Land Use Regulation as a Barrier to Entry: Evidence from the Texas Lodging Industry

Junichi Suzuki*

University of Toronto

January 23, 2013

Abstract

This paper examines the anticompetitive effects of land use regulation using microdata on mid-scale chain hotels in Texas. I construct a dynamic entry-exit model that endogenizes hotel chains' reactions to land use regulation. My estimates indicate that imposing stringent regulation increases costs considerably. Hotel chains nonetheless enter highly regulated markets even if entry probabilities are lower, anticipating fewer rivals and hence greater market power. Consumers incur the costs of regulation indirectly in the form of higher prices. (JEL: R3, L1, L5)

*Department of Economics, University of Toronto. Address: 150 St. George Street Toronto ON, M5S 3G7 Canada. Email: j.suzuki@utoronto.ca. This manuscript is based on the second chapter of my 2009 University of Minnesota Ph.D. dissertation. I am grateful to my advisors, Pat Bajari and Tom Holmes for their patience and advice. I also wish to thank Victor Aguirregabiria, Martin Burda, Gilles Duranton, Kyoo Il Kim, Rob McMillan, Ichiro Obara, Minjung Park, Amil Petrin and Bob Town for helpful discussions and Yoshifumi Konishi, Julia Thornton Snider and Michael Walrath for giving me detailed comments. This work was made possible by the facilities of the Shared Hierarchical Academic Research Computing Network (SHARCNET: www.sharcnet.ca). The author would like to acknowledge the Connaught Fund for supporting this research. All remaining errors are my own.

1 Introduction

In many countries, zoning is the primary means by which local governments regulate private land use within their boundaries. Zoning governs land use in a host of different ways that include prohibiting commercial activity in certain areas, limiting the height of buildings, specifying minimum lot sizes, requiring the presence of private parking and specifying the type of materials for building exterior. The main rationale for such local government intervention is to prevent problems due to market failure. For example, restricting the size of commercial signs may be a sound policy in order to deliver the public good of uncluttered streets. Yet, zoning may also have undesirable consequences.

One possible negative side effect of land use regulations concerns their impact on local competition by increasing costs of local businesses and hence discouraging entry. For instance, some regulations require local businesses to use expensive materials such as brick for the exterior of their buildings, or to deviate from a prototype building design. Although business owners can request re-zoning or special exceptions, these requests need to go through processes that could involve city administration or politics, often giving rise to considerable additional expense.

Such anticompetitive effects of land use regulation have been at the heart of several law suits and are therefore well-known among legal scholars.[1] However, these effects have attracted little attention from economists and their quantitative importance is not well-understood. The goal of this paper is to fill this gap by assessing the cost impacts of land use regulation and its consequences for the intensity of local competition.

Anticompetitive effects of land use regulation are relevant to various industries in which firms compete locally, retail industries such as supermarkets, gas stations and hotels being typical examples. Furthermore, some manufacturing industries that produce time-sensitive materials such as concrete also belong to this category. Among these industries, this paper

[1] Legal scholars have debated as to whether municipalities are immune from antitrust liability arising from their local ordinances. See Sullivan (2000) for a summary of these arguments and a discussion of several influential cases.

focuses on the hotel lodging industry in Texas.

Several facts draw attention to the anticompetitive effects of land use regulation in the lodging industry. First, land use regulation appears to be among the major determinants of cost structure, and hence it plays a part in the entry decisions of hotels. This industry is capital-intensive[2] and its primary capital input is undoubtedly buildings. Therefore, it is natural to expect that regulations on buildings should have a significant cost impact. Second, competition in this industry is fairly local. Because of the nature of their product, hotels must locate at the place of consumption; they cannot sell their product without first having a physical location inside a market. As a result, competitors are limited to other hotels in the neighborhood and entry decisions of local rivals are among the primary determinants of their market power. Third, it appears that people in the lodging industry realize that local land use regulation can act as an entry barrier for their competitors. This is indicated by the following quote from a hotel developer:

> There's a short answer to why certain hotel developers choose projects encumbered with difficult zoning or environmental challenges. It's because once those hurdles are cleared, they're often left with a hotel with desirable barriers to entry. [Dela Cruz (2003)]

One of the major obstacles facing empirical studies of land use regulation includes measuring the stringency of such regulations. Complicated rules and discretion in the actual implementation of these regulations indicate that no single index provides a definitive measure of the stringency of land use regulation. Acknowledging this difficulty, I employ various measures based on the written survey collected and summarized by Gyourko et al. (2008). Some of these measures are based on institutional features (e.g., the presence of particular regulations) while some other measures are based on the results of actual implementation (e.g., the average time length to obtain a building permit). Realizing that the focus of these

[2] According to an example shown in Powers (), the capital cost of a typical 120-room hotel accounts for about 20 percent of its total expenditure. This ratio is about twice as much as that of a suburban restaurant.

indices is residential land use regulation, I check the robustness of my estimation results by using different sets of indices, including one that has a more direct relationship with commercial land use regulation.

Descriptive analyses indicate that markets under stringent land use regulation tend to have fewer hotels. However, these regressions do not distinguish the cost impact of land use regulation from its impact on demand. The impact of stringent land use regulation on travel demand is ambiguous: it may attract more leisure travelers by preserving some scenic views, while it may decrease business travelers by discouraging the construction of commercial buildings. Thus, the observed negative correlation in descriptive analyses may overestimate or underestimate the actual cost impact of land use regulation. To avoid this drawback, I pursue a structural estimation approach.

Specifically, I construct a dynamic entry-exit model of hotel chains. A dynamic model seems a reasonable framework to describe local market structure of the lodging industry as opening a new hotel requires considerable investment up front, and hotel chains seem to take into account future market growth when making entry decisions. In the model, hotel chains maximize their expected profits by choosing the number of hotels to open or close in a local market every period. The revenue of a mid-scale chain hotel is allowed to depend on market characteristics, chain characteristics and the number of other hotels present in the same market. Since a new hotel cannibalizes the revenue of other hotels in the same chain, the marginal revenue of opening an additional hotel monotonically decreases. Hotel chains incur entry costs when they open a new hotel and exit costs when they close an existing hotel, while they need to pay operating costs in every period until the hotel closes down. I assume that each hotel chain's entry cost and exit cost are stochastic and the actual sizes of these shocks are observable to that chain only. Therefore, each hotel chain's decision is based on its belief about its competitors' decisions. In a Markov perfect equilibrium, its belief must be consistent with the actual decisions of its rival chains.

Estimation of this model proceeds in three stages. I first estimate the parameters of a hotel-level revenue function. Exploiting the longitudinal structure of the dataset, I identify market-specific revenue shifters that may be attributable to both observable and unobservable time-invariant factors. Taking the revenue function estimates as given, I next recover structural cost parameters by finding a set of parameters that rationalizes both the revenue function estimates and the observed entry-exit decisions over time. These cost parameters are chain-market specific. To take into account the interacting decisions of competing hotel chains while mitigating the computational burden, I employ the estimation method developed by Bajari et al. (2007). Finally, I regress the recovered cost parameter estimates on land use regulation indices along with other control variables.

Three key results emerge, consistent with the hypothesis that stringent land use regulation lessens the intensity of competition by increasing the costs. First, an increase in the stringency of land use regulation by one standard deviation increases operating costs and entry costs by 8 percent and 6 percent, respectively. Second, these cost increases discourage entry, decreasing the equilibrium number of hotels by 0.5 in the typical medium sized market. Third, as a consequence of lessened competition, revenue per room, a good proxy for price, increases by 4 percent.

This paper is the first, to the best of my knowledge, to recover the cost impacts of land use regulation on local business markets. Most economic studies of land use regulation have focused on its impacts on housing and land markets.[3] Few studies have looked at its cost impacts on business.[4]

[3]For example, see McMillen and McDonald (1991b) for land price, Wu and Cho (2007) and Saiz (2010) for land development, McConnell et al. (2006) for density and Glaeser et al. (2005), Glaeser and Ward (2009) and Quigley and Raphael (2005) for housing markets. For a recent survey of empirical studies in this area, see Evans () and Quigley (). *Regional Science and Urban Economics* published a special issue featuring studies of land use regulation. For a summary of these papers, see Cheshire and Sheppard (2004).

[4]One exception is Nishida (2012). In his study on competition between two convenience store chains in Japan, he includes a dummy variable for zoning as a cost factor by presuming it does not affect demand side. He did not find statistically significant cost impacts of zoning. Using French data, Bertrand and Kramarz (2002) examines the effects of zoning on retail employment by reduced form regressions. They use the approval rate of zoning boards as the measure for the stringency of regulation. Election results are used as instruments for the approval rates. Ridley et al. () and OECD () also study the impacts of land use regulation on businesses from different perspective. Ridley et al. () studies to what extent the fraction of zoned area affects the intensity of local competition by forcing firms to locate close to each other. OECD (), which coincidentally has a title similar to this paper, documents several channels through which land use

In relation to the literature on empirical industrial organization, this paper belongs to the literature on firms' entry decisions that originated in papers by Bresnahan and Reiss (1990) and Berry (1992).[5] Among others, this paper is most closely related to Ryan (2012). In his paper, Ryan estimates a dynamic entry-exit model of cement plants and evaluates the welfare consequences of a change in environmental regulation in the Portland cement industry. While Ryan relies on the intertemporal difference in industrial structure for identification, this paper exploits cross-market differences in land use regulation.

The rest of the paper proceeds as follows: Section 2 summarizes the data used in the empirical analysis, and Section 3 presents the results of the descriptive regressions. Section 4 describes the empirical model used for structural estimation. Section 5 explains the estimation method, and Section 6 presents the estimation results. Section 7 sets out the results of counterfactual experiments, and Section 8 discusses the relevance of my empirical model. Section 9 concludes.

2 Data

2.1 Texas Hotel Data

The main data source of this study, *Hotel Occupancy Tax Receipts,* is provided by the Texas Comptroller of Public Accounts.[6] This quarterly data set provides the sale of every single hotel in Texas, as well as other hotel-specific information, including names, street addresses and numbers of rooms. In addition, I recover each hotel's brand affiliation, if any, by looking for particular brand names (e.g., Best Western).[7] The sample period of this data set is from the first quarter of 1990 through the last quarter of 2005. A notable advantage of this data

regulation affects competition and gives several examples taken from OECD member countries.

