by almost ten percentage points (to 74.7%). Isolated hotels without a cluster in town, on the contrary, show a lower probability of being in regime 1 than isolated properties with a cluster in town. The probability decreases by six percentage points (to 58.8%).

If we further control for cluster size, seasonality and firm size, we still find that clustered hotels and monopolists have a higher probability of being in the potential collusive regime while isolated properties without a cluster have a lower probability (Model 3). Hotels with at least one competitor in a radius of 0.2 miles exhibit a 72.6% probability of being in the collusive regime, other things constant, while isolated hotels with a cluster in town only show a 60.8% probability. Monopolists show, in turn, a 72.8% probability of being in regime 1 while isolated hotels without a cluster in town show a 55.1% probability. The direction of the coefficients of the other control variables is also consistent with the discussion of factors, other than agglomeration, considered to affect the sustainability of collusion. The likelihood of tacit collusion decreases with the number of hotels in the cluster provided that it is easier to collude among fewer firms; decreases during high seasons given that collusion is more difficult to maintain during high-demand periods (Rotemberg and Saloner, 1986); and increases with hotel size provided that deviations from a collusive agreement are less profitable for large firms. Figure 4 illustrates the effects of these other variables by plotting the estimated

probability of colluding, conditional on being clustered, as a function of the number of hotels in the cluster and by seasonality and hotel size.

In sum, the results suggest that agglomeration facilitates tacit collusion. Clustered hotels show a higher probability of being in the potential collusive regime than isolated hotels in the same town. Our identification of the collusive regime is also consistent with other factors thought to affect the sustainability of colluding. Furthermore, monopolists, whom behavior is similar to perfect collusion, show as well a higher likelihood of being in the collusive regime while isolated properties without a cluster in town exhibit a lower probability. Monopolists are naturally expected to just follow one regime, equivalent to a perfectly collusive one, regardless of seasonal fluctuations in demand or any other factors. Based on the estimated probabilities of being in regime 1 (derived from Models 2 and 3 for each hotel in our sample), we find that monopolistic firms are in fact the only group of hotels that are always predicted to follow the potential collusive regime.

As a robustness check, we examine whether these findings persist under alternative cluster definitions. We consider a cluster radius of 0.1 miles and a cluster radius of 0.5 miles. The results are presented in Table 9 where regime 1 is the potential collusive regime with higher prices, lower occupancy rates and a lower dispersion in both market outcomes (relative to regime 2). Note that the estimated coefficients of the control variables under the two alternative cluster definitions are very similar to the ones obtained with a cluster radius of 0.2 miles (Model 3 in Table 8). If we either restrict the cluster radius to 0.1 miles or expand the cluster radius to 0.5 miles, we still observe that clustered properties have a higher probability of engaging into tacit collusion than isolated properties with a cluster in town. In the case of a cluster radius of 0.1 miles,

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having a nearby competitor increases the probability by about 17 percentage points, holding all else constant, while in the case of a cluster radius of 0.5 miles, the probability increases by about 26 percentage points. Monopolists again have a higher probability of being in the collusive regime while isolated properties without a cluster in town have a lower, but not significant, probability of being in regime 1. The likelihood of being in the identified collusive regime is also negatively related to cluster size and high-demand seasons and positively related to firm size. For comparison purposes, in Figure 5 we plot the probability of colluding, conditional on being clustered, as a function of cluster size for the different cluster definitions.

6 Conclusions

This paper has empirically examined if agglomeration facilitates tacit collusion in the lodging industry using a quarterly dataset of hotels that operated in rural areas across Texas between 2003 and 2005. Unlike previous studies that use some form of mixture modeling and focus on price behavior, we jointly model a price and occupancy rate equation under a switching regression model to endogenously identify a collusive and non-collusive regime. In the potential collusive regime, hotels are expected to charge higher prices and exhibit lower occupancy rates than in the non-collusive regime, and both prices and occupancy rates are expected to show a lower dispersion. We then analyze if agglomeration increases the probability of being in the collusive regime.

The results indicate that clustered hotels have a higher probability of being in the potential collusive regime than isolated hotels with a cluster in town. In particular, hotels

with a nearby competitor in a radius of 0.2 miles are about twelve percentage points more likely of being in the collusive regime than isolated properties in the same town. Our identification of a collusive regime is also consistent with other factors considered to affect the sustainability of collusion like cluster size, seasonality and firm size, and the results are robust to alternative cluster definitions. Further, monopolists, whom behavior should be similar to perfect collusion, also show a higher likelihood of being in the collusive regime.

These findings support the hypothesis that agglomeration may facilitate tacit collusion by providing opportunities for frequent interaction among clustered hotels, increasing market transparency, and reducing monitoring costs if there is any collusive agreement. The inclusion of other variables thought to affect the sustainability of collusion cannot completely rule out any potential misspecification error in our identification strategy but reduces the possibility of alternative explanations for the results obtained. The nature of our dataset (i.e. quarterly data) prevents us from considering alternative identification strategies; for example, allowing for reversion periods during the collusive regime. Similarly, we take long-run decision variables like capacity, quality and geographic location as given due to the small number of entries/exits and change of affiliations in our sample. Future research should incorporate dynamic aspects into the analysis of agglomeration and tacit collusion.

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Table 1: Distribution of markets by number of hotels

# hotels in market	# markets	%
1	1,027	37.1
2	508	18.3
3	380	13.7
4	133	4.8
5	204	7.4
6	129	4.7
7	79	2.9
8	55	2.0
9	68	2.5
10	56	2.0
More than 10	132	4.8
Total	2,771	100.0

Table 2: Distribution of hotels by size

Size	# hotels	%
Less than 25 rooms	268	30.8
26 - 50 rooms	326	37.5
51 - 75 rooms	171	19.7
76 - 100 rooms	62	7.1
More than 100 rooms	43	4.9
Total	870	100.0

Note: There are more than 845 observations because 23 of the lodging properties changed their affiliation during the sample period.

