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

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Abstract—Agglomeration is a location pattern frequently observed in service industries such as hotels. This paper empirically examines whether agglomeration facilitates tacit collusion in the lodging industry using a quarterly data set of hotels in Texas. We jointly model a price and occupancy rate equation under a switching regression model to identify a collusive and noncollusive 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 tacit collusion.

I. 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 consumers' 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 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 tacit 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 whether agglomeration facilitates tacit collusion in the hotel industry. As Kalnins (2006), revealed, the exchange of price and occupancy information among hotels appears to be very common in the industry (an example is the practice of "call-arounds"). But agglomeration can provide further opportunities for frequent interaction and exchange of information among hotel managers and can also facilitate the sustainability of a tacit collusive agreement (if any) by reducing monitoring costs and increasing market transparency.[3] On-site inspections, if necessary, of rates and vacancy status are less costly among clustered hotels than among hotels located farther apart, making it easier and faster to detect deviations from any potential tacit agreement. For example, lobby visits by employees and observing the parking lot are less costly among hotels located close to one another and can provide some information about the volume of check-ins. Several hotels in rural areas, particularly small-sized hotels of low quality, also maintain the practice of posting signs with prices or "no vacancy" signs, or both, which further facilitates the monitoring between nearby hotels.[4] We examine, then, whether agglomeration facilitates a tacit coordination of prices and occupancy rates. To our knowledge, this is the first empirical study to formally test this hypothesis.

The data used for the analysis are 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 each hotel faces 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).

Collusive regimes differ from noncollusive ones in higher prices and lower quantities. The literature using regime-switching models to identify collusive regimes so far has used only differences in prices. Since this paper identifies a collusive regime using differences in both prices

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

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

[3] Our interviews with a couple of managers from hotels located close to one another confirm that they exchange information more frequently between them (usually more than once a day) than with managers from hotels farther apart, and adjust their rates accordingly. They call each other regularly, make personal visits, or get together for formal or informal meetings outside of hospitality forums. Some managers also admitted that they observe their competitors' parking lots on a regular basis or ask their employees to visit the other hotels' lobbies or even encourage them to make friends with the employees of neighboring hotels.

[4] The nature of our data, described later, suggests that the cost of monitoring may be a function of the distance to competing hotels in our sample. The use of the Internet, for example, as an alternative to on-site inspection for monitoring is not generally applicable in our case. At the time we did a search on the Web to verify the existence of the hotels in our sample, several of the hotels, particularly small-sized independent hotels, did not keep a website or if they did, the website did not allow making reservations. Making phone calls instead may not be a reliable source of information for monitoring if you do it on a regular basis under a tacit agreement.

and quantities (occupancy rates), it exhibits more power in detecting collusive regimes in the literature. A hotel in the sample may follow a particular regime or alternate between regimes across time. In the potential collusive regime with tacit coordination among firms, prices are expected to be higher and occupancy rates to be lower, as predicted by general oligopoly models where firms interact repeatedly and find it profitable to tacitly cooperate under the threat of future punishment (Tirole, 1998; Ivaldi et al., 2003). In addition, 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.

Several methods have been developed in the literature to detect collusive behavior or cartels. Bajari and Ye (2003) argue that competitive bids in auctions should be independent with each other conditional on observed characteristics. Abrantes-Metz et al. (2006) suggest a screen test for collusion using changes in the coefficient of variation of prices. In this paper, we follow the method developed in Porter (1983), Ellison (1994), and Knittel and Stango (2003) of using regime switching models to identify collusive and noncollusive regimes. Porter (1983) estimates a switching regression model to classify prices into collusive and noncollusive regimes during the Joint Executive Committee cartel on railroads in the late nineteenth century; Ellison (1994) reexamines the experience of the railroad cartel using a Markov structure on the transitions between collusive and noncollusive 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. In these papers, a higher-price regime is associated with collusive behavior. Similar to Knittel and Stango (2003), we also examine whether our identification strategy is consistent with other factors thought to affect the sustainability of tacit collusion. In particular, the probability of engaging in 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. Similarly, our identification of a collusive regime is consistent with other factors considered to affect the sustainability of tacit collusion, and the results are robust to alternative cluster definitions. Moreover, all hotels without a competitor in town (monopolists), whose behavior should be equivalent to perfect collusion, are always predicted to fall in the potential collusive regime when deriving binary regime predictions.

The reminder of the paper is organized as follows. Section II further discusses how agglomeration can facilitate tacit collusion. Section III describes the data and certain empirical regularities of the lodging industry in rural areas across Texas. The empirical model is presented in section IV. Section V reports the estimation results, and section VI concludes.

II. 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 (Tirole, 1988; Ivaldi et al., 2003). 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 be deterred from deviating only 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 noncooperative 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 forgone 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 noncollusive 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.

Agglomeration can facilitate the sustainability of a tacit collusive agreement under the assumption that it provides additional opportunities for frequent interaction and exchange of information among hotel managers. The exchange of price and occupancy information is a regular practice in the industry, but managers in hotels located close to one another seem to interact and exchange information more frequently among themselves than with managers of other hotels in town. Agglomeration can also be thought to facilitate tacit collusion under the assumption that it reduces monitoring costs and increases market transpar-

[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).

ency. On-site inspections (if necessary) of rates and vacancy status through lobby visits by employees or by observing parking lots can provide some information about the volume of check-ins and are less costly among clustered hotels than among hotels located farther apart. Additionally, several hotels in rural areas, especially small-sized properties of low quality, maintain the practice of posting signs with prices or "no vacancy" signs, or both, which further facilitates the monitoring among hotels located close to one another.

This implies, then, that clustered hotels can detect and react faster to any potential deviation from a tacit agreement among them and adjust their rates accordingly. In terms of the condition described in equation (1), a faster reaction and retaliation both limits the potential profits from deviating or short-term profits π_i^d, and results in a higher discount factor δ, which increases the perceived cost of future retaliation (Ivaldi et al., 2003). Intuitively, firms will find it easier to cooperate and sustain a tacit agreement when they can react more quickly to a deviation by one of them.[6]

In the analysis, we also control for factors other than agglomeration that can affect the sustainability of tacit collusion: number of competitors (cluster size), seasonality, and firm size.[7] 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.

III. Data

The main data source is the *Texas Hotel Performance Factbook,* published every quarter by Source Strategies. 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 per quarter in gross revenues.[8] The data set also provides the hotel name and address, and indicates whether each property is affiliated to a Top 50+ chain.[9] Hotels are ordered by MSA/Non-MSA, city or town, and zip code.

In this study, we focus on lodging properties that operated in Non-MSA (towns) across the state between 2003 and 2005.[10] A market is defined as all hotels in a given town. Hotels can be located downtown or along the town boundaries, including highway exits. Using towns in rural areas allows us to work with a comparable and geographically isolated set of oligopoly markets, as shown in figure A.1 in the online appendix. The map indicates that the locations in our sample are generally small and separated from one another.[11] This also limits the extent of intermarket competition and helps to correctly identify the number of competitors in each market, as in Bresnahan and Reiss (1991) and Mazzeo (2002).[12] We still control for physical distance to the next closest location in our sample, provided that hotels adjacent to a highway exit in a particular town may also compete to some extent for travelers with hotels at other exits in the same highway but in a different town.

Overall, we have an unbalanced panel of 9,148 observations corresponding to 845 hotels operating in 250 markets between the first quarter of 2003 and the fourth quarter of 2005.[13] We also assigned a product type to each hotel, either low or high quality, based on the quality ratings (number of diamonds awarded) from the American Automobile Association's (AAA) online hotel directory (http://www.aaa-texas.com). Hotels are rated from one to four diamonds in our sample, ranging from simple to upscale. Following Mazzeo (2002), we define low quality as one diamond and high quality as two or more diamonds. 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 in their directory, we assigned the lowest category for independent properties and other minor chains not listed.

The data set was complemented with several market controls for cost and demand conditions widely used in pre-

[6] It is worth mentioning that in this study we take 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 the 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 admissible in the subsequent repeated subgames.

[7] For an extensive description of factors that may facilitate tacit collusion, see Ivaldi et al. (2003).

[8] See table A.1 in the online Appendix for a more detailed description of these variables. According to SSI, properties below $18,000 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 data sets 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 and motels accounting for 80% of the market but publishes only aggregate results. It also maintains the Lodging Census Database, which does not include financial information.

[9] The Top 50+ chains are determined and tracked by Source Strategies and may vary across time.