[5] See Berry and Reiss () for a recent survey in this area.

[6] Other studies using this dataset include Chung and Kalnins (2001), Kalnins (2004) and Conlin and Kadiyali (2006).

[7] To increase the accuracy of this process, I rely on other sources, such as *AAA Tourbook*, *Directory of Hotel & Lodging Companies* and various hotel directories provided by the hotel chains themselves.

set is the reliability of its sales data. The original purpose of this data set was to determine the amount of the hotel occupancy tax to be collected by hotel owners and passed on to the state government. Because of this purpose, misreporting is unlawful and can be considered tax evasion.

2.2 Measurement of Land Use Regulation

This study employs the indices developed by Gyourko et al. (2008) to measure the stringency of land use regulation. Based on a written survey collected from 2,649 local governments in the U.S., Gyourko and his coauthors construct eleven subindices that measure the stringency of residential land use regulation from various angles as well as one aggregate index (The Wharton Residential Land Use Regulatory Index, henceforth (WRLURI)) that is based on these subindices. This paper uses the aggregate index and the eight subindices that exhibit variation within Texas.[8] Table 1 shows the list of the eight subindices and provides a brief description of each index. (See Gyourko et al. (2008) for the precise definitions of these subindices.)

One concern with using these indices in my application relates to the possible discrepancy between residential and commercial land use regulation. When these two types of regulation are different in their relative stringency across markets, estimates based on residential land use regulation indices might bias my empirical results. Ideally, I would want to use a set of indices that directly measures the stringency of commercial land use regulation only. However, to the best of my knowledge, such data do not exist. As the best feasible option, this paper instead makes use of the residential land use regulation indices and checks the robustness of the results in the following two ways.

The first robustness check is to use only the subindices that have a direct relationship with commercial and residential land use regulation. Among the eight subindices shown

[8] The subindices that do not have variation within Texas include (1) a measure of state level political pressure, (2) a measure of the influence of state court and (3) the involvement of the local assembly in the implementation of land use regulation.

Table 1: Description of Land Use Regulation Indices

Name	Description
Approval Delay	The average number of months for which developers need to wait to obtain building permits before starting construction.
Density Restrictions	Indicator whether local governments have minimum lot size requirements of one acre or more.
Exactions	Indicator whether developers have to incur the cost of additional infrastructure attributable to their developments.
Open Space	Indicator whether developers have to provide open space for the public.
Political Pressure	Summarizes subjective impressions of the influence of various political groups (council, pressure groups, citizens).
Project Approval	The number of local government bodies from which projects that request no zoning change need to obtain approvals.
Supply Restrictions	Represent the degree of restrictions that limit the number of new buildings
Zoning Approval	The number of local government bodies from which projects that request zoning change need to obtain approvals.

Notes: See Gyourko et al. (2008) for the construction of these indices.

above, Project Approval and Zoning Approval meet this criterion. My inquiry into several municipality websites indicates that the administrative process to request rezoning or reviewing a new project, which is the focus of these subindices, does not depend on the type of building involved in this project.

My second robustness check includes constructing new indices based on regulation relevant to multifamily housing using the raw survey data posted on Gyourko's website. The procedure used to make these new indices is almost the same as what Gyourko and his coauthor employed to construct the original indices except for the treatment of regulation data that are relevant to either single family housing or multifamily housing but not both.[9] Here, the underlying assumption is that relative stringency of land use regulation for multifamily housing (e.g., apartments) across markets is the same as that for commercial buildings including hotels. This assumption reflects the fact that municipalities often impose the same requirements on multifamily housing and commercial building while they impose different requirements on single-family housing. Based on this idea, I construct the three subindices that correspond to Political Pressure, Approval Delay and Supply Restrictions, respectively. I am unable to construct similar indices for the rest of the five subindices because all the information used to construct these indices is relevant to both single family housing and multifamily housing. See the Appendix for the sources of other data.

2.3 Market Definition

This study focuses on local competition between mid-scale chain hotels. To determine mid-scale brands, I follow a scale constructed by Smith Travel Research, an independent consulting firm specializing in the lodging industry. Among the hotel chains owning these mid-scale brands, I consider the six major chains. Table 2 lists the names of these hotel chains and their mid-scale brands in my sample as of the first quarter of 2005. These six chains account

[9] When a subindex is based on regulation for both single-family and multifamily housing, the original procedure constructs this subindex by putting equal weights to regulation for each type of housing. In contrast, my procedure puts all the weight on regulation for multifamily housing.

Table 2: Midscale Chain Hotels in Texas

Companies	Brands
Best Western	Best Western
Cendant	Amerihost, Howard Johnson, Ramada
Choice Hotels	Clarion, Comfort Inn, Quality Inn, Sleep Inn
Hilton Hotels	Hampton Inn
InterContinental	Candlewood, Holiday Inn, Holiday Inn Express
La Quinta	Baymont Inn, La Quinta Inn

Notes: The number of hotels listed is as of the first quarter of 2005.

for about 90 percent of the number of mid-scale chain hotels in Texas.

This narrowed focus is beneficial since it makes my empirical analysis considerably tidier without losing the essential aspects of local lodging markets. First, as indicated by Mazzeo (2002), the lodging market is highly segmented by service grades, and competition is stronger within segments rather than between segments. Second, among the three segments of hotels (economy, mid-scale and upscale), the mid-scale segment is the largest category in terms of both the number of hotels and the number of rooms.

The third reason for focusing on mid-scale chain hotels is that chain hotels have been the primary players in this category.[10][11] Independent hotels are generally considered to be in the economy segment, and because services of the economy segment are different from those of the mid-scale segment, their presence should be of limited importance for the business of mid-scale hotels.

I consider a county as a single local market since more data is available at the county level. In addition, county shape is relatively uniform in Texas and borders have been fixed

[10] In 2005, in Texas, chain hotels account for 37 percent of the total number of hotels, 63 percent of the total rooms and 75 percent of total sales. The apparently high ratio of non-chain properties is unlikely to be problematic for my analysis as these non-chain properties consist of independent hotels and various businesses that are not conventionally considered hotels. Texas statutes (Tax Code, Chapter 156.001) define a hotel as "a building in which members of the public obtain sleeping accommodations for consideration". Ranches, cabins and campgrounds all satisfy this definition. Although I remove properties that are obviously not hotels from my sample, there are a significant number of properties whose actual categories are unclear.

[11] As most hotel chains are franchisers, in reality, entry decisions are a joint decision of franchisers and franchisees, while pricing decisions are made by franchisees. In the U.S., it is illegal that franchisers set the price. This paper abstracts this franchising process by considering entry/exit decisions as a hotel chain's problem. This is the same to assume the inelastic supply of potential franchisees.

for a long time. My sample consists of counties that survive after applying the following four filters: (1) counties must provide land use regulation indices, (2) counties must not be the flagship counties of the four largest MSAs,[12] (3) counties must have a population of more than fifty thousand in 2005 and (4) counties must have undergone at least four opens/closures of the mid-scale chain hotels during the sample period. Among the 254 counties in Texas, my sample consists of 35 counties. The first criterion simply excludes markets with no regulation information. The second criterion is adopted as these flagship counties have so many hotels that it is hard to believe that each of them serves as a single market. The third criterion is to eliminate small markets as these markets are more likely to undergo very few turnovers, the source of identification of my structural model. The last criterion serves to eliminate the rest of the markets whose turnover is too limited to identify structural parameters. I adopt the third criterion to minimize the number of markets removed due to the number of turnovers themselves (i.e., the fourth criterion) as this last criterion generates a concern about endogenous selection. The first three criteria leave 39 counties and the last criterion is used to eliminate another four counties from the sample. Figure 1 shows the geographical distribution of these 35 counties.

2.4 Summary Statistics

Table 3 reports summary statistics of variables that describe the 35 markets in my sample. The median market has seven mid-scale chain hotels or a total of 619 rooms, and earns about more than three million dollars per quarter. Table 3 also shows considerable variation between the markets in my sample. In terms of population, the market at the sample third quartile is more than three times larger than that of the market at the sample first quartile. About 80 percent of the markets in this sample have access to an interstate highway and more than one-third of them have access to commercial airports. For all the land use regulation indices, large values imply stringent regulation. The indices that are not binary variables

[12]These four counties are Bexar (San Antonio), Dallas (Dallas-Fort Worth), Harris (Houston), Tarrant (Dallas-Fort Worth) and Travis (Austin).

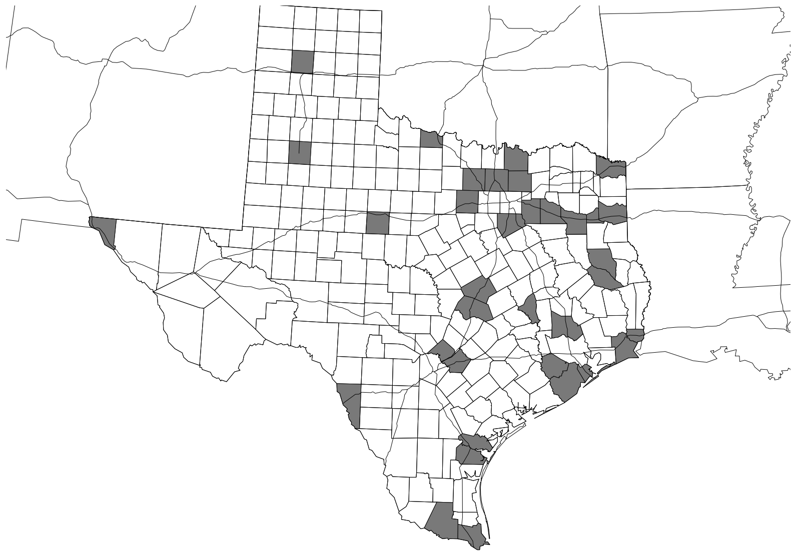

Figure 1: Graphical Representation of Sample Counties (Dark areas)

are normalized so that their sample average and standard deviations are equal to zero and one, respectively.[13]

Table 4 shows the sample correlation coefficients between the land use regulation indices and (log) population. First, land use regulation tends to be more stringent in markets with larger population size. Both the aggregate index (WRLURI) and three subindices show statistically significant positive correlation with population. Second, as expected, the aggregate index is positively correlated with some but not all of the subindices. Third, the three indices that are based on regulation for multifamily housing show strong correlations (not reported) with the original corresponding indices. Each correlation coefficient is higher than 0.96.