Table 3: Distribution of hotels by chain affiliation and quality type

| Chain affiliation | Quality rating | | | % total |
	Low	High	Total	
Best Western	0	78	78	9.0
Holiday	0	39	39	4.5
Days	1	35	36	4.1
Comfort	0	30	30	3.4
Super 8	1	29	30	3.4
Econolodge	0	16	16	1.8
Ramada	1	12	13	1.5
Motel 6	12	0	12	1.4
Best Value	1	10	11	1.3
Other chains	8	29	37	4.3
Total "Top 50+" chains	24	278	302	34.7
Others	530	38	568	65.3
Total	554	316	870	100.0
% total	63.7	36.3	100.0	

Note: There are more than 845 observations because 23 of the lodging properties changed their affiliation during the sample period. Low and high quality correspond to one and two or more "diamonds", respectively, under AAA's rating. Holiday includes Holiday Inn and Holiday Inn Express while Comfort includes Comfort Inn and Comfort Suites.

Table 4: Distribution of hotels by relative location, size and quality type

	Clustered		Isolated, cluster in town		Monopolist		Isolated, no cluster in town		Total	
	#	%	#	%	#	%	#	%	#	%
By size										
Up to 25 rooms	57	18.8	62	27.9	56.0	55.5	93.0	38.3	268	30.8
26 - 50 rooms	116	38.2	86	38.7	35.0	34.7	89.0	36.6	326	37.5
51 - 75 rooms	74	24.3	46	20.7	8.0	7.9	43.0	17.7	171	19.7
76 - 100 rooms	34	11.2	13	5.9	1.0	1.0	14.0	5.8	62	7.1
More than 100 rooms	23	7.6	15	6.8	1.0	1.0	4.0	1.7	43	4.9
By quality type										
Low	157	51.6	132	59.5	91.0	90.1	174.0	71.6	554	63.7
High	147	48.4	90	40.5	10.0	9.9	69.0	28.4	316	36.3
Total	304	100.0	222	100.0	101	100.0	243	100.0	870	100.0
% total	34.9		25.5		11.6		27.9		100.0	

Note: There are more than 845 observations because 23 of the lodging properties changed their affiliation during the sample period. A hotel is considered clustered if it has a competitor in a radius of 0.2 miles. Low and high quality correspond to one and two or more "diamonds", respectively, under AAA's rating.

Table 5: ADR and occupancy rate by relative location

	ADR	Occupancy rate
Mean		
Clustered	52.8	51.3
Isolated, cluster in town	57.6	49.8
t-test	0.00	0.00
Total sample	55.2	49.5
Standard deviation		
Clustered	24.5	15.1
Isolated, cluster in town	34.2	15.8
sd-test	0.00	0.01
Total sample	33.8	15.6

Note: A hotel is considered clustered if it has a competitor in a radius of 0.2 miles. Mean comparison test is based on two sample t-test with unequal variances using Welch's formula for degrees of freedom; Prob(|T|>|t|) reported. Equality of variance test based on Levene's robust test; Pr > F reported.

Table 6: Summary statistics for variables used in the analysis

	Mean	St. dev.	Min	Max
ADR (US$)	55.2	33.8	17.5	524.2
Occupancy rate	0.50	0.16	0.02	0.98
Firm variables				
Clustered	0.35	0.48	0.00	1.00
Isolated, cluster in town	0.26	0.44	0.00	1.00
Monopolist	0.11	0.32	0.00	1.00
Isolated, no cluster in town	0.27	0.44	0.00	1.00
Number of nearby hotels	1.76	1.40	1.00	9.00
Clustered (0.1 miles)	0.25	0.43	0.00	1.00
Number of nearby hotels (0.1 miles)	1.38	0.79	1.00	6.00
Clustered (0.5 miles)	0.53	0.50	0.00	1.00
Number of nearby hotels (0.5 miles)	2.75	2.68	1.00	14.00
Medium or large hotel	0.32	0.47	0.00	1.00
High quality	0.37	0.48	0.00	1.00
Best Western	0.09	0.29	0.00	1.00
Best Value	0.01	0.11	0.00	1.00
Comfort	0.03	0.18	0.00	1.00
Days	0.04	0.20	0.00	1.00
Econolodge	0.02	0.13	0.00	1.00
Holiday	0.05	0.21	0.00	1.00
Motel 6	0.02	0.12	0.00	1.00
Super 8	0.04	0.19	0.00	1.00
Ramada	0.02	0.12	0.00	1.00
Market variables				
HHI	0.34	0.28	0.06	1.00
Population	26,960	18,617	370	82,055
Per capita personal income (US$)	23,839	4,590	11,013	55,301
Gas stations	12	9	0	40
Value of land per acre (US$)	1,689	1,243	150	5,785
Weekly wage (US$)	208	42	93	480
Distance to a MSA (miles)	69.2	33.4	22.4	252.0
Central Texas	0.14	0.35	0.00	1.00
Gulf Coast	0.05	0.21	0.00	1.00
High Plains	0.10	0.30	0.00	1.00
Metroplex	0.07	0.25	0.00	1.00
Northwest Texas	0.08	0.26	0.00	1.00
South Texas	0.23	0.42	0.00	1.00
Southeast Texas	0.07	0.26	0.00	1.00
Upper East Texas	0.12	0.33	0.00	1.00
Upper Rio Grande	0.05	0.22	0.00	1.00
West Texas	0.08	0.27	0.00	1.00
# observations				**9,148**