[10] The second half of 2005 may be an atypical period because of the sudden increase in the demand for hotel rooms after Hurricanes Katrina and Rita. However, according to a list of hotels and 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.

[11] The average and minimum longitudinal (Euclidean) distance between locations (towns) is 266 and 16 miles, respectively. The whole list of locations, by region, is reported in table A.2 in the online appendix.

[12] Bresnahan and Reiss (1991) study the relationship of 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), 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 thirty longest U.S. interstate highways.

[13] 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 and exits in some markets.

TABLE 1.—DISTRIBUTION OF MARKETS BY NUMBER OF HOTELS

Number of Hotels in Market	Number of 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

vious studies on the lodging industry (see Baum & Haveman, 1997; Chung & Kalnins, 2001; Mazzeo, 2002; Kalnins & Chung, 2004). 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 MSA, distance to the next closest location, and regional dummies.[14] (Table A.3. the online Appendix describes the sources of information consulted to construct these variables.)

A. *The Lodging Industry in Non-MSA across Texas*

Table 1 presents the distribution of markets by number of operating firms at each quarter during the period 2003 to 2005. Considering that we have data for twelve quarters, each market can be observed up to twelve times. It follows that our sample basically consists of small oligopolies. In four of every five markets observed, there are five or fewer hotels operating. More specifically, 37% of the markets are monopolies, 18% are duopolies, and another 26% have between three and five competitors.

With respect to the geographical location of hotels in a market relative to the other competitors in town, we allocate each hotel to one of four possible location categories: clustered, isolated with a cluster of hotels in town, monopolist, and isolated without any cluster in town. A hotel is considered clustered if it has at least one competitor in a radius of 0.2 miles. An isolated property with a cluster in town is a hotel with competitors in town that are more than 0.2 miles from the hotel but where at least two of these competitors are within 0.2 miles from each other. A monopolist is a hotel without any competitors in town, and an isolated property with no cluster in town is a hotel with competitors in town that are all more than 0.2 mile apart from each other.

Since the exact extent of a cluster is an empirical matter, we limit the cluster radius to 0.2 mile and later compare our estimation results to those obtained under other two alternative measures: 0.1 and 0.5 mile.[15] These conservative measures are also in line with the idea that for agglomeration to facilitate the sustainability of a tacit collusive agreement, hotels should be located sufficiently close to each other to decrease monitoring costs and increase market transparency, and for managers to interact and exchange information more frequently between each other, so any potential deviation can be easily and quickly detected.

In table 2 we report the distribution of hotels by their relative location, size, and quality type. Several patterns emerge from the table. First, the majority of the hotels in our sample are small-sized properties, generally of low quality, which is consistent with the small size of the markets considered for the analysis. In particular, 68% of the hotels do not have more than fifty rooms, and 64% of the hotels are of low quality (rated with one diamond).[16] Although not reported in the table, there is also a strong correlation between low-quality type and independent hotels and small franchises. Second, 35% of the hotels in our sample are clustered: they have at least one nearby competitor in a radius of 0.2 miles (the average cluster size is three hotels). This fraction decreases to 24% if we reduce the radius to 0.1 mile and increases to 52% if we extend the radius to half a mile. Another 25% of the hotels do not have a nearby competitor in a radius of 0.2 mile but face a cluster of hotels in town. Finally, clustered hotels seem to be larger and of higher quality than the other groups of hotels. Monopolists, in contrast, are much smaller and of lower quality, probably because they are generally located in the smallest towns.

A closer look at the level of heterogeneity among hotels in a market and cluster also confirms that the degree of product differentiation in our sample is very low. Table 3 reports average variety indexes based on hotel quality, both within a market (town) and within a cluster. The index of product variety is the antilog of Shannon's entropy, following Straathof (2007). This index is preferred over the Gini coefficient because it can be decomposed without losing its functional form and has the property that it reduces to the number of product types if all types have the same weight. We construct both an index where each hotel in a market (cluster) has an equal weight and an index that further takes into account the size of the hotel (number of rooms).[17]

[14] Distance to MSA is measured as the mileage between the town and the nearest MSA; distance to the next closest location is the physical distance to the next closest town in our sample.

[15] This empirical issue is similar to the problem that arises when establishing geographi boundaries to identify a firm's close competitors. Netz and Taylor (2002), for example, use market radii of 0.5 mile, 1 mile, and 2 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.

[16] Another 24% of the hotels in our sample have two diamonds, 12% have three diamonds, and only one hotel (Lajitas Golf Resort and Spa) has four diamonds.

[17] The variety index is defined as $V(N) = \prod_N w_i^{-w_i}$, where N is the total number of possible product varieties (qualities) in a market and w_i is the weight of quality i, $i = 1, \ldots, N$. In this case, the weight w_i is equal to the fraction of hotels of a quality i in the market (cluster) or to the fraction of rooms of quality i in the market (cluster). Note that the index can range from one to N varieties.

TABLE 2.—DISTRIBUTION OF HOTELS BY RELATIVE LOCATION, SIZE, AND QUALITY TYPE

	Clustered		Isolated, Cluster in Town		Monopolist		Isolated, No Cluster in Town		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
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	

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 at least one competitor in the town in a radius of 0.2 mile. An isolated property with a cluster in town is a hotel with competitors in town that are more than 0.2 mile from the hotel, but where at least two of these competitors are within 0.2 mile from each other. A monopolist, in turn, is a hotel without any competitors in town, while an isolated property with no cluster in town is a hotel with competitors in town that are all more than 0.2 mile from each other. Low-quality corresponds to one diamond in AAA's rating, and high quality corresponds to two or more diamonds.

TABLE 3.—VARIETY OF HOTELS IN EACH MARKET AND CLUSTER BASED ON QUALITY

	Average Markets			Average Clusters		
Variety index	All Markets	Markets with More Than One Hotel	Markets with More Than Two Hotels	Cluster 0.1 Mile	Cluster 0.2 Mile	Cluster 0.5 Mile
Based on two varieties (low and high quality)						
Simple index	1.33	1.53	1.65	1.40	1.45	1.50
	(0.44)	(0.45)	(0.39)	(0.48)	(0.47)	(0.46)
Index accounting for hotel size	1.32	1.51	1.63	1.37	1.41	1.47
	(0.42)	(0.43)	(0.39)	(0.45)	(0.44)	(0.44)
Based on four varieties (one to four diamonds)						
Simple index	1.48	1.76	1.96	1.55	1.60	1.71
	(0.66)	(0.70)	(0.69)	(0.54)	(0.57)	(0.64)
Index accounting for hotel size	1.48	1.76	1.96	1.51	1.55	1.68
	(0.66)	(0.69)	(0.68)	(0.51)	(0.54)	(0.62)
Number of observations	2,771	1,744	1,236	1,011	1,281	1,604

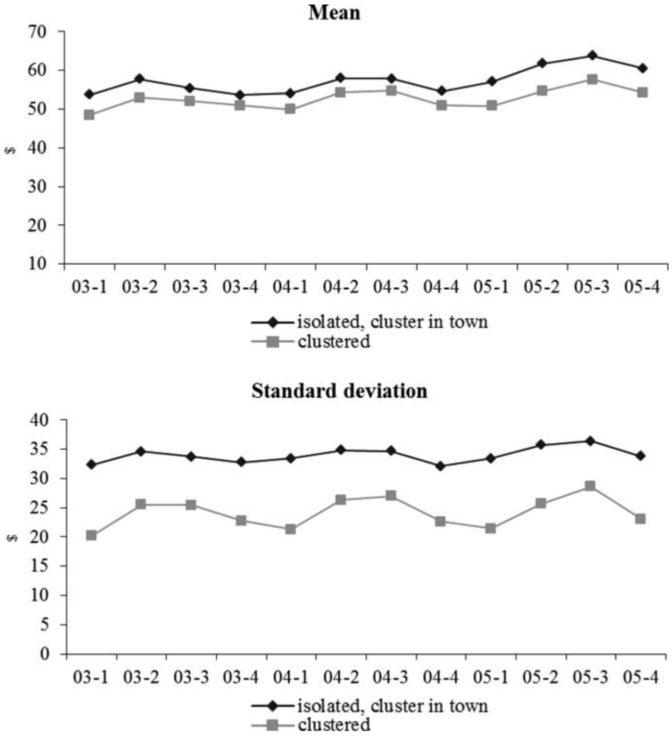
The variety index is based on the antilog of Shannon's entropy, following Straathof (2007). The index is constructed for each market (town) and cluster. A cluster is formed by two or more hotels in a town within a radius of 0.1, 0.2, or 0.5 mile. Hotel size is the number of rooms in the hotel. Low quality is equivalent to one diamond under AAA's rating, and high quality corresponds to two or more diamonds. Standard deviations reported in parentheses.