3 Descriptive Analysis

This section examines the empirical relationship between land use regulation and two endogenous variables—quantity (the number of mid-scale chain hotels) and price (revenue per

[13]When counties in my sample contain more than one municipalities and land use regulation indices are available for both municipalities, I use the weighted average of the original indices of these municipalities for my analysis. City population is used as a weight.

Table 3: Summary Statistics of Markets in the Sample

	Mean	Std.Dev.	P25	P50	P75
Midscale Hotels					
# of Hotels	9.00	5.25	5.00	7.00	13.00
# of Rooms	790.69	563.17	343.00	619.00	1,094.00
Quarterly Sales (in millions)	3.01	2.61	1.10	2.22	4.60
Indices for Land Use Regulation					
WRLURI (aggregate index)	0.00	1.00	-0.63	0.07	0.82
Approval Delay	0.00	1.00	-0.79	-0.22	0.50
Density Restrictions	0.28	0.38	0.00	0.01	0.51
Exactions	0.86	0.31	0.90	1.00	1.00
Open Space	0.54	0.44	0.00	0.69	1.00
Political Pressure	0.00	1.00	-0.79	-0.01	0.52
Project Approval	0.00	1.00	-0.47	-0.03	1.01
Supply Restrictions	0.00	1.00	-0.31	-0.31	-0.31
Zoning Approval	0.00	1.00	-0.17	-0.17	0.61
Other County Characteristics					
Population (in thousands)	225.27	190.94	89.13	125.89	319.70
Area (in sq mi)	869.78	257.31	786.04	899.49	939.91
Per Capita Income (in thousands)	28.38	5.74	26.21	28.52	31.30
# of Establishments (in thousands)	4.35	3.36	1.63	3.46	6.17
MSA Dummy	0.86	0.36	1.00	1.00	1.00
Airport Dummy	0.37	0.49	0.00	0.00	1.00
Interstate Highway Dummy	0.80	0.41	1.00	1.00	1.00
Construction Price Index	0.78	0.03	0.76	0.78	0.81

Notes: N=35. All data are as of the first quarter of 2005. WRLURI stands for the Wharton Residential Land Use Regulation Index. Land use regulation index becomes higher as it becomes more stringent. Hotel data are from Hotel Occupancy Tax Receipts. Land use regulation indices are from Gyoruko et al. (2008). All other county data are from County Business Patterns, Regional Economics Information System, PSMeans and road maps. Number of establishments counts any business unit (e.g., supermarkets, factories, business officess and hotels) that has physical locations in corresponding counties.

Table 4: Correlation Matrix between Market Size and Land Use Regulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ln Population	1.00	.	.	.	.	.	.	.	
(2) WRLURI	0.44**	1.00	.	.	.	.	.	.	
(3) Approval Delay	0.43**	0.58**	1.00	.	.	.	.	.	
(4) Density Restrictions	0.03	0.48**	0.14	1.00	.	.	.	.	
(5) Exactions	-0.08	0.00	0.01	-0.21	1.00	.	.	.	
(6) Open Space	0.25	0.58**	0.28	-0.09	0.08	1.00	.	.	
(7) Political Pressure	0.36**	0.71**	0.17	0.03	0.02	0.46**	1.00	.	
(8) Project Approval	0.26	0.52**	0.18	0.21	-0.11	0.22	0.19	1.00	
(9) Supply Restrictions	-0.10	-0.09	-0.11	0.13	0.14	-0.26	–0.10	-0.25	1.00
(10) Zoning Approval	-0.09	-0.24	-0.30*	-0.15	-0.20	0.09	0.05	-0.24	-0.10

Notes: N=35. See Table 1 for the definitions of abbreviations of the land use regulation indices. Correlation coefficients with ** and * are statistically significant at the five and the ten percent level, respectively.

room)—by running simple regressions.[14][15] Regressors consist of the land use regulation indices and various controls that characterize local markets. I use the ordered logit for the number of hotels and the ordinary least squares (OLS) for the revenue per room.

The impact of stringent land use regulation on the equilibrium quantity and the equilibrium price of local lodging markets is not obvious. According to my hypothesis, stringent land use regulation decreases the *supply* of lodging services by increasing the cost for hotels. However, its impact on the *demand* is ambiguous. On the one hand, stringent regulation could decrease local travel demand by discouraging some businesses, hence decreasing demand for business travel. On the other hand, it could increase local travel demand by preserving a particular local environment (e.g., a nice view or clean water) that is attractive to either leisure travelers or certain industries. The standard supply-demand framework predicts that when stringent land use regulation *increases* local travel demand overall, the equilibrium price increases while the change in equilibrium quantity is indeterminate. In contrast, when stringent land use regulation *decreases* local travel demand overall, the equilibrium *quantity*

[14] The regression using the total number of rooms as the dependent variable generates similar results.

[15] An increase in revenue per-room does not necessarily mean an increase in prices since not only prices, but also occupancy rates (the number of rooms sold over the total number of rooms), affect the revenue per-room.

decreases while the change in equilibrium *price* is indeterminate.

Tables 5 and 6 report the estimates of these functions based on the data as of the first quarter of 2005. First, the regression results show that my control variables explain about one-third in the variation in the equilibrium quantity and that adding land use regulation indices to the regressors increases the (pseudo) R-squared by 6 percentage points. In contrast, the same control variables explain 41 percent of the variation in the equilibrium prices while adding land use regulation indices increases the R-squared by 23 percentage points. Second, the parameter estimates indicate that markets with stringent regulation tend to have fewer hotels and higher prices, suggesting the anticompetitive effects of land use regulation. In Table 5, the parameter estimate for WRLURI is statistically significant at the ten percent level, while that for Project Approval in the second column is statistically significant at the five percent level. In Table 6, the parameter estimate for WRLURI is positive but not statistically significant. In contrast, the parameter estimates for Project Approval, Open Space and Supply Restrictions are statistically significant at least at the ten percent level in all but one specification.[16] The estimated impacts of stringent regulation are economically significant as well. For example, consider an imaginary market whose characteristics are equal to the sample median values. My estimates in the second columns of Tables 5 and 6 indicate that this market is expected to have 10.1 hotels. When the value of Project Approval increases by one standard deviation, the expected number of hotels decreases to 8.7 and the equilibrium prices increases by 8.8 percent.[17]

One concern with these regression results relates to the possible impacts of land use regulation on the size of hotels. When the cost impacts of land use regulation depend on the number of hotels but not their size, hotel chains might have an incentive to open one large hotel instead of opening two small hotels. If that were the case, even in the absence of any

[16] In the second column of Table 6, the parameter estimate for Project Approval is marginally insignificant at the ten percent level. Its p-value is 0.103.

[17] Another interesting question, which is related but not directly asked here, concerns the role of zoning on market structure. Houston is well-known for its lack of formal zoning. Simple extrapolation of regressions (available upon request) suggests that the number of hotels in Harris County, where Houston is located, is at least seven percent greater than the average number of hotels in markets that are observationally equivalent.

Table 5: Ordered Logit Estimates

Dep. Var.	# of Hotels			
	(1)	(2)	(3)	(4)
WRLURI	-0.772*			
	(0.421)			
Project Approval		-1.029**	-0.844	-0.911
		(0.493)	(0.603)	(0.603)
Zoning Approval		0.430	0.406	0.434
		(0.362)	(0.414)	(0.430)
Approval Delay			-0.088	0.080
			(0.571)	(0.567)
Density Restrictions			-0.701	-0.815
			(0.980)	(0.990)
Exactions			-0.005	0.224
			(1.698)	(1.494)
Open Space			1.250	1.098
			(0.984)	(0.975)
Political Pressure			-0.433	-0.195
			(0.517)	(0.496)
Supply Restrictions			0.240	0.305
			(0.417)	(0.415)
Exclude regulation for single-family housing	No	N/A	No	Yes
Log Likelihood	-61.216	-58.831	-57.438	-57.582
Pseudo R-squared	0.349	0.374	0.389	0.388

Notes: N=35. Standard errors are in parentheses. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. See Table 1 for the definitions of land use regulation indices. Estimates and standard errors for control variables and thresholds are suppressed. These control variables include population, the number of establishments, per capita income, area, construction price index and dummy variables for MSA, access to commercial airports and Interstate Highway. Pseudo R-squared of the ordered logit of the number of hotels on control variables only are 0.331.

Table 6: OLS Estimates

Dep. Var.	ln (Revenue Per Room)			
	(1)	(2)	(3)	(4)
WRLURI	0.068			
	(0.047)			
Project Approval		0.088	0.124*	0.125*
		(0.052)	(0.069)	(0.066)
Zoning Approval		0.076	0.056	0.042
		(0.054)	(0.053)	(0.052)
Approval Delay			-0.055	-0.095
			(0.095)	(0.092)
Density Restrictions			0.032	0.045
			(0.102)	(0.106)
Exactions			-0.120	-0.151
			(0.170)	(0.164)
Open Space			0.321**	0.324**
			(0.135)	(0.120)
Political Pressure			-0.064	-0.059
			(0.058)	(0.059)
Supply Restrictions			0.078**	0.079**
			(0.034)	(0.037)
Exclude regulation for single-family housing	No	N/A	No	Yes
R-squared	0.440	0.483	0.631	0.649

Notes: N=35. Robust standard errors are in parentheses. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. See Table 1 for the definitions of land use regulation indices. Estimates and standard errors for control variables and thresholds are suppressed. These control variables include population, the number of establishments, per capita income, area, construction price index and dummy variables for MSA, access to commercial airports and Interstate Highway. R-squared of the OLS of the revenue per room on control variables only are and revenue-per-room on control variables only are 0.411.

demand effects of land use regulation, a negative correlation between the number of hotels and the land use regulation indices may not necessarily imply lessened competition.

To address this concern, I regress the average number of rooms per hotel on the land use regulation indices as well as other control variables. Table 7 reports the results of these regressions. First, the parameter estimates for the indices that affect the number of hotels (WRLURI, Project Approval) are not statistically significant even at the ten percent level. Therefore, the observed negative correlations between the number of hotels and these two indices reported in Table 5 do not seem spurious. Second, the parameter estimates for Open Space present both statistically and economically significant negative impacts on the size of hotels. These results may suggest that markets with this particular regulation tend to have smaller hotels and charge higher prices, while the number of hotels itself is not affected.