Table 7: Least squares regressions of price (ADR) and occupancy rate

	Log ADR		Log Occ	
	Coeff.	Std. err.	Coeff.	Std. err.
Constant	-0.787	0.512	0.108	0.293
Clustered	-0.152	0.030	0.066	0.018
Monopolist	-0.035	0.029	0.091	0.021
Isolated, no cluster in town	-0.016	0.021	0.048	0.015
Log nearby hotels	0.088	0.028	-0.041	0.015
Medium or large hotel	-0.056	0.011	-0.085	0.010
High quality	0.314	0.019	0.129	0.014
Best Western	0.041	0.018	0.208	0.014
Best Value	-0.427	0.032	-0.102	0.032
Comfort	0.176	0.019	0.219	0.018
Days	-0.114	0.019	0.070	0.017
Econolodge	-0.230	0.021	-0.128	0.024
Holiday	0.260	0.019	0.324	0.015
Motel 6	-0.082	0.022	0.380	0.015
Super 8	-0.154	0.020	0.083	0.018
Ramada	-0.205	0.025	0.055	0.026
HHI	-0.136	0.060	-0.088	0.047
Log population	-0.036	0.013	-0.031	0.009
Log per capita income	0.241	0.043	-0.020	0.026
Gas stations	-0.011	0.002	0.005	0.001
Log value of land	0.135	0.015	-0.014	0.010
Log wage	0.198	0.047	-0.085	0.032
Log distance to MSA	0.123	0.017	-0.014	0.012
Central Texas	0.169	0.034	-0.073	0.026
High Plains	0.003	0.038	-0.047	0.031
Metroplex	0.241	0.042	-0.035	0.029
Northwest Texas	-0.026	0.036	-0.033	0.028
South Texas	0.275	0.034	0.030	0.026
Southeast Texas	0.167	0.039	-0.005	0.029
Upper East Texas	0.253	0.032	-0.028	0.026
Upper Rio Grande	0.381	0.056	0.067	0.041
West Texas	0.128	0.041	0.003	0.031
# observations		9,148		9,148
R-squared		0.272		0.204

Note: White robust standard errors reported, clustered on area-time period.
All models include time-period dummies.

Table 8: Switching regression model of price (ADR) and occupancy rate

	Model 1				Model 2				Model 3			
	Log ADR		Log Occ		Log ADR		Log Occ		Log ADR		Log Occ	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Regime 1												
Constant	2.979	0.255	-0.646	0.230	3.033	0.240	-0.575	0.230	2.795	0.240	-0.752	0.245
Clustered	0.119	0.019	0.070	0.020	0.120	0.024	0.059	0.023	0.114	0.026	0.053	0.021
Monopolist	0.100	0.018	0.017	0.018	0.100	0.022	0.007	0.021	0.090	0.023	0.000	0.020
Isolated, no cluster in town	0.078	0.013	0.005	0.013	0.072	0.016	0.008	0.015	0.072	0.017	0.007	0.015
Log nearby hotels	-0.013	0.016	-0.052	0.018	-0.009	0.021	-0.050	0.019	-0.018	0.021	-0.046	0.017
Medium or large hotel	0.021	0.010	-0.080	0.011	0.017	0.012	-0.078	0.011	0.030	0.013	-0.102	0.010
High quality	0.462	0.017	0.113	0.016	0.468	0.020	0.115	0.018	0.479	0.019	0.134	0.015
HHI	0.206	0.036	-0.023	0.037	0.215	0.044	-0.020	0.047	0.196	0.052	-0.027	0.040
Log population	-0.067	0.008	-0.013	0.008	-0.069	0.010	-0.014	0.009	-0.066	0.010	-0.015	0.008
Log per capita income	-0.062	0.024	-0.016	0.023	-0.059	0.025	-0.020	0.024	-0.036	0.028	-0.010	0.024
Gas stations	0.003	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.003	0.001	0.002	0.001
Log value of land	0.072	0.009	0.005	0.010	0.074	0.012	0.003	0.011	0.079	0.012	0.007	0.010
Log wage	0.133	0.030	0.017	0.030	0.119	0.034	0.017	0.033	0.103	0.036	0.012	0.028
Log distance to MSA	0.070	0.013	-0.010	0.013	0.068	0.015	-0.013	0.014	0.078	0.015	0.010	0.014

(Cont.)

| | Model 1 | | | | Model 2 | | | | Model 3 | | | |
| | Log ADR | | Log Occ | | Log ADR | | Log Occ | | Log ADR | | Log Occ | |
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Regime 2												
Constant	-0.196	0.978	-1.698	0.898	-0.183	1.140	-1.845	1.354	-0.453	1.042	-1.294	1.066
Clustered	-0.538	0.068	-0.110	0.068	-0.490	0.072	-0.177	0.064	-0.606	0.078	-0.140	0.069
Monopolist	-0.031	0.050	0.133	0.046	0.032	0.058	0.118	0.045	0.013	0.057	0.146	0.048
Isolated, no cluster in town	-0.144	0.034	0.105	0.033	-0.168	0.035	0.111	0.031	-0.185	0.038	0.117	0.034
Log nearby hotels	0.289	0.057	0.073	0.056	0.289	0.059	0.103	0.053	0.365	0.066	0.096	0.057
Medium or large hotel	-0.252	0.032	-0.089	0.031	-0.261	0.032	-0.091	0.030	-0.144	0.039	-0.181	0.039
High quality	0.080	0.039	0.073	0.041	0.074	0.043	0.059	0.040	0.034	0.042	0.022	0.041
HHI	-0.354	0.155	-0.732	0.151	-0.325	0.160	-0.802	0.147	-0.508	0.160	-0.622	0.151
Log population	-0.031	0.019	-0.058	0.018	-0.038	0.020	-0.058	0.018	-0.061	0.020	-0.054	0.022
Log per capita income	0.480	0.097	0.273	0.099	0.465	0.105	0.306	0.131	0.605	0.102	0.236	0.108
Gas stations	-0.015	0.003	-0.005	0.003	-0.015	0.003	-0.007	0.003	-0.020	0.003	-0.004	0.003
Log value of land	0.182	0.031	-0.023	0.029	0.195	0.033	-0.020	0.030	0.206	0.031	-0.032	0.030
Log wage	-0.225	0.077	-0.240	0.070	-0.197	0.079	-0.270	0.070	-0.302	0.078	-0.210	0.073
Log distance to MSA	0.003	0.049	0.013	0.043	-0.017	0.047	0.015	0.041	-0.093	0.051	-0.039	0.045

(Cont.)