When considering all markets (towns) in our sample, the average index is 1.32 to 1.33 if we allow two possible product varieties (low and high quality) and 1.48 if we allow four possible product varieties (one to four AAA diamonds). If we exclude monopolistic markets from our sample, the index raises to 1.51 to 1.53 and 1.76, respectively, while if we exclude markets with only one or two hotels, the corresponding indexes are 1.63 to 1.65 and 1.96. These measures indicate that regardless of the number of competitors, the markets are generally dominated by one type of product variety (the average is fewer than two product varieties in all cases). Clusters also exhibit a low degree of variety inside the cluster. The index ranges from 1.37 to 1.71 across the different cluster radii considered for the analysis. Overall, this low level of heterogeneity among hotels in our sample suggests that the risk of coordinated behavior is not necessarily low, given that tacit collusion is easier to achieve when all firms offer similar products than when they offer highly differentiated products. In the estimations, we still include this variety index to account for potential complementarity or substitutability across hotels, particularly among clustered hotels, as well as for hotel quality, chain affiliation, and hotel size as sources of product differentiation.

In this study, we are particularly interested in examining the price and occupancy rate behavior of clustered hotels relative to isolated hotels in the same town. Figures 1 and 2 indicate that clustered hotels may behave differently from isolated properties. 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 versus \$57.6 in isolated hotels with a cluster in town. The average occupancy rate among clustered properties is 51.3%, and 49.8% among isolated properties. The differences for both average daily rates and occupancy rates are statistically significant at a 1% level, as shown in table 4. In terms of dispersion, clustered hotels exhibit a much lower dispersion in prices than isolated hotels with a cluster in town and a slightly lower dispersion in occupancy rates across the year. The standard deviations for both prices and occupancy rates are also statistically significant different at the 1% level (see table 4).

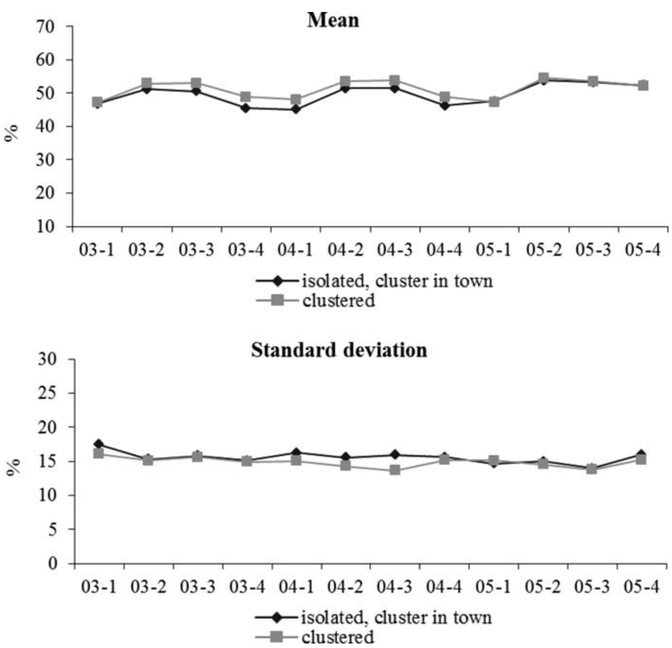
This initial look at the data provides mixed support regarding the hypothesis that agglomeration facilitates tacit

FIGURE 1.—AVERAGE DAILY RATE (ADR), BY RELATIVE LOCATION



A hotel is considered clustered if it has a competitor in town in a radius of 0.2 mile. See table 4 for the overall mean comparison and equality of variance tests.

FIGURE 2.—OCCUPANCY RATE, BY RELATIVE LOCATION



A hotel is considered clustered if it has a competitor in town in a radius of 0.2 mile. See table 4 for overall mean comparison and equality of variance tests.

collusion. If agglomeration increases the probability of colluding and if there are no deviations from the tacit collusive agreement (if any), we would, expect a lower dispersion in prices and occupancy rates among clustered properties,

TABLE 4.—AVERAGE DAILY RATE (ADR) AND OCCUPANCY RATE BY RELATIVE LOCATION

		ADR	Occupancy Rate
Mean			
Clustered		52.8	51.3
Isolated, cluster in town		57.6	49.8
Two-sample t test: H_0: diff $= 0$	$\Pr(\lvert T\rvert > \lvert t\rvert)$	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
Equality of variance test: H_0: diff $= 0$	$\Pr > F$	0.00	0.01
Total sample		33.8	15.6

A hotel is considered clustered if it has at least one competitor in the town 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. The equality of variance test is based on Levene's robust test.

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.[18]

Next, we formally examine whether agglomeration facilitates tacit collusion. We propose a switching regression model to classify prices and occupancy rates into a potential collusive and noncollusive regime 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 following the potential collusive regime than isolated hotels in the same town.

IV. The Empirical Model

This section develops a switching regime model to analyze if clustered hotels are more likely to engage in tacit collusive behavior than isolated properties in the same town. We jointly model a price and occupancy rate equation under a mixture modeling to identify a collusive and noncollusive 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 tacit collusion.[19]

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

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

[19] 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 noncollusive one. They suggest examining whether the probability of being in the identified collusive regime varies with factors thought to affect the sustainability of tacit collusion.

Table 5.—Summary Statistics for Variables Used in the Analysis

	Mean	SD	Minimum	Maximum
ADR (US$)	55.2	33.8	17.5	524.2
Occupancy rate	0.50	0.16	0.02	0.98
Firm variables				
Clustered, cluster radius = 0.2 mile	0.35	0.48	0.00	1.00
Isolated, cluster in town	0.26	0.44	0.00	1.00
Monopolist	0.11	0.32	0.00	1.00
Isolated, no cluster in town	0.27	0.44	0.00	1.00
Number of nearby hotels in a radius of 0.2 mile	1.76	1.40	1.00	9.00
Number of nearby competitors of similar quality in a radius of 0.2 mile	0.47	1.12	0.00	8.00
Cluster variety index based on hotel quality, cluster radius = 0.2 mile	1.25	0.49	1.00	3.00
Clustered, cluster radius = 0.1 mile	0.25	0.43	0.00	1.00
Number of nearby hotels in a radius of 0.1 mile	1.38	0.79	1.00	6.00
Number of nearby competitors of similar quality in a radius of 0.1 mile	0.26	0.69	0.00	5.00
Cluster variety index based on hotel quality, cluster radius = 0.1 mile	1.15	0.38	1.00	3.00
Clustered, cluster radius = 0.5 mile	0.53	0.50	0.00	1.00
Number of nearby hotels in a radius of 0.5 mile	2.75	2.68	1.00	14.00
Number of nearby competitors of similar quality in a radius of 0.5 mile	1.01	1.76	0.00	9.00
Cluster variety index based on hotel quality, cluster radius = 0.5 mile	1.48	0.65	1.00	3.00
Medium or large hotel	0.32	0.47	0.00	1.00
High quality	0.37	0.48	0.00	1.00
Best Western	0.09	0.29	0.00	1.00
Best Value	0.01	0.11	0.00	1.00
Comfort	0.03	0.18	0.00	1.00
Days	0.04	0.20	0.00	1.00
Econolodge	0.02	0.13	0.00	1.00
Holiday Inn	0.05	0.21	0.00	1.00
Motel 6	0.02	0.12	0.00	1.00
Super 8	0.04	0.19	0.00	1.00
Ramada	0.02	0.12	0.00	1.00
Market variables				
HHI	0.34	0.28	0.06	1.00
Population	26,960	18,617	370	82,055
Per capita personal income (US$)	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
Distance to closest town (miles)	25.3	8.1	16.4	65.3
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 (upper Central Texas)	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
Number of observations				9,148

$$\ln p_{imt} = \delta_1^s + \delta_2^s MktStructure_{mt} + X_{imt}\gamma^s + \varepsilon_{imt}^s, \qquad (2)$$

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

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 noncollusive one (NC). The variable $MktStructure_{mt}$ measures the level of 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 5.