The results above suggest some impact of land use regulation on the entry-exit decisions of the chain hotels and on the equilibrium prices. Nonetheless, these correlations can be the consequence of demand decreases caused by stringent land use regulation and the supply side might have nothing to do with it. To identify these two channels separately from the data, I need to rely on a model and estimate its structural parameters.

4 The Dynamic Entry-Exit Model of Hotel Chains

In this section, I construct a dynamic entry-exit model where N hotel chains may operate multiple hotels in a local market $m \in \{1, 2, \cdots, M\}$. I omit subscript m from all variables in this section for simplicity. At the beginning of each period, each chain simultaneously decides whether it should open a new hotel or close its existing hotels, if any. Both opening a new hotel and closing an existing hotel incur costs while operating existing hotels incurs operating costs. The presence of hotels operated by rival chains affects chain i's entry and exit decisions through their impacts on the revenue of hotels belonging to chain i.

Table 7: OLS Estimates of Regulation Impacts on the Size of Hotels

Dep. Var.	ln (Number of Rooms Per Hotel)			
	(1)	(2)	(3)	(4)
WRLURI	-0.060			
	(0.036)			
Project Approval		-0.022	-0.033	-0.030
		(0.038)	(0.043)	(0.040)
Zoning Approval		-0.026	-0.035	-0.038
		(0.035)	(0.027)	(0.028)
Approval Delay			-0.024	-0.026
			(0.044)	(0.042)
Density Restrictions			-0.096	-0.088
			(0.080)	(0.077)
Exactions			-0.125	-0.134
			(0.105)	(0.102)
Open Space			-0.279**	-0.273**
			(0.075)	(0.073)
Political Pressure			0.051	0.048
			(0.035)	(0.032)
Supply Restrictions			-0.023	-0.026
			(0.031)	(0.030)
Exclude regulation for single-family housing	No	N/A	No	Yes
R-squared	0.705	0.687	0.829	0.828

Notes: N=35. Robust standard errors are in parentheses. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. Other regressors whose results are suppressed include chain dummies, population, the number of establishments, per capita income, area, construction price index, dummy variables for MSA, access to commercial airports and Interstate Highway. Population, the number of establishments, per capita income and area are in log. R-squared of the regressions of the number of rooms on the control variables only is 0.679.

4.1 State Space

Denote each chain by $i \in \{1, ..., N\}$ and each period by $t \in \{1, 2, .., \infty\}$. Each chain operates at most H hotels in a market. A *common* state at period t consists of (i) a vector of the number of hotels operated by each chain $\mathbf{h_t} = (h_{1t,} h_{2t}, \ldots, h_{Nt}) \in \{0, 1, \ldots, H\}^N$ and (ii) a vector of exogenous market-specific characteristics (e.g., population) $\mathbf{x_t} \in X \subset \mathbb{R}^L$. This common state is observable to both hotel chains and econometricians. Denote this common state variable by $\mathbf{s_t} = (\mathbf{h_t}, \mathbf{x_t}) \in S \equiv \{0, 1, \ldots, H\}^N \times X$. At the beginning of every period, chain i receives two private shocks, one for the entry cost υ_{1it} and one for the exit cost υ_{2it}. These shocks are i.i.d. draws from their joint CDF functions $F(\cdot)$. While the shape of the distribution function $F(\cdot)$ is common and known to all players, realized cost shocks $\boldsymbol{\upsilon}_{\mathbf{it}} = (\upsilon_{1it}, \upsilon_{2it})$ are private and only observable to chain i.

4.2 Choice Space

At the beginning of every period, each chain simultaneously chooses the number of hotels it opens or closes. Let a_{it} denote the *change* in the number of hotels chain i operates between period t and $t+1$. Positive a_{it} indicates opening a new hotel while negative a_{it} indicates closing one of its existing hotels. I assume that choices made at period t are realized at $t+1$; hence $h_{it+1} = h_{it} + a_{it}$ holds. I also assume that hotel chains do not open or close more than one hotels in the same period.[18] Since the resulting number of hotels after this change still has to be an element of $\{0, 1, \ldots, H\}$, chain i's choice set is a function of the number of

[18] This assumption is not restrictive in practice since in the data hotel chains rarely open or close more than one hotels in the same quarter. Out of 15,120 data points in my sample, only 17 data points (0.11 percent) experience this event. In estimation, I treat these data points as if the change were (minus) one rather than (minus) two.

hotels it currently operates, h_{it}, and is written as

$$A_{it}\left(h_{it}\right)=\begin{cases}\{\quad\;\; 0,\; 1\;\}, & \text{if } h_{it}=0,\\ \{\; -1,\; 0,\; 1\;\}, & \text{if } 0<h_{it}<H,\\ \{\; -1,\; 0\quad\;\}, & \text{if } h_{it}=H.\end{cases} \tag{1}$$

4.3 Period Profit

Chain i's expected period profit is given by the remainder of its expected revenue after subtracting the operating costs of its existing hotels, the entry cost of opening a hotel if it opens one and the exit cost of a hotel it closes if it closes one. Given the current state $(\mathbf{s_t}, \boldsymbol{\upsilon}_{\mathbf{it}})$ and its choice $a_{it} \in A_{it}(h_{it})$, chain i's choice-specific expected period profit is written as:

$$\pi_i\left(a_{it}, \mathbf{s_t}, \boldsymbol{\upsilon}_{\mathbf{it}}\right) = ER_i\left(\mathbf{s_t}\right) - \delta_i h_{it} - \mathbf{1}\left(a_{it}=1\right)\left(e_i - \rho_1 \upsilon_{1it}\right) - \mathbf{1}\left(a_{it}=-1\right)\left(-\rho_2 \upsilon_{2it}\right), \tag{2}$$

where $ER_i(\mathbf{s}_t)$ represents the expected revenue of chain i from its current operation of h_{it} hotels, δ_i denotes the cost of operating a hotel for one period,[19] $(e_i - \rho_1 \upsilon_{1it})$ is the entry cost and $(-\rho_2 \upsilon_{2it})$ is the exit cost. Here, the mean exit cost is assumed to be zero, and ρ_1 and ρ_2 represent scale parameters for entry and exit costs, respectively.[20] Exploiting the linearity of (2), I rewrite it as the product of two vectors:

$$\pi_i\left(a_{it}, \mathbf{s_t}, \boldsymbol{\upsilon}_{\mathbf{it}}\right) = \Psi\left(a_{it}, \mathbf{s_t}, \boldsymbol{\upsilon}_{\mathbf{it}}\right)' \boldsymbol{\theta}_{\mathbf{i}}, \tag{3}$$

where $\Psi\left(a_{it}, \mathbf{s_t}, \boldsymbol{\upsilon}_{\mathbf{it}}\right) = \left[ER_i\left(\mathbf{s_t}\right), -h_{it}, -1\left(a_{it}>0\right), 1\left(a_{it}>0\right)\upsilon_{1it}, 1\left(a_{it}<0\right)\upsilon_{2it}\right]$ and $\boldsymbol{\theta}_{\mathbf{i}} = [1, \delta_i, e_i, \rho_1, \rho_2]$.

[19] I assume that operating costs exhibit constant returns to the number of hotels to maintain the linearity of the period profit function while maintaining a small number of parameters.

[20] I put minus signs before the ρs for notational convenience.

4.4 Transition of the State Variables

I assume that exogenous market-specific characteristics $\mathbf{x_t}$ follow a Markov process. Let $P(\mathbf{s}'|\mathbf{s},\mathbf{a}) : S \times S \times A \rightarrow [0,1]$ denote the evolution of the common state variables $\mathbf{s}$ conditional on hotel chains' choices $\mathbf{a}$, where $\mathbf{a} \in A = \{-1,0,1\}^N$.

4.5 Markov Perfect Equilibrium

I assume that chain i's decision is characterized by a pure Markov strategy $\sigma_i(\mathbf{s},\boldsymbol{\upsilon}_\mathbf{i}) : S \times \mathbb{R} \rightarrow A$. Let $\sigma(\mathbf{s},\boldsymbol{\upsilon}) = \{\sigma_1(\mathbf{s},\boldsymbol{\upsilon}), \ldots, \sigma_N(\mathbf{s},\boldsymbol{\upsilon})\}$ be a vector of each chain's Markov strategy while $\sigma_{-i}(\mathbf{s},\boldsymbol{\upsilon}) = \sigma(\mathbf{s},\boldsymbol{\upsilon}) \backslash \{\sigma_i(\mathbf{s},\boldsymbol{\upsilon})\}$ be a vector of all but chain i's Markov strategies. Let $\beta \in (0,1)$ denote a discount factor common to all chains. Chain i's discounted sum of expected profits at state $\mathbf{s}$ under σ is

$$V_i(\mathbf{s};\sigma) = E\left[\sum_{\tau=0}^{\infty} \beta^\tau \Psi_i\left(\sigma_i\left(\mathbf{s}_{\boldsymbol{\tau}},\boldsymbol{\upsilon}_{\mathbf{i}\boldsymbol{\tau}}\right), \mathbf{s}_{\boldsymbol{\tau}}, \boldsymbol{\upsilon}_{\mathbf{i}\boldsymbol{\tau}}\right)\boldsymbol{\theta}_\mathbf{i}\right| \sigma_{-i}, \mathbf{s}_0 = \mathbf{s}\right] = W_i(\mathbf{s};\boldsymbol{\sigma})\,\boldsymbol{\theta}_i, \tag{4}$$

where the expectation of the above formula is defined by the distributions of $\upsilon_{i\tau}$ and $\mathbf{s}_\tau$, and $W_i(\mathbf{s};\boldsymbol{\sigma}) = E\left[\sum_{\tau=0}^{\infty} \beta^\tau \Psi_i\left(\sigma_i\left(\mathbf{s}_{\boldsymbol{\tau}},\boldsymbol{\upsilon}_{\mathbf{i}\boldsymbol{\tau}}\right), \mathbf{s}_\tau, \boldsymbol{\upsilon}_{\mathbf{i}\boldsymbol{\tau}}\right)\right| \sigma_{-i}, \mathbf{s}_0 = \mathbf{s}]$.