	Model 1			Model 2			Model 3	
	Coeff.	Std. err.		Coeff.	Std. err.		Coeff.	Std. err.
Probability of Regime 1								
Constant	0.769	0.042		0.611	0.073		0.440	0.088
Clustered				0.594	0.100		0.751	0.199
Monopolist				0.474	0.135		0.543	0.132
Isolated, no cluster in town				-0.253	0.107		-0.235	0.103
Log nearby hotels							-0.314	0.159
High season							-0.156	0.078
Medium or large hotel							1.354	0.112
σ_ε^1	0.229	0.003		0.230	0.003		0.230	0.004
σ_u^1	0.233	0.003		0.234	0.004		0.238	0.003
ρ^1	0.366	0.006		0.372	0.005		0.376	0.005
σ_ε^2	0.429	0.009		0.431	0.010		0.441	0.009
σ_u^2	0.438	0.008		0.437	0.007		0.440	0.008
ρ^2	0.342	0.010		0.343	0.011		0.310	0.012
# observations		9,148			9,148			9,148
Log likelihood		-5,483.5			-5,419.4			-5,299.3

Note: All models include major top-chain, regional and time-period dummies. The top chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday, Motel 6, Super 8, and Ramada. A hotel is considered clustered if it has a nearby competitor in a radius of 0.2 miles. Variance of correlation coefficient obtained using the delta method.

## Table 9: Switching regression model of price (ADR) and occupancy rate, alternative cluster definitions

| | Cluster radius = 0.1 miles | | | | Cluster radius = 0.5 miles | | | |
| | Log ADR | | Log Occ | | Log ADR | | Log Occ | |
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Regime 1								
Constant	3.007	0.232	-0.774	0.235	2.500	0.244	-0.870	0.238
Clustered	0.055	0.027	0.065	0.026	0.114	0.021	0.024	0.019
Monopolist	0.073	0.020	-0.012	0.019	0.055	0.023	-0.014	0.021
Isolated, no cluster in town	0.049	0.014	-0.009	0.013	0.028	0.019	-0.009	0.018
Log nearby hotels	0.036	0.029	-0.043	0.028	-0.034	0.014	-0.044	0.013
Medium or large hotel	0.029	0.012	-0.109	0.012	0.038	0.012	-0.098	0.012
High quality	0.482	0.017	0.134	0.017	0.485	0.018	0.137	0.017
HHI	0.199	0.038	0.002	0.039	0.229	0.054	-0.034	0.050
Log population	-0.070	0.009	-0.012	0.009	-0.065	0.010	-0.022	0.010
Log per capita income	-0.048	0.024	-0.004	0.024	-0.014	0.027	0.004	0.025
Gas stations	0.003	0.001	0.002	0.001	0.002	0.001	0.002	0.001
Log value of land	0.080	0.010	0.011	0.011	0.082	0.012	0.008	0.011
Log wage	0.096	0.032	-0.005	0.032	0.107	0.037	0.025	0.031
Log distance to MSA	0.074	0.013	0.004	0.014	0.080	0.014	0.009	0.013
Regime 2								
Constant	-0.302	1.110	-1.298	1.137	-0.472	1.285	-0.991	1.110
Clustered	-0.498	0.111	-0.319	0.104	-0.354	0.060	-0.202	0.050
Monopolist	-0.004	0.052	0.120	0.047	0.038	0.056	0.158	0.047
Isolated, no cluster in town	-0.228	0.036	0.082	0.031	-0.117	0.042	0.140	0.036
Log nearby hotels	0.168	0.112	0.283	0.106	0.190	0.037	0.084	0.031
Medium or large hotel	-0.122	0.039	-0.168	0.038	-0.196	0.041	-0.183	0.037
High quality	0.037	0.040	0.003	0.040	0.088	0.044	0.030	0.040
HHI	-0.531	0.165	-0.605	0.154	-0.306	0.173	-0.768	0.158
Log population	-0.074	0.019	-0.054	0.019	-0.042	0.021	-0.033	0.020
Log per capita income	0.612	0.110	0.230	0.118	0.553	0.121	0.204	0.115
Gas stations	-0.020	0.004	-0.004	0.003	-0.015	0.003	-0.006	0.003
Log value of land	0.183	0.032	-0.035	0.030	0.195	0.035	-0.036	0.031
Log wage	-0.253	0.078	-0.197	0.071	-0.306	0.080	-0.223	0.069
Log distance to MSA	-0.122	0.052	-0.029	0.046	-0.036	0.055	-0.041	0.042

(Cont.)

	Cluster radius = 0.1 miles		Cluster radius = 0.5 miles	
	Coeff.	Std. err.	Coeff.	Std. err.
Probability of Regime 1				
Constant	0.409	0.075	0.034	0.087
Clustered	1.282	0.301	1.530	0.157
Monopolist	0.632	0.130	0.838	0.136
Isolated, no cluster in town	-0.044	0.091	-0.022	0.122
Log nearby hotels	-0.692	0.324	-0.456	0.089
High season	-0.165	0.070	-0.150	0.072
Medium or large hotel	1.367	0.110	1.333	0.108
σ_ε^1	0.232	0.003	0.232	0.003
σ_u^1	0.241	0.003	0.237	0.003
ρ^1	0.373	0.006	0.382	0.005
σ_ε^2	0.431	0.010	0.451	0.010
σ_u^2	0.443	0.007	0.441	0.007
ρ^2	0.314	0.011	0.278	0.013
# observations		9,148		9,148
Log likelihood		-5,280.0		-5,266.3

Note: All models include major top-chain, regional and time-period dummies. The top chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday, Motel 6, Super 8, and Ramada. Variance of correlation coefficient obtained using the delta method.