The property-specific variables include dummy variables for the geographic location of hotels relative to their nearby competitors (clustered, isolated with a cluster of hotels in town, monopolist, isolated with no cluster in town), cluster size, number of other hotels in the cluster of similar quality, cluster heterogeneity measured through a variety index based on hotel quality (one, to four diamonds), a dummy variable if the hotel is of medium or large size (has more than fifty rooms), and dummy variables for high-quality and affiliations to major chains in our sample.[20] These control variables are intended to account for possible sources

[20] The major chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday Inn, Motel 6, Super 8, and Ramada.

of product differentiation (hotel quality, size, and chain affiliation), the degree of complementarity or substitutability across nearby hotels (number of hotels of similar quality, variety index), and for potential agglomeration and spatial competition effects (whether clustered and cluster size).

The market-specific variables, which have been generally used in other studies, 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, distance to the closest town, and regional dummies. These firm- and market-specific variables are supposed to account for cost and demand factors that may affect a firm's competitive behavior, besides market concentration. Per capita personal income and population, for example, could be positively correlated with hotel demand in the sense that wealthier and larger towns usually have more businesses and people to visit. The number of gas stations in area, which could serve as a proxy for travelers passing through and visiting an area, should also be correlated with hotel demand.[21] Wages and the value of land are expected to account for firm costs, while a higher distance to a MSA or to the next closest town could be associated with a higher demand or higher market power in the vicinity of the area.

We can further assume that the error terms in each regime s, $s = \{C, NC\}$, are bivariate normally distributed such that $(\varepsilon^s_{imt}, u^s_{imt}) \sim N_2(0, 0, \sigma^{s2}_{\varepsilon}, \sigma^{s2}_{u}, \rho_s)$ where $\rho_s = \sigma^s_{\varepsilon u}/\sigma^s_{\varepsilon}\sigma^s_{u}$. Then the log likelihood for the jth firm-quarter period can be modeled as

$$\ln l_j = \ln\left(h\frac{1}{2\pi\sigma^C_{\varepsilon}\sigma^C_{u}\sqrt{1-\rho^2_C}}\exp\left(\frac{-z^C_j}{2(1-\rho^2_C)}\right) + (1-h)\frac{1}{2\pi\sigma^{NC}_{\varepsilon}\sigma^{NC}_{u}\sqrt{1-\rho^2_{NC}}}\exp\left(\frac{-z^{NC}_j}{2(1-\rho^2_{NC})}\right)\right), \tag{4}$$

where $z^s_j = \varepsilon^{s2}_j\big/\sigma^{s2}_{\varepsilon} + u^{s2}_j\big/\sigma^{s2}_{u} - 2\rho^s\varepsilon^s_j u^s_j\big/\sigma^s_{\varepsilon}\sigma^s_{u}$ and the mixing parameter h, $h \in [0, 1]$, is defined as the probability that a firm will tacitly collude.

In the collusive regime, firms are expected to charge higher prices, which also result in lower occupancy rates than in the noncollusive regime. Additionally, during successful periods of tacit collusion, we expect a lower dispersion in prices and occupancy rates. Identifying a potential collusive regime, then, requires testing if $\delta^C_1 > \delta^{NC}_1$, $\alpha^C_1 < \alpha^{NC}_1$, $\sigma^C_{\varepsilon} < \alpha^{NC}_{\varepsilon}$, and $\sigma^C_u < \alpha^{NC}_u$.

Note that in the empirical framework, the two identified regimes do not necessarily correspond to two fixed time periods. Furthermore, hotels may or may not alternate between the two regimes. Switching from a collusive to a noncollusive regime may occur, if any, when a firm cheats or deviates from the tacit collusive path and triggers some retaliation by the other firms involved in the tacit agreement (reversion period). Identifying the exact pattern of collusive and noncollusive or retaliation periods (if any), however is beyond the scope of the study due to the nature of our data (quarterly data). Retaliation periods, for example, could last less or more than a quarter.

We focus on deriving the probability of being in the potential collusive and examining the factors that drive this probability, particularly whether being clustered. We model the mixing parameter h or probability of engaging in tacit collusion both as a constant (but allowing variations in certain regions due to unobserved market factors intrinsic to these regions) and as a function of the geographical location of a hotel relative to its nearby competitors. In the first case, $h = G(\kappa_1 + \kappa_2 R_1 + \kappa_3 R_2)$ where R_1 is a dummy variable equal to 1 if the hotel is located in Central Texas or the Metroplex (upper Central Texas), R_2 equals 1 if the hotel is located in the South or the Gulf Coast, and $G(\cdot)$ is approximated with a logistic CDF.[22] In the second case,

$$h_j = G(\kappa_1 + \kappa_2 Clustered_j + \kappa_3 Monop_j + \kappa_4 Isolated\_no\_cluster_j + \kappa_5 R_1 + \kappa_6 R_2)$$

where *Clustered* equals 1 if the hotel has at least one nearby competitor in the town in a radius of 0.2 miles, *Monop* equals 1 if the hotel is the only one operating in the town, and *Isolated_no_cluster* equals 1 for hotels with competitors in town that are all more than 0.2 miles apart from each other. The dummy variable for isolated properties with a cluster of hotels in town is the base category. The first specification assumes that the probability of tacit collusion is constant across hotels but may vary by specific regions, 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 if agglomeration facilitates collusion is equivalent to testing if $\kappa_2 > 0$.

Provided that our identification strategy of a collusive and noncollusive 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. The idea is to reduce the possibility of alternative explanations for the results obtained. 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. 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 & Saloner, 1986).[23] Finally, the prob-

[21] Gas stations serve both residents of and travelers passing through and visiting a market. As Chung and Kalnins (2001) suggested, 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.

[22] These regions are also clearly the most important in the state in terms of visitor spending (State of Texas: Economic Development and Tourism Office, http://www.governor.state.tx.us/ecodev/).

[23] 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 (during low seasons) since the forgone profits from inducing a price war are relatively low (Haltiwanger & Harrington, 1991).

ability of colluding should also increase with firm size since deviations from any tacit collusive agreement are typically more profitable for smaller than for larger firms.[24]

In the estimation of the price and occupancy rate equations specified in equations (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 the 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 Fernandez and Marin (1998) indicated, 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 is very small, as well as the number of hotels that changed their affiliations (and possibly their capacity or quality level).

V. Results

We now discuss 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 underidentification test and Wald's 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.[25] Hansen's J statistic for overidentifying restrictions also indicates that with 5% level of significance, we cannot reject the null hypothesis that these instruments are valid instruments (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^2 from 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.[26]

For clarity of exposition and comparison purposes, we first report the results from a simple one-regime model in table 6. Note that HHI is treated endogenously and the instrument is the HHI of the closest urban area to the town.[27] 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 31.5% higher prices than low-quality ones, reflecting the higher costs associated with providing additional quality. These hotels report at the same time a 12.8% higher occupancy rate. Besides, medium and large hotels charge 5.6% lower prices than small hotels and exhibit an 8.3% 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, but 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 agglomeration or spatial competition effects, although disentangling these effects is beyond the extent of this study. Agglomeration models will predict a higher price and occupancy rate among clustered hotels due to a higher matching quality and matching probability between supply and demand (travelers can better evaluate their options due to lower search costs and are more likely to find a hotel that matches or closely resembles their preferences) and due to a heightened demand (see also Helsley & Strange, 1990; Fischer & Harrington, 1996), while spatial competition models will predict a lower price and a higher occupancy rate due to a price competition effect and a market share effect (see note 18).

The controls for complementarity or substitutability across hotels in turn show mixed results. The number of nearby hotels of similar quality, which may approximate the level of substitutability between a hotel in the observation and its nearby competitors, does not affect prices but has a positive effect on occupancy rates. The variety index is negatively associated with prices, indicating that prices are lower in more heterogeneous clusters.

With respect to the market-specific variables, market concentration has a negative effect on prices and does not

[24] 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 (at around 50%). As Kalnins (2006) noted, the nationwide occupancy rate of an average hotel is roughly 60%, while the break-even occupancy (the percentage of rooms that must be sold on average for a hotel to show positive pretax income) is roughly estimated at 53%.

[25] Results are available on 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 the Cragg and Donald Wald test for weak identification to the case of non-i.i.d. errors.

[26] 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, although we lose observations for one period.

[27] We do not report the coefficient estimates for the time period dummies to save space.