In a Markov perfect equilibrium, every chain's equilibrium strategy must be the best response to its rivals' equilibrium strategies. Formally speaking, a Markov perfect equilibrium of this dynamic entry-exit model consists of a vector of Markov strategies σ^* such that

$$V_i\left(\mathbf{s};\sigma_i^*,\sigma_{-i}^*\right) \geq V_i\left(\mathbf{s},\sigma_i',\sigma_{-i}^*\right) \text{ for all } i,\ \mathbf{s} \in S \text{ and } \sigma_i'. \tag{5}$$

Exploiting the linearity of the period profit function, this equilibrium condition is rewritten as

$$\left\{W_i\left(\mathbf{s};\sigma_i^*,\sigma_{-i}^*\right) - W_i\left(\mathbf{s};\sigma_i',\sigma_{-i}^*\right)\right\}\boldsymbol{\theta}_i \geq 0 \text{ for all } i,\ \mathbf{s} \in S \text{ and } \sigma_i'. \tag{6}$$

5 Estimation

I estimate the structural parameters of the model presented in the previous section by applying the estimation method proposed by Bajari et al. (2007) to the data from M local markets. Estimation consists of three stages. In the first stage, I separately estimate hotel-level revenue functions, hotel chains' policy functions and transition functions. In the second stage, I find the set of structural cost parameters that makes the observed policy the most profitable choice compared to possible alternatives, given the environment specified by the transition functions and the hotel-level revenue function. In the third stage, I infer the relationship between the recovered market-specific cost parameters and the stringency of land use regulation by running regressions.

5.1 First Stage

Consider a local market $m \in \{1, 2, \cdots, M\}$. Let r_{ikmt} denote the revenue of chain i's kth hotel in period t in market m. This revenue is given by

$$\ln r_{ikmt}\left(\mathbf{s}_{mt}\right) = \gamma_i + \eta_{1m} + \mathbf{x}'_{\mathbf{1}m\mathbf{t}}\boldsymbol{\eta}_{\mathbf{2}} - \eta_3 \ln\left(\Sigma_j h_{jmt}\right) - \eta_4 \ln h_{imt} + \epsilon_{ikmt}, \tag{7}$$

where γ_i is a chain dummy, η_{1m} is a market fixed effect and ϵ_{ikmt} is an error term. Exogenous market-specific characteristics $\mathbf{x}_{\mathbf{1}m\mathbf{t}}$ consist of (i) population, (ii) the number of establishments, and (iii) state-level sales of mid-scale hotels. The last of these is included to capture the state-wide time trend.[21] I also include the quarter-specific dummies, which I omit from (7) for the sake of the simplicity. The fourth and fifth regressors, $\Sigma_j h_{jt}$ and h_{it}, represent the revenue impacts of the presence of other hotels in the same market. The fourth term represents the intensity of local competition, and the fifth term captures the possible substitution between hotels belonging to the same chain (cannibalization effects).

[21] I do not employ time dummy variables here. The model including them does not allow me to simulate hotel chains' revenue out of the sample period, while such simulations are necessary in the second stage.

I estimate this function by the OLS. The consistency of these OLS estimates relies on the assumption that ϵ_{ikmt} satisfies strong exogeneity. In particular, I assume that ϵ_{ikmt} is an i.i.d. draw from a normal distribution.[22] To justify this assumption, I control for the following three factors that might be a source of serial correlation: (i) time-invariant market-specific characteristics, (ii) time-invariant chain-specific characteristics and (iii) quarterly shocks. The dummy variables inserted in (7) deal with the first three factors. Time trends do not appear here since state-wide sales in $\mathbf{x}_{1m\mathbf{t}}$ capture the time trend.

I represent hotel chains' policy functions by a variant of the multinomial logit model. I impose three assumptions. First, the private cost shocks, υ_{1imt} and υ_{2imt}, have the same scale parameter, namely $\rho_1 = \rho_2 = \rho$. Second, these private cost shocks are an i.i.d. draw from the Type I extreme value distribution whose mean is zero and whose variance is $\frac{\pi^2}{6}$. Third, the maximum number of hotels a chain can operate in a market is seven (i.e., $H = 7$).[23] Let $\Pi\left(a_{imt}, \mathbf{s}_{imt}\right)$ be the deterministic part of chain i's choice-specific value function normalized by ρ. Then

$$\Pi_i\left(a_{imt}, \mathbf{s}_{mt}\right) = \begin{cases} \frac{1}{\rho}\left[\begin{array}{c} ER_i\left(\mathbf{s}_{mt}\right) - \delta_{im} h_{imt} - 1\left(a_{imt} = 1\right) e_{im} \\ +\beta EV_i\left(\mathbf{s}_{mt+1}; \sigma_i^*, \sigma_{-i}^* | \mathbf{s}_{mt}, a_{imt}\right) \end{array}\right] & \text{if } a_{imt} \in A_i\left(\mathbf{s}_{mt}\right) \\ -\infty & \text{otherwise} \end{cases}. \quad (8)$$

Under this notation, chain i's decision problem is written as

$$\max\left(\Pi_i\left(1, \mathbf{s}_{mt}\right) + \upsilon_{1imt},\ \Pi_i\left(0, \mathbf{s}_{mt}\right),\ \Pi_i\left(-1, \mathbf{s}_{mt}\right) + \upsilon_{2imt}\right). \quad (9)$$

Although υ_{1imt} and υ_{2imt} are assumed to be drawn from the Type I extreme value distribution, the choice probability of the conventional multinomial logit model is not applicable here since hotel chains' payoffs are not subject to any cost shock when they neither open nor

[22] Imposing normality here allows me to calculate $E\left(r_{ikmt}\left(s_{mt}\right)\right)$ in an analytical form. Consistency does not require this assumption though.

[23] This upper limit is not restrictive. During the sample period, only one hotel chain hits this limit.

close a hotel (i.e., $a_{imt} = 0$). Therefore, I derive the choice probabilities that directly capture this particular feature.[24][25] To estimate these policy functions, I need to specify both $\Pi(1, \mathbf{s}_{mt}) - \Pi(-1, \mathbf{s}_{mt})$ and $\Pi(0, \mathbf{s}_{mt}) - \Pi(-1, \mathbf{s}_{mt})$ as a function of observable characteristics. I approximate them as a linear function of state variables $\mathbf{s}_{mt}$, chain-fixed effects and market fixed effects.[26] The land use regulation indices do not appear here as they are perfectly collinear with the market fixed effects. I use maximum likelihood for this estimation. See the Appendix for the estimation of the transition functions of $\mathbf{x}_{1mt}$.

5.2 Second Stage

In the second stage, I estimate the set of chain i's structural cost parameters in market m $\{\delta_{im}, e_{im}\}$, and a scale parameter ρ, assuming ρ is common to every local market. Intuitively, this estimation is made possible by finding the set of the parameters under which chain i's observed policy becomes the best response to its rivals' observed policies. I first estimate $W_{im}(\mathbf{s}; \sigma_{im}, \sigma_{-im})$ defined in the previous section by forward simulations. I consider the following two situations: (1) when all the chains follow the observed policy; and (2) when all the chains except chain i follow the observed policies, while chain i follows a policy that is slightly different from its observed policy. I consider N_I types of such alternative policies $\{\sigma_{im}^k\}_{k=1}^{N_I}$. For notational convenience, let σ_{im}^0 denote chain i's observed policy. The goal is to estimate $W_i(\mathbf{s}; \sigma_{im}^k, \sigma_{-im}^0)$ for every $k \in \{0, 1, \cdots, N_I\}$. For the kth estimation, I simulate each chain's decisions over T periods for Ns times by using the policy functions and transition functions obtained in the first stage. I also record chain i's expected revenue $\left\{\widetilde{ER}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$, the number of hotels it operates $\left\{\tilde{h}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$, its entry and exit decisions $\left\{\tilde{a}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$ and its

[24] See Supplementary Appendix for the derivations of these choice probabilities.

[25] Taking into account this aspect of the model is important to make forward simulations explained later consistent with the model.

[26] Ideally, one might want to employ a more flexible form by inserting, for example, a dummy variable for each chain-market pair or estimating a policy function for each market. I do not take this approach as it requires a large number of observations for each chain-market pair.

private cost shocks $\{\tilde{\upsilon}^n_{1im\tau}, \tilde{\upsilon}^n_{2im\tau}\}^T_{\tau=0}$.[27] I use the revenue function estimated in the first stage to calculate $\widetilde{ER}^{k,n}_{im\tau}$. The resulting estimator is

$$\tilde{W}_{im}\left(\sigma^k_{im}, \sigma^0_{-im}\right) = \frac{1}{N_S}\sum_{n=1}^{N_S}\sum_{\tau=0}^{T}\beta^t \begin{bmatrix} \widetilde{ER}^{k,n}_{im\tau}, -\tilde{h}^{k,n}_{im\tau}, -1\left(\tilde{a}^{k,n}_{im\tau}=1\right), 1\left(\tilde{a}^{k,n}_{im\tau}=1\right)\tilde{\upsilon}^n_{1im\tau}, \\ -1\left(\tilde{a}^{k,n}_{im\tau}=-1\right), 1\left(\tilde{a}^{k,n}_{im\tau}=-1\right)\tilde{\upsilon}^n_{2im\tau} \end{bmatrix}. \tag{10}$$

See Supplementary Appendix for the algorithm relating to these forward simulations, including the way to choose inequalities. In the actual estimations, I employ the following settings: $N_I = 800$, $N_S = 10,000$, $T = 80$ and $\beta = 0.974$.[28]

I next estimate the structural cost parameters by using the simulation results obtained from (10). Let $g_{imk}(\boldsymbol{\theta}_{im})$ denote a function that calculates to what extent the observed policy σ^0_{im} brings more profit to chain i compared to the kth alternative policy σ^k_{im} when its rivals follow the observed policies σ^0_{-im}. Then

$$g_{imk}(\boldsymbol{\theta}_{im}) = \left\{\tilde{W}_{im}\left(\sigma^0_{im}, \sigma^0_{-im}\right) - \tilde{W}_{im}\left(\sigma^k_{im}, \sigma^0_{-im}\right)\right\}\boldsymbol{\theta}_{im}. \tag{11}$$

I evaluate a set of parameters $\boldsymbol{\theta}_{im}$ by employing the following loss function:

$$\left(\min\left\{g_{imk}(\boldsymbol{\theta}_{im}), 0\right\}\right)^2. \tag{12}$$

This loss function gives zero when the observed policy σ^0_{im} brings more profit than the kth alternative policy σ^k_{im}. When the opposite is true, this function gives the squared expected difference in the resulting profits between these two policies. Finally, I estimate a set of the structural cost parameters $\Theta^* = \{\boldsymbol{\theta}^*_{im}\}_{i,m}$ by finding the one that minimizes the sum of this loss function across chains, markets and alternative policies subject to nonnegativity

[27]These two shocks do not have a superscript k since I use the same set of draws for every policy $k \in \{0, \cdots, N_I\}$.