Figure 1: Evolution of the lodging industry in Non MSA across Texas 1995-2005

room nights avail.   room nights sold   occupancy

revenues   ADR
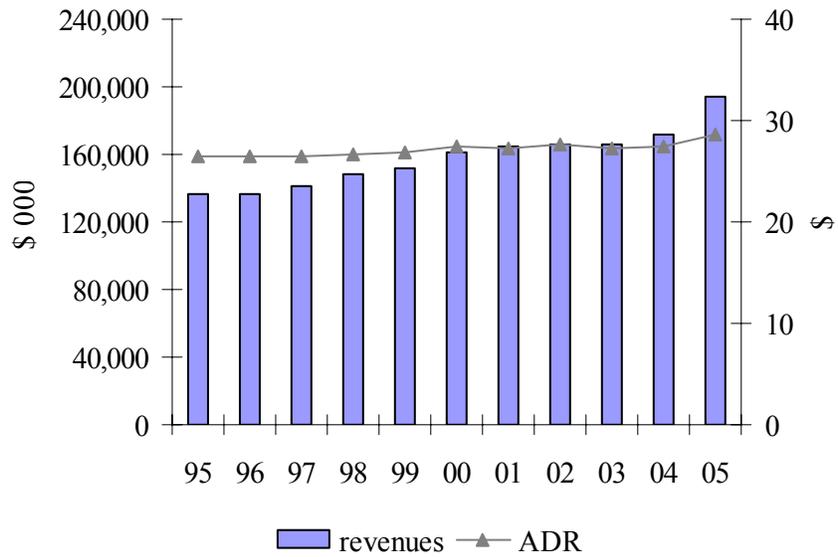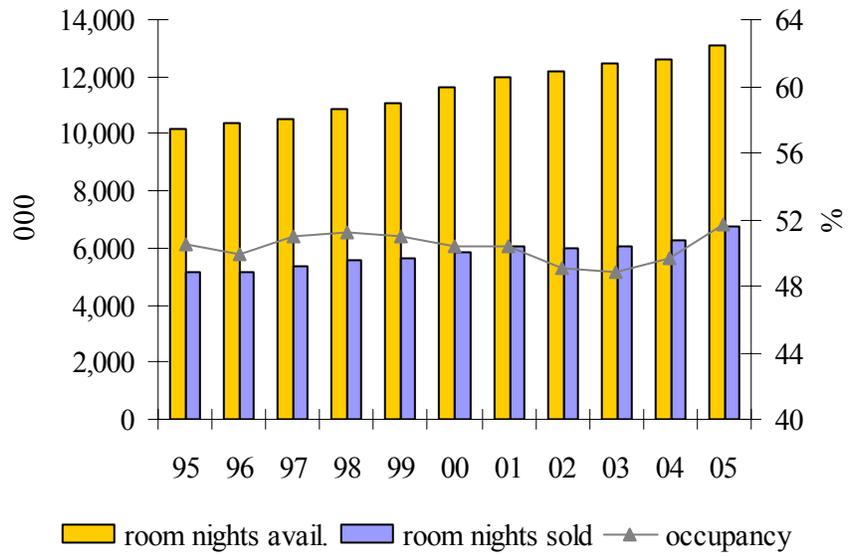
Note: Amounts expressed in 1982-84 CPI-adjusted dollars.
Source: www.travel.state.tx.us/asp/customreports.aspx

Figure 2: ADR by relative location

Mean

Standard deviation
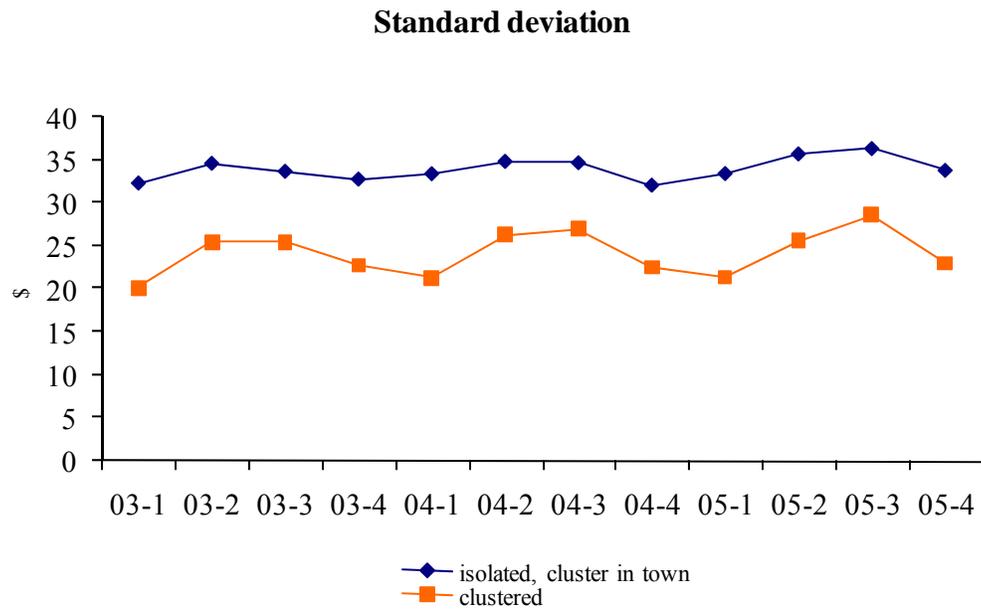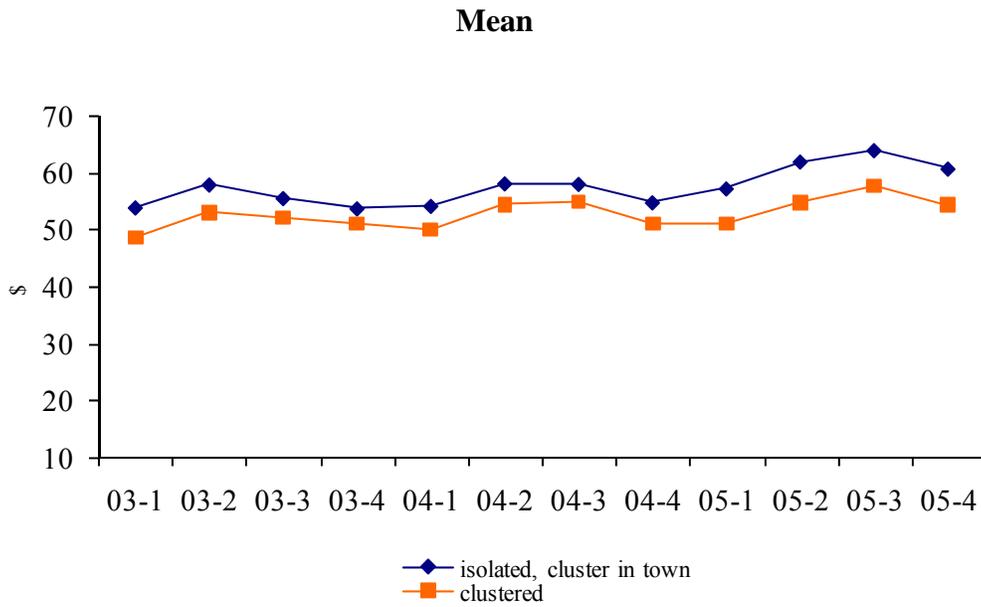
Note: A hotel is considered cluster if it has a competitor in a radius of 0.2 miles.