TABLE 6.—SEMIPARAMETRIC 2SLS REGRESSIONS OF PRICE (ADR) AND OCCUPANCY RATE (CLUSTER RADIUS = 0.2 MILE)

	Log ADR		Log Occupancy	
	Coefficient	SE	Coefficient	SE
Constant	−0.748	0.512	−0.099	0.323
Clustered	−0.129	0.037	0.129	0.023
Monopolist	0.092	0.067	0.256	0.052
Isolated, no cluster in town	0.006	0.022	0.078	0.017
Log number of nearby hotels	0.101	0.037	−0.105	0.026
Log number of nearby competitors similar quality	−0.010	0.029	0.044	0.019
Cluster variety index	−0.029	0.015	0.000	0.013
Medium or large hotel	−0.056	0.011	−0.083	0.010
High quality	0.318	0.019	0.128	0.014
Best Western	0.045	0.018	0.209	0.014
Best Value	−0.424	0.032	−0.102	0.031
Comfort	0.177	0.019	0.213	0.018
Days	−0.114	0.019	0.064	0.017
Econolodge	−0.228	0.020	−0.138	0.024
Holiday Inn	0.263	0.019	0.318	0.015
Motel 6	−0.081	0.023	0.383	0.015
Super 8	−0.156	0.020	0.077	0.018
Ramada	−0.199	0.025	0.049	0.026
HHI	−0.206	0.091	−0.250	0.068
Log population	−0.038	0.013	−0.027	0.010
Log per capita income	0.229	0.043	−0.021	0.026
Gas stations	−0.011	0.002	0.003	0.001
Log value of land	0.138	0.015	−0.008	0.010
Log wage	0.210	0.047	−0.076	0.031
Log distance to MSA	0.128	0.017	−0.007	0.012
Log distance to closest town	0.003	0.013	0.031	0.010
Central Texas	0.172	0.034	−0.064	0.026
High Plains	0.014	0.036	−0.038	0.031
Metroplex	0.242	0.042	−0.026	0.029
Northwest Texas	−0.024	0.034	−0.020	0.028
South Texas	0.276	0.033	0.037	0.026
Southeast Texas	0.159	0.039	−0.001	0.029
Upper East Texas	0.261	0.032	−0.014	0.026
Upper Rio Grande	0.380	0.053	0.054	0.041
West Texas	0.123	0.040	−0.002	0.031
Number of observations		9,148		9,148
R^2		0.272		0.207

White robust standard errors reported, clustered on area-time period. All models include time period dummies. A hotel is considered clustered if it has a nearby competitor in town in a radius of 0.2 mile. The number of nearby hotels corresponds to the number of hotels that are within a radius of 0.2 mile from the hotel in the observation (the same for the number of nearby competitors of similar quality). The variety index is calculated based on hotel quality (one to four diamonds). Metroplex is located to the north of Central Texas. HHI is treated as endogenous.

significantly affect occupancy rates. A 1 standard deviation decrease in the HHI (0.28) results in a 5.2% increase in prices. This result might seem counterintuitive but in certain oligopolistic models, the "displacement effect" may dominate the "competitive effect" with increased competition, which will result in higher prices (Satterthwaite, 1979; Rosenthal, 1980; Sutton, 1991).[28] 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. Additionally, distance to a MSA is positively correlated with prices, while a larger distance between towns involves higher occupancy rates. 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.

We now turn to the MLE results of the switching regression model, which classifies prices and occupancy rates into two regimes. As noted above, we jointly model a price and occupancy rate equation under each regime, and the two regimes do not correspond to two fixed time periods. Hotels, then, may or may not alternate between regimes. The results are presented in table 7.[29] Regime 1 is identified as the potential collusive regime provided that hotels charge

[28] Intuitively, in oligopolistic models where sellers have both a captive and a free-entry market, an increase in the number of sellers can reduce the probability that a seller will attract more customers, decreasing their demand elasticity for the average expected customer, and increasing their price. Empirically, a similar negative relationship between concentration and prices has been found in other industries with oligopolistic competition, for example, the airline industry (Borenstein, 1989; Stavins, 2001).

[29] The coefficient estimates for the chain, regional, and time period dummies are omitted to save space (similar for tables 8 and 9 discussed below).

TABLE 7.—SWITCHING REGRESSION MODEL OF PRICE (ADR) AND OCCUPANCY RATE (CLUSTER RADIUS = 0.2 MILE)

	Model 1				Model 2				Model 3			
	Log ADR		Log Occupancy		Log ADR		Log Occupancy		Log ADR		Log Occupancy	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Regime 1												
Constant	3.182	0.268	−0.835	0.279	3.318	0.276	−0.673	0.286	3.240	0.277	−0.992	0.274
Clustered	0.073	0.030	0.100	0.029	0.074	0.028	0.091	0.029	0.063	0.025	0.083	0.028
Monopolist	0.043	0.046	0.069	0.043	0.030	0.044	0.058	0.044	0.034	0.041	0.047	0.045
Isolated, no cluster in town	0.072	0.017	0.014	0.016	0.064	0.017	0.015	0.016	0.068	0.016	0.011	0.016
Log number of nearby hotels	0.059	0.037	−0.090	0.035	0.063	0.032	−0.093	0.034	0.068	0.029	−0.087	0.031
Log nearby competitors similar quality	−0.049	0.027	0.023	0.026	−0.047	0.024	0.030	0.026	−0.069	0.022	0.022	0.024
Cluster variety index	−0.044	0.019	0.008	0.017	−0.044	0.017	0.010	0.018	−0.040	0.016	0.013	0.016
Medium or large hotel	0.028	0.013	−0.077	0.013	0.024	0.011	−0.074	0.012	0.036	0.012	−0.098	0.012
High quality	0.443	0.018	0.104	0.017	0.451	0.017	0.104	0.019	0.464	0.017	0.125	0.017
HHI	0.125	0.058	−0.076	0.057	0.143	0.055	−0.073	0.057	0.119	0.054	−0.072	0.058
Log population	−0.069	0.010	−0.011	0.010	−0.072	0.009	−0.012	0.009	−0.071	0.009	−0.011	0.009
Log per capita income	−0.042	0.027	−0.017	0.024	−0.042	0.026	−0.022	0.026	−0.029	0.025	−0.005	0.025
Gas stations	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001
Log value of land	0.060	0.011	0.007	0.011	0.061	0.011	0.004	0.011	0.066	0.012	0.009	0.011
Log wage	0.110	0.038	0.037	0.034	0.093	0.035	0.027	0.036	0.076	0.036	0.026	0.035
Log distance to MSA	0.064	0.015	−0.004	0.014	0.058	0.013	−0.009	0.014	0.071	0.014	0.015	0.014
Log distance to closest town	−0.014	0.011	0.013	0.011	−0.016	0.011	0.012	0.011	−0.030	0.011	0.017	0.011
Regime 2												
Constant	−1.644	1.304	−2.488	1.607	−2.111	1.393	−2.429	1.685	−3.576	1.331	−0.841	1.053
Clustered	−0.669	0.093	0.149	0.085	−0.680	0.104	0.071	0.095	−0.772	0.108	0.091	0.094
Monopolist	0.065	0.152	1.015	0.132	0.087	0.158	1.004	0.133	0.188	0.165	0.931	0.132
Isolated, no cluster in town	−0.119	0.042	0.265	0.038	−0.156	0.042	0.273	0.037	−0.177	0.048	0.277	0.039
Log number of nearby hotels	0.529	0.117	−0.092	0.110	0.617	0.134	−0.023	0.121	0.646	0.137	−0.033	0.119
Log nearby competitors similar quality	−0.165	0.077	0.121	0.076	−0.225	0.090	0.099	0.083	−0.100	0.091	0.117	0.082
Cluster variety index	−0.089	0.047	−0.086	0.045	−0.128	0.054	−0.114	0.052	−0.160	0.054	−0.098	0.049
Medium or large hotel	−0.267	0.032	−0.093	0.031	−0.278	0.034	−0.100	0.030	−0.144	0.039	−0.206	0.037
High quality	0.108	0.042	0.096	0.042	0.107	0.048	0.093	0.045	0.063	0.045	0.044	0.042
HHI	−0.062	0.218	−1.367	0.186	−0.048	0.226	−1.370	0.195	−0.190	0.233	−1.217	0.185
Log population	−0.027	0.020	−0.058	0.019	−0.031	0.020	−0.059	0.021	−0.048	0.020	−0.058	0.019
Log per capita income	0.503	0.104	0.237	0.110	0.489	0.108	0.244	0.096	0.638	0.105	0.145	0.090
Gas stations	−0.011	0.003	−0.007	0.003	−0.011	0.003	−0.007	0.003	−0.014	0.003	−0.005	0.003
Log value of land	0.228	0.034	0.017	0.030	0.255	0.034	0.015	0.029	0.296	0.033	−0.018	0.029
Log wage	−0.135	0.078	−0.143	0.069	−0.075	0.085	−0.144	0.068	−0.119	0.082	−0.127	0.067
Log distance to MSA	−0.016	0.049	0.041	0.040	0.003	0.049	0.040	0.041	−0.006	0.059	−0.056	0.045
Log distance to closest town	0.097	0.043	0.142	0.038	0.110	0.043	0.127	0.036	0.144	0.045	0.085	0.039
Probability of regime 1												
Constant			1.317	0.068			1.128	0.098			0.935	0.102
Clustered							0.562	0.097			0.610	0.220
Monopolist							0.342	0.121			0.463	0.130
Isolated, no cluster in town							−0.270	0.099			−0.306	0.108
Log number of nearby hotels											−0.237	0.130
High season											−0.140	0.072
Medium or large hotel											1.434	0.114
If Central Texas or Metroplex			−0.987	0.088			−0.883	0.094			−0.846	0.100
If South Texas or Gulf Coast			−0.795	0.083			−0.803	0.091			−0.905	0.100
σ_ε^1			0.231	0.004			0.230	0.003			0.228	0.003
σ_u^1			0.236	0.004			0.234	0.004			0.236	0.003
ρ^1			0.362	0.005			0.368	0.005			0.374	0.005
σ_ε^2			0.426	0.010			0.434	0.011			0.454	0.010
σ_u^2			0.437	0.007			0.435	0.008			0.437	0.007
ρ^2			0.338	0.010			0.330	0.010			0.271	0.013
Number of observations				9,148				9,148				9,148
Log likelihood				−5,344.3				−5,290.9				−5,169.3