[28]Note that the unit of the time period is quarterly rather than yearly. Hence $T = 80$ is equivalent to 20 years and $\beta = 0.974$ is equivalent to a 0.9 annual discount rate.

constraints:[29]

$$\min_{\boldsymbol{\Theta}\geq\mathbf{0}} \frac{1}{N \cdot M \cdot N_I} \sum_{i=1}^{N} \sum_{m=1}^{M} \sum_{k=1}^{N_I} \left(\min\left\{g_{imk}\left(\boldsymbol{\theta}_{im}\right), 0\right\}\right)^2. \tag{13}$$

5.3 Third Stage

The last step infers the impacts of the stringency of land use regulation on the structural cost parameters (δ_{im}, e_{im}) by running regressions.[30] I assume that the logarithms of these costs are linear functions of the land use regulation indices, hotel chain dummies, other observable and unobservable market characteristics and an error term. I estimate this model using random effects.

6 Results

6.1 First Stage

Table 8 shows the estimation results of the policy function. To see the empirical importance of unobservable market-specific characteristics, I estimate this function under two different specifications: one with market dummy variables and one without. The estimation results indicate that including market dummy variables in regressors is crucial to properly characterize the policy functions. As shown in Table 8, these two specifications provide quite different conclusions concerning the extent to which the presence of incumbents affects hotel chains' entry decisions. These results suggest that observable characteristics (i.e., population and

[29] What distinguishes (δ_{im}, e_{im}) from $(\delta_{i'm'}, e_{i'm'})$ in this estimation is the variation in the parameter estimates of market dummies and chain dummies in both the revenue function and the policy function. These dummies are either chain-specific or market-specific but not chain-market specific. Therefore estimation in the second stage is the mapping from both chain-specific variables and market-specific variables to chain-market specific variables. Due to the nonlinearity of this mapping, resulting structural parameters do not have additivity such as $\delta_{im} = \delta_i + \delta_m$ for all i and m.

[30] There are several situations in which land use regulation may affect the operating costs of hotels. First, obeying regulations may require frequent maintenance of buildings. Second, in markets with tight regulation on signs, hotels need to advertise their presence in more expensive ways such as advertisements in travel guides.

Table 8: Estimates of Policy Functions

	Policy Functions			
	(1)		(2)	
	$\Pi(1)$ $-\Pi(-1)$	$\Pi(0)$ $-\Pi(-1)$	$\Pi(1)$ $-\Pi(-1)$	$\Pi(0)$ $-\Pi(-1)$
# of Hotels	0.012	-0.001	-0.249**	-0.114**
	(0.044)	(0.038)	(0.070)	(0.058)
# of Hotels under	-0.949**	-0.670**	-0.986**	-0.726**
the Same Chain	(0.113)	(0.091)	(0.124)	(0.105)
Log Likelihood	-2186.111		-2143.426	
Market Dummy	No		Yes	

Notes: N=13,230. Standard errors are in parentheses. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. Estimates and standard errors of control variables (population, the number of establishments, market dummies and chain dummies) are suppressed. Likelihood functions take into account the constraint that no closure is possible when hotel chains operate no hotels.

establishments) are not sufficient to characterize the demand size of local markets. Hereafter I use the estimation results of the model using market dummy variables.

To provide some idea about what these estimates imply, I calculate the change in Best Western's predicted entry (i.e., $a_{imt} = 1$) and exit (i.e., $a_{imt} = -1$) probabilities in a market[31] when the number of hotels in this market increases. I consider the following two cases: In case one, the number of hotels belonging to the other hotel chains increases from ten to fifteen while Best Western operates only one hotel. In case two, the number of hotels operated by Best Western increases from zero to five while the number of hotels operated by the other chains is fixed at eleven. In both cases, the total number of hotels increases from eleven to sixteen. Figure 2 shows the results from this exercise. In case one, Best Western's entry probability decreases from about 9.5 percent to 4.9 percent as its rival chains open new hotels while its exit probability slightly increases from 0.8 percent to 1.4 percent. In contrast, reflecting high substitution among hotels in the same chain, its entry probability decreases from 12 percent to 1.6 percent and its exit probability increases from 0 percent to

[31] This figure uses data from Potter County, a part of the Amarillo MSA, in the first quarter of 2005.

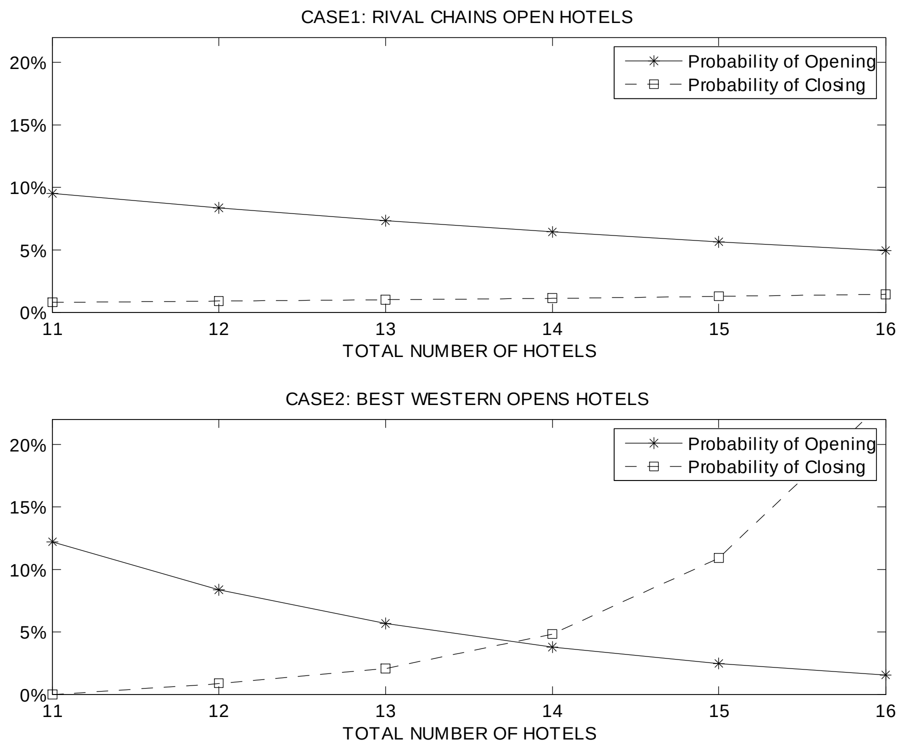

Figure 2: Impacts of the number of incumbents on Best Western's entry decisions

24 percent.

Table 9 reports the estimation results of the hotel-level revenue function specified in (7). I use the OLS for this estimation. To take into account possible correlations between the error terms of hotels that operate in the same market at the same time, I employ standard errors robust to clustering. I first estimate this function with and without using market dummy variables. I also estimate the same model by adding the number of rooms of rival hotels to the regressors.

First, the first two columns of Table 9 show that including market-specific dummy variables significantly changes some of the estimates. In particular, the parameter estimate for the number of rival hotels (the first row) changes from -0.058 to -0.383 and this estimate becomes statistically significant when including dummy variables. These results suggest that ignoring market-specific unobservable factors leads to inconsistent parameter estimates.

Second, the presence of other hotels significantly reduces the revenue of a hotel. In particular, its revenue impact becomes more severe when the hotel and its rival hotels belong to the same chain, reflecting possible cannibalization. Figure 3 illustrates the implication of these results by showing how the revenue of a hotel, rather than that of a chain, decreases as other hotels open. To highlight the distinct revenue impacts from hotels belonging to the same chain and those belonging to its rival chains, the figure considers two situations: (1) when all of its rival hotels belong to other hotel chains, and (2) when the hotel and all of its rival hotels belong to the same chain. My estimation results imply that a hotel's revenue under duopoly is about 23 percent lower than under monopoly when its rival belongs to a different chain. However, when its rival hotel belongs to the same chain, its revenue decreases by 34 percent.[32]

Third, the number of rooms in rival hotels appears to affect the revenue of a hotel. According to our estimates in Column (3) of Table 9, a one percent increase in the number of rooms of rival hotels decreases a hotel's revenue by 0.1 percent. The parameter estimate for log of number of hotels also decreases from -0.383 to -0.221, reflecting a positive correlation between the number of hotels and the number of rooms. For further analysis, I use the parameter estimates in Column (2) of Table 9.[33]

To check the quantitative importance of controlling the stringency of land use regulation on the demand side, I regress the estimated market fixed effects of the revenue function on the land use regulation indices as well as the other control variables used in the descriptive analysis. Omitted regression results suggest the importance of controlling the impacts of land use regulation on the demand side to isolate the cost impacts of land use regulation.

[32]One might wonder why more intense competition due to the change from monopoly to duopoly does not decrease the revenue of a hotel more than fifty percent. This conjecture is not necessarily true in my setting, which abstracts hotel chains' within-market location decisions. The location of the second hotel is generally different from that of the first one and as a result the first hotel needs to compete with the second hotel for only a fraction of its potential customers.

[33]I do not explicitly include the size of a hotel into my structural model despite the statistical significance of the parameter estimate of the total number of rooms. First, including the size of a hotel would make estimation very difficult as we would need to estimate the probability of a rare event such as the opening of a large hotel. Second, the resulting model would have a huge state space making counterfactual experiments virtually impossible except in very simple (and hence unrealistic) cases. Third, the parameter estimate of the total number of rooms is arguably not economically significant. According to my estimates, ceteris paribus, a ten percent increase in the total number of rooms decreases the revenue of a hotel by less than one percent.