Figure 3: Occupancy rate by relative location

Mean

Standard deviation
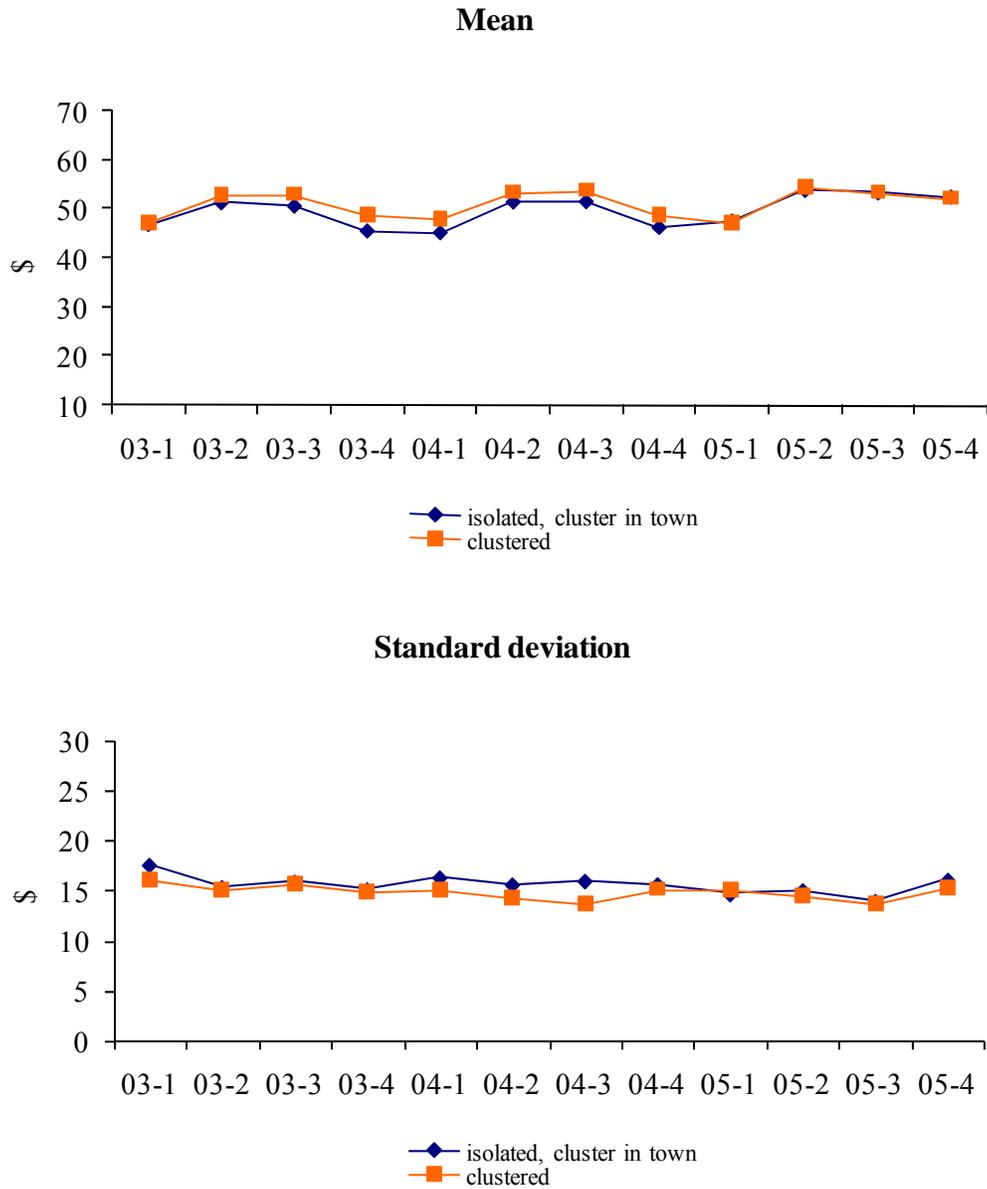
Note: A hotel is considered cluster if it has a competitor in a radius of 0.2 miles.