All models include major top chain, regional, and time period dummies. The top chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday Inn, Motel 6, Super 8, and Ramada. A hotel is considered clustered if it has a nearby competitor in town in a radius of 0.2 mile. Number of nearby hotels corresponds to the number of hotels that are within a radius of 0.2 mile from the hotel in the observation (the same for the number of nearby competitors of similar quality). The variety index is calculated based on hotel quality (one to four diamonds). Metroplex is located to the north of Central Texas. HHI is treated as endogenous. Variance of correlation coefficient obtained using the delta method.

significantly higher prices than in regime 2, which also result in lower occupancy rates. This follows from the magnitude and significance of the constant terms under each regime ($\delta_1^{R1} > \delta_1^{R2}$ and $\alpha_1^{R1} < \alpha_1^{R2}$). This also implies that our empirical model is not just distinguishing between high- and low-demand seasons, since in high seasons, we expect both high prices and high occupancy rates.[30] Additionally, prices and occupancy rates also show a lower dispersion

[30] Below we show that there is a lower probability of being in regime 1 (high prices, lower occupancy rates) during high seasons—the second and third quarters of the year.

during regime 1, as inferred from the lower standard deviation of the modeled prices and occupancy rates reported at the bottom of table 7 ($\sigma_{\varepsilon}^{R1} < \alpha_{\varepsilon}^{R2}$, and $\sigma_{u}^{R1} < \alpha_{u}^{R2}$). This provides further evidence that regime 1 is a potential collusive regime.

Note that we allow for three different specifications when modeling the mixing parameter h or probability of being in the suspected tacit collusive regime. In model 1, h is modeled as a constant with regional shifts, while in model 2, we further 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 influence the sustainability of tacit collusion. Model 3 should be regarded, then, as the most complete model in the sense that we further account for number of nearby competitors, seasonality, and firm size, all of which are generally considered to affect the sustainability of a tacit agreement (if any). Examining the direction of the effect of these variables will help us to determine if there is any potential misspecification error in our identification strategy, although it does not rule it out.

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 we allow 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.[31] For example, quality type has a higher positive impact during the suspected collusive regime. In model 3, during the tacit collusive period, high-quality hotels charge almost 47% higher prices than low-quality hotels and report a 12.6% higher occupancy rate; during the noncollusive period, the price and occupancy rate difference between high- and low-quality hotels is not significantly different. Similarly, clustered hotels seem to charge lower prices than isolated properties with a cluster in town only during the noncollusive regime (60.2% lower prices), while during the suspected tacit collusive regime, they charge slightly higher prices (5.8% higher prices). In terms of occupancy rates, clustered hotels report a higher occupancy rate than the isolated properties in the town during both regimes, but the difference is much higher during noncollusive regimes. Besides, market concentration has only a negative effect on prices during the noncollusive regime and is not statistically significant; during the potential collusive regime, a 1 standard deviation increase in the HHI results in a 3.8% increase in prices. Although further examining the impact of different control variables on hotels' prices and occupancy rates is not the main objective of the paper, these results reflect the importance of allowing for different regimes when analyzing marginal effects of firm- and market-specific characteristics on hotels' competitive behavior.

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 70.9%.[32] Note that the probability of engaging in tacit collusion is lower for properties located in both Central Texas and the Metroplex (upper Central Texas) and South Texas and the Gulf Coast, areas with a more developed lodging industry than other rural regions in the state. When we further 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 of engaging in tacit collusion than isolated properties in the town (base group). In particular, hotels with nearby competitors in a radius of 0.2 mile have a 10 percentage point higher probability of being in regime 1 than isolated properties (78% versus 68%). Monopolists, whose behavior should resemble perfect collusion, are also more likely to be in the potential collusive regime than isolated properties with a cluster in town, and isolated hotels without a cluster in town show a lower probability.

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 in town have a lower probability (model 3). Clustered hotels exhibit a 70% probability of being in the collusive regime, other things constant, while isolated hotels with a cluster in town only show a 63% probability. Monopolists have a 73% probability of being in regime 1, while isolated hotels without a cluster in town show a 55% probability. At the sample means, then, monopolists are the most likely to be in the potential collusive regime; however, when converting the estimated probabilities for each hotel in our sample to binary regime predictions, using the standard 0.5 rule, we find that all monopolists are predicted to follow the potential collusive regime, in contrast to the other types of hotels. So regardless of the flexibility of our model, where hotels are allowed to follow two regimes, all monopolistic hotels in our sample are always predicted to be in the collusive regime (as expected), which provides further evidence in favor of our identification strategy.

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 & Saloner, 1986); and increases with hotel size provided that deviations from a collusive agreement are less profitable for large firms.[33]

[31] We allow for different coefficients of the control variables under each regime in order to have a more flexible model.

[32] From the regression, $h = \exp(1.321 - 0.976\bar{R}_1 - 0.792\bar{R}_2)/(1 + \exp(1.321 - 0.976\bar{R}_1 - 0.792\bar{R}_2)) = 70.9\%$.

[33] The fact that small firms are less likely to be in the potential collusive regime also suggests that they are not necessarily following the behavior of large firms, which reduces the possibility of umbrella pricing. The same reasoning applies when analyzing the behavior of isolated properties relative to clustered hotels in the same town: isolated hotels (the outside firms) have a lower probability of being in the collusive regime relative to clustered hotels (the potential colluding firms).