Table 9: Revenue Function Estimates

	(1)	(2)	(3)
Log of # of Hotels	-0.058	-0.383**	-0.217**
	(0.080)	(0.060)	(0.084)
Log of # of Hotels under the Same Chain	-0.182**	-0.224**	-0.235**
	(0.054)	(0.055)	(0.055)
Log of (# of Rooms of Rival Hotels +1)			-0.095**
			(0.034)
Market Dummy	No	Yes	Yes
R-squared	0.367	0.437	0.438

Notes: N=12,877. Clustered standard errors are in parentheses. Each cluster is market and time period specific. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. Other control variables include population, the number of establishments and sales. Estimates and standard errors for these control variables, market dummies, chain dummies and quarter dummies are suppressed.

Although none of the estimates on land use regulation indices is *individually* significant when all the indices are included, these estimates are *jointly* significant at the five percent level according to the relevant F test. Also, land use regulation indices are quantitatively important. For example, the change in the values of these indices from the first sample quartile to the third sample quartile decreases revenue by 12 percent. The estimation results of the transition functions for state-level sales, market-level establishments and population are reported in the Supplementary Appendix.

6.2 Second Stage

Table 10 reports the descriptive statistics pertaining to the cost parameter estimates (δ_{mi}, e_{mi}).[34][35] Under the assumption that the mean exit cost is zero, the average hotel chain incurs $250,800 each quarter to operate a hotel and about $2.4 million to open a new hotel in the average market. Their standard deviations indicate that these cost parameter estimates vary signif-

[34] In general, second stage estimates can be set estimates as they are the solution of the inequality-based minimization problem. These estimates become a singleton when there are no parameter vectors that satisfy all the inequality conditions. Our estimates become a singleton for this reason.

[35] The estimate of the scale parameter ρ is 689.0.

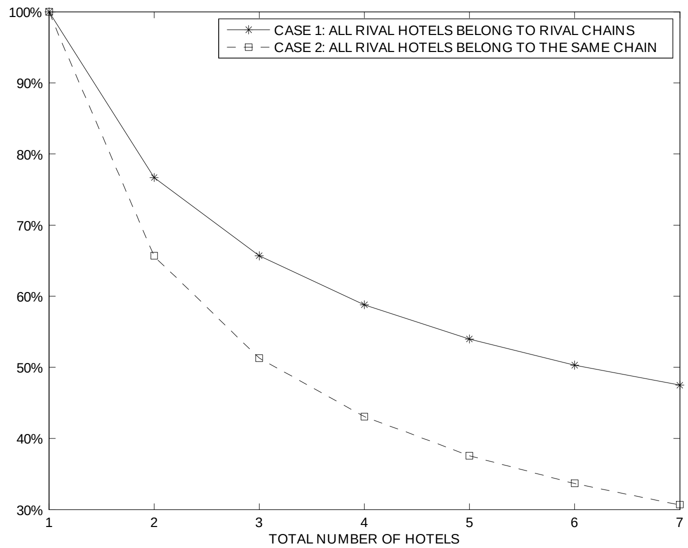

Figure 3: Revenue Impacts of Having Rival Hotels

icantly across the markets. Furthermore, the last six rows of this table indicate significant cost differences across chains. The differences can be explained by differences in both capacity and quality, such as the availability of free breakfast or business centers. To provide some idea of the relevance of these estimates, I estimate the construction cost of new Best Western and La Quinta hotels using detailed information of the prototype models of these two chains and square foot cost provided by industrial sources. (See Appendix for details of this calculation.) According to these estimates, constructing a Best Western hotel and a La Quinta hotel costs $2.4 million and $4.5 million, respectively. While the obtained costs are surprisingly close to my entry cost estimates for Best Western ($2.4 million vs $2.4 million), there is a discrepancy between these two numbers for La Quinta ($4.5 million vs $1.4 million). The presence of discrepancy between entry cost estimates and construction cost is not necessarily problematic per se as not all the construction costs are sunk,[36] and not all the entry costs are construction costs.[37] However, this does not explain why the results are so different between these two chains. One possible explanation is the reliability of La Quinta's policy function estimates. Compared to other chains, La Quinta hotels underwent relatively

[36]For example, one can recover a part of the construction cost by selling one's property.

[37]For example, the costs of obtaining a business license is a part of entry costs but not necessarily be considered as construction costs.

Table 10: Summary Statistics of the Cost Parameter Estimates

	Operating Cost (δ)		Entry Cost (e)	
	Mean	Std. Dev.	Mean	Std. Dev.
All Samples	250.8	141.6	2,365.0	701.7
Chains				
Best Western	186.8	61.5	2,372.4	602.0
Cendant	144.0	59.0	2,579.6	254.5
Choice Hotels	142.9	50.8	2,419.6	368.2
Hilton	246.6	93.8	2,868.9	478.3
Inter-Continental	418.7	123.2	2,295.1	710.6
La Quinta	418.6	93.3	1,387.8	895.7

Notes: All statistics are in thousands of dollars in 2000. The operating cost captures the amount of cost a hotel incurs for its three-month operation.

little turnover during the sample period. That may make La Quinta's estimates less reliable than the others.

6.3 Third Stage: Cost Function Regression

Table 11 reports the random effects estimates of the operating cost function (δ_{mi}) and the entry cost function (e_{mi}).[38] To minimize the risk of omitted variable problems, all the regressions contain the control variables used in the regressions in Section 3 as their regressors.[39] I estimate these two functions using three different specifications. Each specification is different in the types of regulation indices used: (i) the aggregate index (WRLURI), (ii) the subindices that are directly connected to commercial land use regulation (Project Approval and Zoning Approval), and (iii) all the subindices.[40]

First, an increase in the stringency of land use regulation by one standard deviation increases operating costs by eight to nine percent. These results are robust to specifications.[41]

[38] The standard errors reported here take into account the fact that this regression uses the cost estimates rather than the actual costs. Since these cost estimates appear as the dependent variable rather than a regressor, measurement error appears as an additional component of the error term. In this case, the conventional formula for robust standard errors is applicable.

[39] These regressors include population, the number of establishments, per capita income, area, construction price index and dummy variables for MSA, access to commercial airports and interstate highways.

[40] I also estimate the same model using the regulation indices that exclude regulation for single-family housing. The results are quantitatively similar to the one using all the subindices.

[41] I only look at the estimates that are statistically significant at least at the ten percent level.

Second, its impacts on entry costs vary across specifications. In the first two specifications, no estimates are statistically significant. In contrast, the last specification (Column 6 of Table 11) reports 6 percent increase in the entry costs. The statistical insignificance of the impacts on the entry costs in some specification is puzzling. One obvious suspect is the measurement error in the second stage estimates. Another possible explanation is that expenses that appear to sunk are not really sunk. For example, legal fees to obtain a building permit may not be completely sunk as its property value may reflect the difficulty of getting a permit. Third, in Column 6, the point estimate for Approval Delay is negative and statistically significant. One possible interpretation of this negative estimate is that this index is correlated with some unobservable market characteristics and the resulting estimate represents the impacts of these factors rather than those of land use regulation.

7 Counterfactual Experiments

This section reports the results of counterfactual experiments, using the parameter estimates obtained in the previous section. The goal of this exercise is to quantitatively evaluate the cost impacts of land use regulation on the decisions of hotel chains and hence the intensity of competition. To isolate this particular effect, I construct a counterfactual environment where a change in land use regulation affects only costs but not demand. Ideally, one wants to simulate the entry-exit decisions of the six hotel chains in a market whose characteristics change overtime. However, solving a Markov perfect equilibrium of such a game is numerically demanding. For that reason, I instead simulate the model by fixing exogenous market characteristics (i.e., population, the number of establishments, and state-level sales) at their values in 2005, while limiting the maximum number of hotels a chain can operate to three. These simplifications make the associated game numerically tractable by giving it a discrete state space of reasonable size. I solve the model numerically by the policy function iteration.

My counterfactual experiments consider the three markets, each of whose population

Table 11: Estimates of Cost Impacts of Regulation

Dependent Variable	ln (Operating Costs)			ln (Entry Costs)		
	(1)	(2)	(3)	(4)	(5)	(6)
WRLURI	0.087**			-0.058		
	(0.039)			(0.040)		
Project Approval		0.088*	0.041		0.016	0.085*
		(0.050)	(0.034)		(0.034)	(0.045)
Zoning Approval		0.031	-0.006		0.033	0.037
		(0.032)	(0.032)		(0.030)	(0.034)
Approval Delay			-0.055			-0.082**
			(0.052)			(0.032)
Density Rest.			-0.061			-0.066
			(0.090)			(0.104)
Exactions			-0.116			0.172*
			(0.106)			(0.103)
Open Space			0.063			-0.005
			(0.088)			(0.080)
Political Pressure			0.082**			-0.048
			(0.036)			(0.031)
Supply Restrictions			-0.048			0.036
			(0.038)			(0.031)

Notes: N=198. Random effects estimates. Robust clustered standard errors are in parentheses. Estimates with ** and * are statistically significant at the five percent and the ten percent level, respectively. Other regressors whose results are suppressed include chain dummies, population, the number of establishments, per capita income, area, construction price index, dummy variables for MSA, access to commercial airports and interstate highways. Population, the number of establishments, per capita income and area are in logs.

is at the first (Orange county), second (Taylor county) and the third (Williamson county) sample quartile, respectively. In each of these three markets, I derive a Markov perfect equilibrium under three different policies: (i) lenient, (ii) observed and (iii) stringent. Each of these policies differs in the value of land use regulation indices. Under the observed policy, operating costs and entry costs are set equal to my second stage estimates of this market. Under the lenient policy, these costs are set equal to the amount when this market's land use regulation indices were lower by one standard deviation. To calculate this change, I use the parameter estimates in the third column of Table 11. I set the parameters to be zero when their estimates are not statistically significant at the ten percent level. I calculate operating costs and entry costs in the stringent policy in a similar way. Under the stringent policy, land use regulation indices are higher by one standard deviation.