**Figure 4: Probability of colluding, conditional on being clustered**
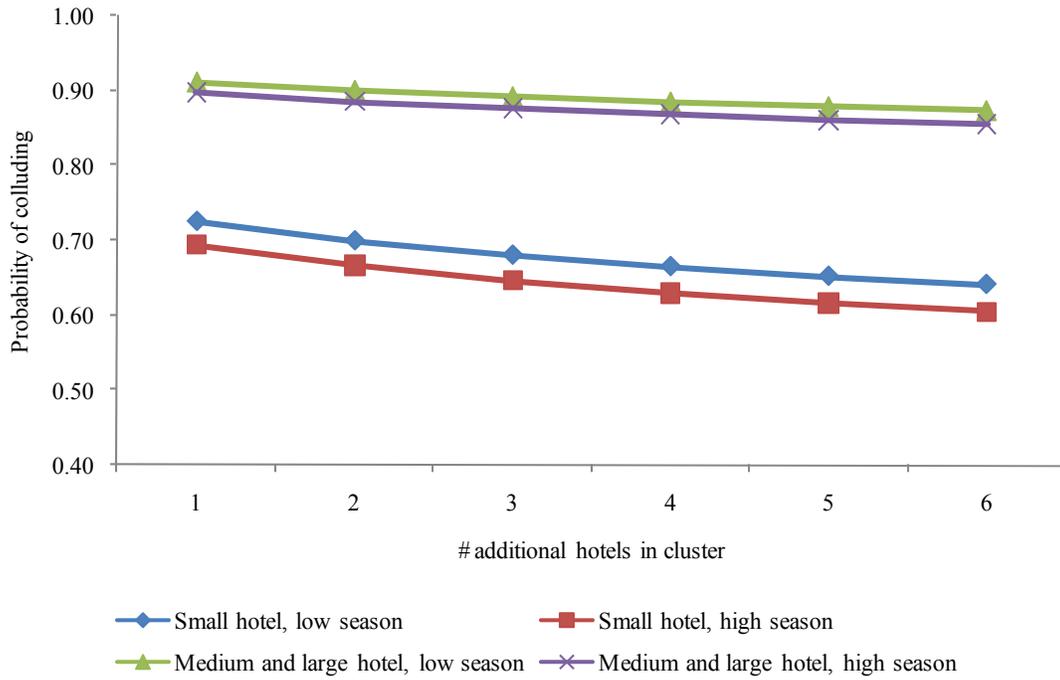
Figure 5: Probability of colluding, conditional on being clustered, by cluster definition
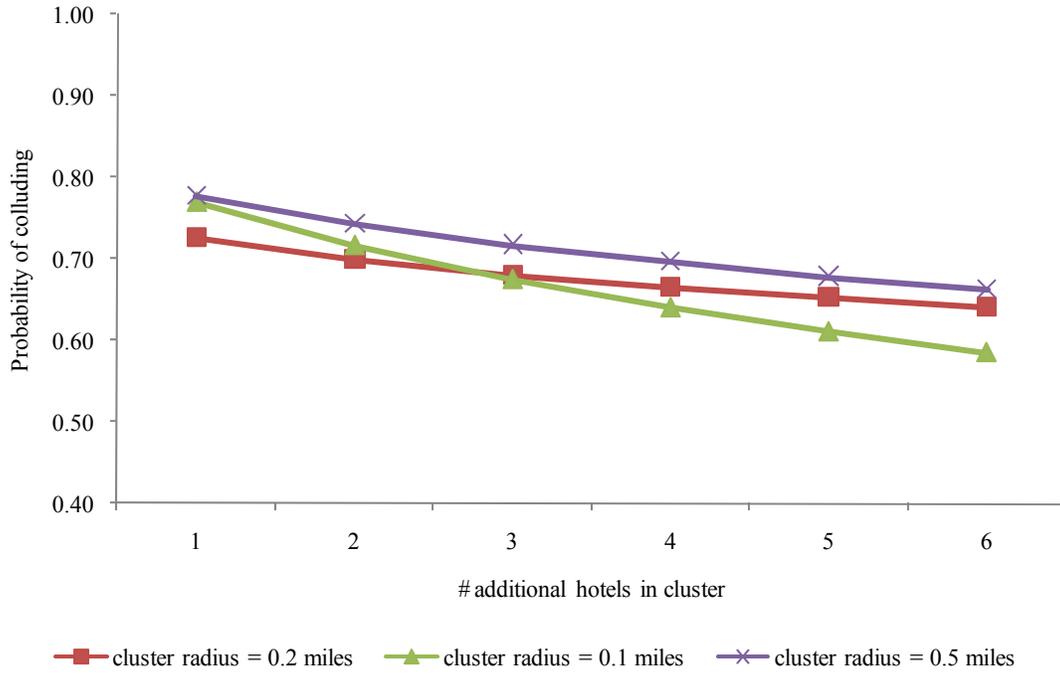
Note: Probabilities based on a small hotel and low season.

Table A.1: Texas Hotel Performance Factbook – Description of variables

Room counts	Are checked annually in chain directories and the Texas American Automobile Association (AAA) tour book. These properties account for approximately 80% of the state revenues. Properties are also checked by calling census and physical inspection by Source Strategies Inc. (SSI). For independent properties too small to be listed, the room counts reported to the Texas state government are used (unless they appear unreasonable). As a result, "Chains" room counts are very close to actual, while independent room counts could be slightly overstated.
Average Daily Rates (ADR)	Obtained from financial reports, appraisers, private SSI surveys, chain and AAA directories, and another reliable industry database.
Occupancy rate	Is calculated from room nights sold and room nights available. All occupancy figures represent fully-weighted averages. Room nights sold are obtained by dividing gross room revenues reported to the State of Texas Comptroller by ADR. Room nights available are calculated from room counts times the number of days in the period.
"Chains"	Are defined as one of the "Top 50+" brands determined and tracked by SSI. These brands may vary across time. Our sample includes, among others, Americas Best Value, Best Western, Budget Host, Comfort, Days, Econo Lodge, Hampton, Holiday, La Quinta, Motel 6, Ramada, and Super 8.

Note: According to SSI, on an overall basis the changes in ADR reported are within a few tenths of one-percent of Smith Travel's "Lodging Outlook". Smith Travel Research (STR) is a private research firm that gets full financial reports of hotel/motel properties, accounting for 80% of the market, but it only publishes aggregate results.