FIGURE 3.—PROBABILITY OF COLLUDING, CONDITIONAL ON BEING CLUSTERED (CLUSTER RADIUS = 0.2 MILE)

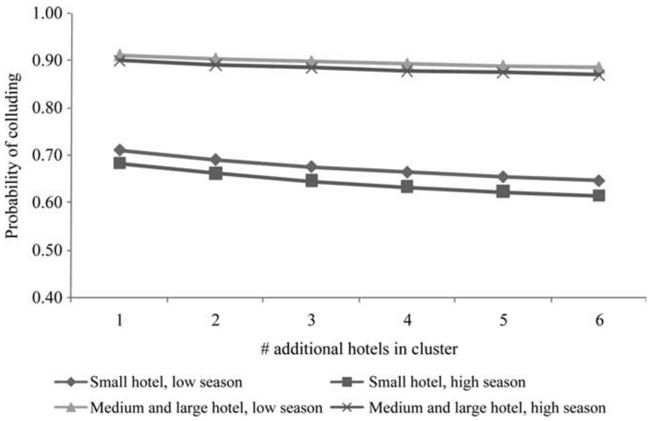
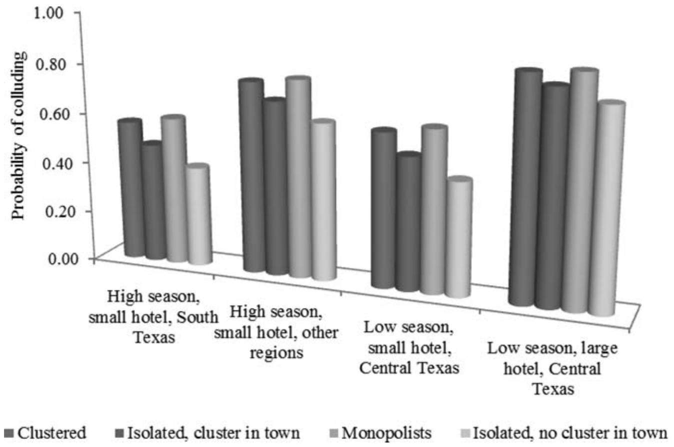


FIGURE 4.—AVERAGE PROBABILITY OF COLLUDING FOR DIFFERENT HOTEL TYPES UNDER ALTERNATIVE SCENARIOS (CLUSTER RADIUS = 0.2 MILE)



A hotel is considered clustered if it has at least one competitor in a radius of 0.2 mile. An isolated property with a cluster in town is a hotel with competitors in town that are more than 0.2 mile from the hotel, but where at least two of these competitors are within 0.2 mile from each other. A monopolist is a hotel without any competitors in town, while an isolated property with no cluster in town is a hotel with competitors in town that are all more than 0.2 mile from each other.

Figure 3 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. Figure 4 further plots, at the sample means, the estimated probabilities of the different hotel types under alternative scenarios based on hotel size, seasonality, and geographic location to show that monopolistic and clustered hotels always exhibit a higher probability of being in the potential collusive regime.

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, whose behavior should resemble perfect collusion, are always predicted to fall in the tacit 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 8 where regime 1 is again the potential collusive regime with higher prices, lower occupancy rates, and a lower dispersion in both market outcomes, relative to regime 2, as inferred from the constant terms and the estimated standard deviations of the price and occupancy rate equations. 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 mile (model 3 in table 7).

If we either restrict the cluster radius to 0.1 mile or expand the cluster radius to 0.5 mile, we still observe that clustered hotels have a higher probability of engaging in tacit collusion than isolated properties with a cluster in town. In the case of a cluster radius of 0.1 mile, holding all else constant, clustered hotels have a 73% probability of being in the potential collusive regime versus 62% for isolated properties with a cluster in town; in the case of a cluster radius of 0.5 mile, the probabilities are 69% versus 51%, respectively.[34] Monopolists also exhibit the highest probability of being in the collusive regime at the sample means and are always predicted to fall in the potential collusive regime when converting the estimated probabilities to binary regime predictions. Additionally, the likelihood of being in the identified collusive regime is negatively correlated with cluster size and high-demand seasons and positively correlated with firm size. Figure 5, for example, shows that the probability of tacitly colluding, conditional on being clustered, is decreasing in cluster size for the different cluster definitions.[35]

We also sought to account for lagged decision variables when modeling the probability of being in the potential collusive, considering that past decisions, such as deviations from a tacit agreement (if any), may affect the likelihood of colluding in the next period.[36] In particular, we include two indicators of whether prices and occupancy rates in the previous period are higher than the hotel's sample-wide averages. The estimation results using this alternative speci-

[34] On average, the probability for a clustered hotel to engage in tacit collusion decreases as we increase the cluster radius: 73% in a cluster radius of 0.1 mile, 70% in a radius of 0.2 mile, and 69% in a radius of 0.5 mile. According to the tacit collusion theory, the likelihood of engaging in a collusive agreement decreases with higher monitor costs. This finding supports to some extent the hypothesis that monitoring costs are lower for clustered hotels (particularly among those located sufficiently close to one another) than for hotels located farther apart.

[35] We also performed an additional robustness test by excluding all monopoly markets, which roughly represent one-third of the markets in our sample. We still identify two regimes and find that clustered hotels show a higher probability of being in the suspected collusive regime, relative to the other groups of hotels. In particular, the probability of clustered hotels to engage in tacit collusion at the sample means is equal to 68% versus 60% of isolated hotels with a cluster in town and 54% of isolated hotels without a cluster in town. The other factors considered to affect the sustainability of a tacit agreement (cluster size, seasonality, and firm size) also have the expected signs. The estimation results are available on request.

[36] We thank one of the referees for this suggestion.

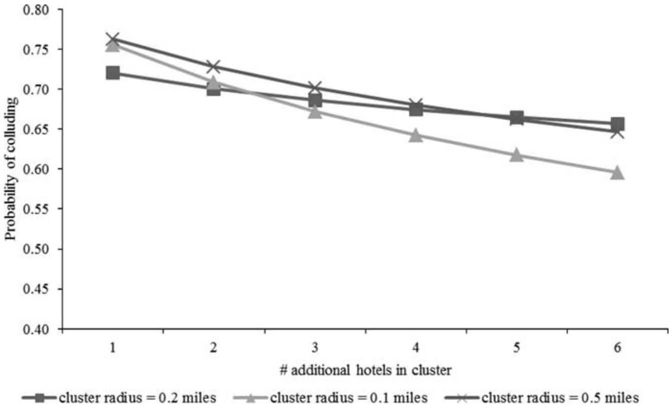
TABLE 8.—SWITCHING REGRESSION MODEL OF PRICE (ADR) AND OCCUPANCY RATE, ALTERNATIVE CLUSTER DEFINITIONS: MODEL 3

	Cluster Radius = 0.1 Mile				Cluster Radius = 0.5 Mile			
	Log ADR		Log Occupancy		Log ADR		Log Occupancy	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Regime 1								
Constant	3.562	0.275	−0.915	0.275	2.991	0.282	−1.053	0.287
Clustered	0.079	0.036	0.138	0.038	0.064	0.027	0.016	0.026
Monopolist	−0.018	0.040	−0.008	0.043	−0.109	0.055	0.042	0.060
Isolated, no cluster in town	0.043	0.015	−0.014	0.015	−0.013	0.024	0.001	0.024
Log number of nearby hotels	0.004	0.048	−0.147	0.052	−0.049	0.027	−0.037	0.023
Log nearby competitors similar quality	0.025	0.035	0.072	0.036	−0.001	0.020	−0.024	0.017
Cluster variety index	−0.025	0.017	0.011	0.017	0.041	0.015	0.019	0.014
Medium or large hotel	0.030	0.012	−0.102	0.012	0.037	0.013	−0.091	0.012
High quality	0.460	0.016	0.124	0.016	0.455	0.019	0.125	0.016
HHI	0.158	0.052	−0.007	0.055	0.245	0.073	−0.087	0.080
Log population	−0.072	0.009	−0.009	0.009	−0.064	0.011	−0.019	0.010
Log per capita income	−0.048	0.024	0.001	0.025	−0.012	0.028	0.007	0.025
Gas stations	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Log value of land	0.063	0.010	0.011	0.010	0.065	0.012	0.016	0.011
Log wage	0.055	0.031	0.004	0.033	0.067	0.038	0.028	0.032
Log distance to MSA	0.067	0.013	0.004	0.013	0.067	0.016	0.008	0.014
Log distance to closest town	−0.026	0.011	0.014	0.011	−0.025	0.013	0.018	0.012
Regime 2								
Constant	−4.712	0.983	−0.980	1.175	−3.725	1.151	−0.827	1.096
Clustered	−0.678	0.170	0.095	0.160	−0.049	0.085	0.174	0.073
Monopolist	0.237	0.156	0.845	0.139	0.190	0.204	1.343	0.164
Isolated, no cluster in town	−0.257	0.047	0.257	0.042	−0.149	0.066	0.466	0.055
Log number of nearby hotels	0.439	0.227	−0.117	0.214	−0.190	0.085	−0.096	0.077
Log nearby competitors similar quality	−0.109	0.145	0.332	0.143	0.430	0.069	0.063	0.058
Cluster variety index	−0.132	0.072	−0.077	0.070	−0.095	0.047	−0.086	0.040
Medium or large hotel	−0.119	0.044	−0.196	0.040	−0.167	0.042	−0.215	0.041
High quality	0.068	0.047	0.023	0.043	0.233	0.056	0.070	0.047
HHI	−0.345	0.224	−1.098	0.198	−0.096	0.279	−1.813	0.231
Log population	−0.057	0.021	−0.053	0.021	−0.038	0.024	−0.033	0.022
Log per capita income	0.693	0.089	0.149	0.100	0.551	0.101	0.124	0.097
Gas stations	−0.016	0.003	−0.004	0.003	−0.011	0.003	−0.009	0.003
Log value of land	0.288	0.035	−0.020	0.031	0.300	0.037	0.001	0.030
Log wage	−0.008	0.074	−0.113	0.073	−0.129	0.079	−0.117	0.065
Log distance to MSA	0.040	0.062	−0.063	0.052	0.171	0.057	−0.074	0.043
Log distance to closest town	0.159	0.037	0.072	0.040	0.113	0.041	0.094	0.036
Probability of regime 1								
Constant			0.962	0.091			0.489	0.106
Clustered			1.060	0.377			1.462	0.176
Monopolist			0.476	0.126			0.818	0.140
Isolated, no cluster in town			−0.227	0.109			−0.213	0.135
Log number of nearby hotels			−0.592	0.348			−0.449	0.101
High season			−0.155	0.072			−0.119	0.077
Medium or large hotel			1.438	0.117			1.463	0.114
If Central Texas or Metroplex			−0.882	0.095			−0.814	0.103
If South Texas or Gulf Coast			−1.045	0.102			−1.064	0.106
σ_ε^1			0.228	0.003			0.228	0.004
σ_u^1			0.236	0.004			0.234	0.003
ρ^1			0.372	0.006			0.387	0.006
σ_ε^2			0.454	0.012			0.463	0.010
σ_u^2			0.437	0.009			0.436	0.007
ρ^2			0.253	0.014			0.202	0.014
Number of observations				9,148				9,148
Log likelihood				−5,154.1				−5,102.5

All models include major top chain, regional, and time period dummies. The top chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday Inn, Motel 6, Super 8, and Ramada. A hotel is considered clustered if it has a nearby competitor in town in a radius of 0.1 (0.5) mile. The number of nearby hotels corresponds to the number of hotels that are within a radius of 0.1 (0.5) mile from the hotel in the observation (the same for the number of nearby competitors of similar quality). The variety index is calculated based on hotel quality (one to four diamonds). Metroplex is located to the north of Central Texas. HHI is treated as endogenous. The variance of correlation coefficient is obtained using the delta method.

fication are presented in table 9. Note that the inclusion of these additional regressors does not materially affect our main results (see table 7, model 3). Clustered hotels show a higher probability of being in the potential collusive regime (similar to monopolists), and the factors considered to affect the sustainability of tacit collusion (cluster size, seasonality, and firm size) all have the expected signs. The signs of the lagged indicators, however, are not consistent with the fact that potential deviations from a collusive agreement in the previous period (a price lower than the average and a higher occupancy rate) will affect the likelihood of maintaining the agreement in the current period. As noted above, the nature of our data (quarterly data) might be limiting our capability of effectively capturing or

FIGURE 5.—PROBABILITY OF COLLUDING, CONDITIONAL ON BEING CLUSTERED, BY CLUSTER DEFINITION



Probabilities based on a small hotel and low season.

accounting for retaliation periods, which may last only days, weeks, or months. These lagged variables could be capturing lagged seasonal effects.

VI. Conclusion

This paper has empirically examined if agglomeration facilitates tacit collusion in the lodging industry using a quarterly data set 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 identify a collusive and noncollusive regime. Hotels in our sample may follow a particular regime or alternate between regimes across time. In the potential collusive regime, hotels are expected to charge higher prices and exhibit lower occupancy rates than in the noncollusive regime, and both prices and occupancy rates are expected to show a lower dispersion. We focus on analyzing whether 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 nearby competitors in a radius of 0.2 mile are about 10 percentage points more likely to be 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 tacit collusion like cluster size, seasonality, and firm size, and the results are robust to alternative cluster definitions. Furthermore, monopolists, whose behavior should resemble perfect collusion, are always predicted to fall in the potential collusive regime when deriving binary regime predictions using the standard 0.5 rule.

These findings support the hypothesis that agglomeration may facilitate tacit collusion among clustered hotels (if any) by providing additional opportunities for frequent

TABLE 9.—SWITCHING REGRESSION MODEL OF PRICE (ADR) AND OCCUPANCY RATE, ALTERNATIVE SPECIFICATION, FOR MODEL 3 (CLUSTER RADIUS = 0.2 MILE)

	Log ADR		Log Occupancy	
	Coefficient	SE	Coefficient	SE
Regime 1				
Constant	1.632	0.477	−0.950	0.464
Clustered	0.068	0.035	0.083	0.027
Monopolist	0.014	0.058	0.021	0.049
Isolated, no cluster in town	0.065	0.020	0.007	0.018
Log number of nearby hotels	0.069	0.040	−0.089	0.030
Log nearby competitors similar quality	−0.064	0.028	0.030	0.022
Cluster variety index	−0.045	0.019	0.014	0.018
Medium or large hotel	0.033	0.013	−0.094	0.012
High quality	0.472	0.021	0.122	0.016
HHI	0.142	0.076	−0.043	0.064
Log population	−0.074	0.010	−0.012	0.009
Log per capita income	−0.033	0.031	0.005	0.027
Gas stations	0.002	0.001	0.001	0.001
Log value of land	0.065	0.014	0.007	0.012
Log wage	0.070	0.039	0.038	0.031
Log distance to MSA	0.068	0.017	0.011	0.014
Log distance to closest town	−0.030	0.013	0.017	0.011
Regime 2				
Constant	−2.972	1.254	−0.575	1.044
Clustered	−0.777	0.112	0.072	0.095
Monopolist	0.286	0.187	0.895	0.139
Isolated, no cluster in town	−0.160	0.054	0.268	0.042
Log number of nearby hotels	0.666	0.143	0.006	0.122
Log nearby competitors similar quality	−0.116	0.100	0.092	0.084
Cluster variety index	−0.172	0.058	−0.111	0.051
Medium or large hotel	−0.153	0.048	−0.192	0.042
High quality	0.074	0.053	0.045	0.045
HHI	−0.325	0.258	−1.169	0.201
Log population	−0.042	0.026	−0.054	0.020
Log per capita income	0.634	0.105	0.148	0.094
Gas stations	−0.015	0.003	−0.005	0.003
Log value of land	0.295	0.038	−0.009	0.031
Log wage	−0.059	0.089	−0.135	0.070
Log distance to MSA	0.004	0.061	−0.059	0.047
Log distance to closest town	0.133	0.048	0.052	0.041
Probability of Regime 1				
Constant			0.868	0.127
Clustered			0.479	0.247
Monopolist			0.470	0.163
Isolated, no cluster in town			−0.328	0.130
Log number of nearby hotels			−0.144	0.195
High season			−0.090	0.056
Medium or large hotel			1.375	0.120
If Central Texas or Metroplex			−0.843	0.113
If South Texas or Gulf Coast			−0.892	0.115
If lagged price > average			−0.377	0.091
If lagged occupancy > average			0.303	0.086
σ_ε^1			0.225	0.004
σ_u^1			0.226	0.004
ρ^1			0.377	0.006
σ_ε^2			0.466	0.011
σ_u^2			0.426	0.008
ρ^2			0.269	0.014
Number of observations				8,303
Log likelihood				−4,501.6

All models include major top chain, regional, and time period dummies. The top chains are Best Western, Best Value, Comfort, Days, Econolodge, Holiday Inn, Motel 6, Super 8, and Ramada. A hotel is considered clustered if it has a nearby competitor in town in a radius of 0.2 mile. Number of nearby hotels corresponds to the number of hotels that are within a radius of 0.2 mile from the hotel in the observation (the same for the number of nearby competitors of similar quality). The variety index is calculated based on hotel quality (one to four diamonds). Metroplex is located to the north of Central Texas. HHI is treated as endogenous. Variance of correlation coefficient obtained using the delta method. The reduction in the number of observations results from the addition of the lagged variables when modeling the probability of being in regime 1.

interaction and exchange of information among hotel managers and by reducing monitoring costs and increasing market transparency. We recognize that 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 data set (quarterly data) also prevents us from identifying the exact pattern of collusive and noncollusive or retaliation periods that hotels follow. It further limits the possibility of 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 and 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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