Table A.2: AAA Diamond rating

One Diamond	These establishments typically appeal to the budget-minded traveler. They provide essential, no-frills accommodations. They meet the basic requirements pertaining to comfort, cleanliness, and hospitality.
Two Diamond	These establishments appeal to the traveler seeking more than the basic accommodations. There are modest enhancements to the overall physical attributes, design elements, and amenities of the facility typically at a moderate price.
Three Diamond	These establishments appeal to the traveler with comprehensive needs. Properties are multifaceted with a distinguished style, including marked upgrades in the quality of physical attributes, amenities, and level of comfort provided.
Four Diamond	These establishments are upscale in all areas. Accommodations are progressively more refined and stylish. The physical attributes reflect an obvious enhanced level of quality throughout. The fundamental hallmarks at this level include an extensive array of amenities combined with a high degree of hospitality, service, and attention to detail.

Source: www.aaa-texas.com.

Table A.3: Sources of information consulted to construct market controls

Source	Variable
Texas State Data Center and Office of the State Demographer Texas Population Estimates Program http://txsdc.utsa.edu/tpepp/txpopest.php	*Population* Annual population at the county level.
Bureau of Economic Analysis http://bea.gov/bea/regional/reis	*Per capita income* Annual per capita personal income at the county level.
Google Maps www.google.com	*Gas stations* Number of gas stations at each location.
Real State Center at Texas A&M University www.recenter.tamu.edu/data/agp	*Value of land* Median per-acre value of rural land per year at the land market area.
Bureau of Labor Statistics www.bls.gov/data/home.htm	*Wage* Average weekly wage on leisure and hospitality per quarter at the county level.
Texas Comptroller of Public Accounts Texas Mileage Guide www.window.state.tx.us/comptrol/texastra.html **MapQuest** (for missing locations) www.mapquest.com	*Distance to MSA* Mileage between location and nearest MSA.
Texas Tourism Travel Industry website Economic Impact of Travel 2005 www.travel.state.tx.us/EconomicImpact.aspx	Regional dummies based on Uniform State Service Regions.

Table A.4: Locations included in the study by region

Regions	Locations
Central Texas (42 locations)	Blanco, Brenham, Buchanan Dam, Buffalo, Burnet, Cameron, Centerville, Chappell Hill, Clifton, Fairfield, Flatonia, Giddings, Goldthwaite, Granite Shoals, Groesbeck, Hamilton, Hico, Hillsboro, Hilltop Lakes, Horseshoe Bay, Iredell, Jewett, Johnson City, Kingsland, Kopperl, La Grange, Laguna Park, Lake Whitney, Llano, Madisonville, Marble Falls, Marlin, Meridian, Mexia, Navasota, Rockdale, Round Top, San Saba, Schulenburg, Streetman, Tow, Whitney.
Gulf Coast (12)	Bay City, Columbus, Eagle Lake, El Campo, Frelsburg, Huntsville, Matagorda, Midfield, Palacios, Pierce, Weimar, Wharton.
High Plains (28)	Borger, Brownfield, Canadian, Childress, Clarendon, Dalhart, Denver City, Dimmit, Dumas, Floydada, Friona, Hereford, Levelland, Littlefield, Memphis, Muleshoe, Pampa, Perryton, Plainview, Post, Shamrock, Spearman, Stratford, Tulia, Vega, Wellington, Wheeler, Wildorado.
Metroplex (12)	Bluff Dale, Bonham, Corsicana, Dublin, Gainesville, Glen Rose, Graford, Granbury, Mineral Wells, Mingus, Stephenville, Strawn.
Northwest Texas (28)	Albany, Aspermont, Ballinger, Bowie, Breckenridge, Brownwood, Cisco, Coleman, Colorado City, Comanche, De Leon, Early, Eastland, Graham, Haskell, Jacksboro, Knox City, Nocona, Olney, Quanah, Ranger, Santa Anna, Seymour, Snyder, Stamford, Sweetwater, Valera, Vernon.
South Texas (48)	Alice, Beeville, Brackettville, Camp Wood, Carrizo Springs, Concan, Cotulla, Crystal City, Cuero, Del Rio, Dilley, Eagle Pass, Edna, Escobares, Falfurrias, Fredericksburg, Freer, George West, Gonzales, Hallettsville, Hebbronville, Hunt, Ingram, Kenedy, Kerrville, Kingsville, Leakey, Mountain Home, Orange Grove, Pearsall, Port Mansfield, Premont, Raymondville, Refugio, Rio Frio, Rio Grande City, Riviera, Rocksprings, Roma, Sarita, Shiner, Smiley, Stonewall, Three Rivers, Utopia, Uvalde, Yoakum, Zapata.
Southeast Texas (20)	Broaddus, Brookeland, Center, Crockett, Diboll, Etoile, Hemphill, Jasper, Kirbyville, Livingston, Lufkin, Milam, Nacogdoches, Newton, Onalaska, Sam Rayburn, San Augustine, Seven Oaks, Trinity, Woodville.
Upper East Texas (28)	Alba, Athens, Atlanta, Canton, Carthage, Clarksville, Emory, Frankston, Grand Saline, Gun Barrel City, Hawkins, Hughes Springs, Jacksonville, Jefferson, Malakoff, Marshall, Mineola, Mount Pleasant, Mount Vernon, Palestine, Paris, Queen City, Quitman, Rusk, Scroggins, Sulphur Springs, Van, Wills Point.
Upper Rio Grande (11)	Alpine, Big Bend National Park, Fort Davis, Fort Hancock, Lajitas, Marathon, Marfa, Presidio, Shafter, Terlingua, Van Horn.
West Texas (21)	Andrews, Big lake, Big Spring, Brady, Crane, Eden, Fort Stockton, Iraan, Junction, Kermit, Lamesa, Mason, Menard, Monahans, Ozona, Paint Rock, Pecos, Rankin, Sanderson, Seminole, Sonora.

Note: Regions based on Uniform State Service Regions.
Source: www.travel.state.tx.us/EconomicImpact.aspx.