Table 12 reports the results of the counterfactual experiments. Both the number of hotels and the revenue per room take on the average values in an invariant distribution, while the producer surplus comes from the value of the value function in this invariant distribution when no hotels are in operation in the market.[42] These results indicate that the cost increase due to stringent land use regulation has a sizable effect on chains' entry decisions. For example, consider Taylor County, whose population is around the sample median. According to my simulation results, under the lenient policy, the average number of hotels in this market is 7.8. As the policy becomes more stringent, this number decreases to 7.2 (observed) and 6.7 (stringent). Assuming the number of rooms in each hotel is equal to the chain average, these results imply that imposing stringent regulation increases the revenue per room by 4 percent. These increases are suggestive of higher prices in the market with more stringent regulation. Despite their higher market power, the hotel chains do not necessarily make higher profits. According to the results, the total producer surplus decreases by $8.4 million in moving from Lenient to Observed and $7.3 million in moving from Observed to Stringent.

[42] I am unable to calculate the consumer surplus since the model abstracts the demand side by using the revenue function.

Table 12: Results of Counterfactual Experiments for Selected Markets

	Orange	Taylor	Williamson
Market Characteristics			
Population	85.0	125.0	333.5
Number of Establishments	1.4	3.4	5.8
MSA Dummy	1.0	1.0	1.0
Airport Dummy	0.0	1.0	0.0
Interstate Highway Dummy	1.0	1.0	1.0
Regulation Indices			
WRLURI	0.6	0.9	0.8
Project Approval	-0.3	1.1	-0.5
Zoning Approval	-0.2	-1.7	0.0
Expected Number of Hotels			
Lenient	5.4	7.8	8.7
Observed	4.8	7.2	8.1
Stringent	4.3	6.7	7.6
Expected Daily Revenue per Room (in dollars)			
Lenient	36.7	55.6	58.9
Observed	38.7	58.1	61.3
Stringent	40.8	60.6	63.9
Producer Surplus (in million dollars)			
Lenient	23.2	66.4	81.2
Observed	19.0	58.0	71.7
Stringent	15.7	50.7	63.2

Notes: Daily revenue per room is obtained by dividing quarter revenue of Best Western by ninety-two days. Using the value of other hotel chains makes little difference in calculating the percentage change in the revenue per room under the three different policies.

One obvious concern with this exercise is the possibility of multiple equilibria. In Table 12, I report the equilibrium that my computer program happens to find, while other equilibria may exist. A natural question is whether the reported numbers of this equilibrium are significantly different from those of other equilibria in the same game. I suspect that it is unlikely to be the case. In my model, hotel chains' entry decisions are strategic substitutes. While each equilibrium may be different in terms of which chains are more aggressive than the other chains, the aggregate numbers, such as the total number of hotels, are likely to be similar.

8 Discussion

This section discusses several issues concerning the validity of my estimates.

8.1 Sample Selection

The main estimates in the previous section are based on the observations from the 35 counties in Texas. As described in Section 2, these 35 counties are chosen based on the four criteria: (1) land use regulation indices are available, (2) they are not located in the center of the four largest MSAs, (3) population is more than 50,000, and (4) more than four turnovers occurred during the sample period. A natural question is whether these estimates are subject to selection bias.

Among these four, the last criterion seems most problematic as the selection is based on entry-exit decisions of the hotel chains. For example, suppose that markets with high entry costs tend to undergo fewer entries and hence are less likely to be in my sample. If this high entry cost is due to some factors not observable to the econometrician, my regressions in the third stage are subject to a selection bias.

I partially overcome this problem by employing the population threshold (third criterion) so that I can transform endogenous sample selection into exogenous sample selection. Most markets with little turnover are small in terms of population. Since the number of incumbents tends to be small in these markets, incumbents' chance of receiving extreme shocks are relatively low and, therefore, the chance of observing turnover in these markets is also small. Nonetheless, this threshold is not a silver bullet. Even with this threshold, our estimates may still be subject to selection bias as I drop the four counties that have more than 50 thousand population but underwent little turnover.

Another possible source of selection bias relates to the availability of land use regulation indices. When some unobservable factors that affect the availability of the indices are correlated with factors that affect costs, my estimates are subject to selection bias. There are several possible reasons that regulation indices are unavailable. For example, municipalities with no effective land use regulation may have no officer in charge of land use regulation and hence do not answer the survey. As another example, markets with tight regulation may be hesitant to report their regulation to avoid unnecessary scrutiny. In either case, these factors do not seem to affect unobservable market-specific cost factors in a significant way.

8.2 Endogeneity of the Number of Hotels in the Revenue Function Estimates

The validity of the revenue function estimates relies on the strong exogeneity assumption. At the least, this assumption requires that hotel chains have no specific information about their hotels' current and future revenue shocks when they make their entry-exit decisions. In other words, it assumes that past revenue shocks are not a good predictor for current and future revenue shocks. Although the current specification controls for both market and chain fixed effects, such an assumption may still be restrictive at least for the following two reasons. First, it assumes that hotels in the same market under the same chain have the same profitability. This may not be true in reality due to the differences in locations within the market and abilities of their managers. Second, both markets and chains may receive serially-correlated shocks. In these cases, hotel chains may want to increase the number of hotels for example, in markets that received high positive shocks in the past as they expect these positive shocks to stay for a while. Incorporating these shocks into the structural model requires it to have unobservable state variables. The structural model presented in this paper abstracts away these factors, as doing so prohibits the use of the two-step estimation approach.

8.3 Endogeneity of Land Use Regulation

Market-specific costs and the stringency of land use regulation may be determined simultaneously. For example, consider a local market whose cost of doing business is high for some reason other than land use regulation. To stimulate its economy, the local government of this market might not impose tight regulations to attract businesses. If this is the case, the regression estimates are possibly inconsistent. The standard solution of this problem is to find valid instruments that exogenously shift the stringency of land use regulation. However, there is little hope of finding such valid instruments,[43] let alone the fact that I would have to find eight different such instruments.

8.4 Age of Hotels

Another factor my structural model does not explicitly take into account is the age of buildings. Operating hotels at certain quality levels may become more expensive as buildings get older. If this were a primary cause of closures of hotels, structural estimates of my model could be misleading. To examine this concern, I calculate the five-year survival rates of new hotels in ten different cohorts. If the age of buildings explained most closure of hotels, I would expect very few hotels to close within their first five years. Table 13 reports these survival rates. Roughly speaking, about one out of every four hotels is out of business within the first five years. These closures do not seem to be the result of the age of building. Although not all the new hotels are necessarily new buildings, it is hard to imagine that people open hotels anticipating their closure in five years because of the age of their buildings.

[43] McMillen and McDonald (1991a) examines the possible selection bias in land value function estimation when zoning decisions are endogenous. For instruments, they use an indicator variable that denotes whether a parcel is incorporated or not by municipalities. This instrument is not applicable here since my study focuses on the effects of land use regulation on a county as a whole rather than each single parcel within a county.

Table 13: Five-year Survival Rates of New Hotels

Years of Opening	# of Hotels	Five-year Survival Rates
1991	14	0.571
1992	7	0.571
1993	13	0.615
1994	19	0.684
1995	23	0.913
1996	38	0.816
1997	26	0.769
1998	21	0.667
1999	27	0.704
2000	22	0.773

8.5 Regulation Change During the Sample Period

One underlying assumption of my empirical model is that there are no major changes in the stringency of land use regulation during the sample period. To make sure of the relevance of this assumption, I collect the year in which each market adopted its current zoning ordinance,[44] using the ordinance of the municipality that is the county seat of each market.[45] If a market adopted its current zoning code before the initial sample period of this paper, I can at least say that a major revision of zoning codes did not occur during the sample period.

Table 14 reports the distribution of the thirty five markets in terms of the year they adopted their current zoning codes. Fifty percent of them adopted their current ordinance before the initial sample period, while less than one-fourth of them adopted one during the sample period. Assuming the markets that adopted the current zoning codes after the final sample period had not changed them significantly during the sample period, about seventy percent of these markets did not undergo major revisions of their zoning codes during the sample period. This approach has two limitations. First, it does not take into account amendments to the existing zoning codes: some amendments may have significant impacts

[44] Most of these data are collected from the website of Municipal Code Corporation (http://www.municode.com). The data not available on this website are obtained from various on-line sources including municipalities' websites.

[45] One exception is Bowie County. While its county seat is New Boston, I have used the information from Texarkana as it is clearly larger than New Boston.

Table 14: The Sample Distribution of the Year in which the Current Zoning Codes Adopted

	N
Before the initial sample period (-1990)	17
During the sample period (1990-2005)	9
After the final sample period (2006-2010)	6
N/A	3
Total	35

on the costs of hotels. Second, zoning codes are only one of the factors that may affect the stringency of land use regulation. For example, it could be the case that a change in a member of the zoning committee makes a significant difference in the enforcement of land use regulation.

9 Conclusion

This paper has studied the role of land use regulation as a barrier to entry in local business markets, focusing on the Texas lodging industry. The estimation results indicate that stringent land use regulation lessens local competition by increasing the costs of hotels. According to my estimates, a one standard deviation increase in regulatory stringency increases the operating cost by 8 percent and the entry costs by 6 percent, respectively. This cost increase discourages hotel chains' entry, decreasing the equilibrium number of hotels by 0.5. As a result, the revenue-per-room -a proxy for the price- increases by 4 percent.

To the best of my knowledge, this paper is the first to examine the anticompetitive effect of land use regulation on local business markets empirically. Although people in the lodging business and legal scholars have noticed it, there has been no formal analysis that quantifies this effect. This paper also introduces structural estimation to the empirical literature on studying land use regulation. The structural estimation employed in this paper has the advantage of separately identifying the impacts of land use regulation on costs from those on demand.

Note that this paper focuses on the anticompetitive effect of land use regulation and ignores other possible benefits and costs. Therefore, the results of this paper are not sufficient per se to make final judgments about the efficacy of land use regulation. When it generates benefits to society through some other channels (e.g., resolves externalities), land use regulation could be beneficial overall, despite the potential distortion that has been the focus of this paper.

References

Arellano, M. and S. Bond (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *Review of Economic Studies 58*(2), 277–297.

Bajari, P., C. L. Benkard, and J. Levin (2007). Estimating dynamic models of imperfect competition. *Econometrica 75*(5), 1331–1370.

Berry, S. T. (1992). Estimation of a model of entry in the airline industry. *Econometrica 60*(4), 889–917.

Berry, S. T. and P. C. Reiss. Empirical models of entry and market structure. in M. Armstrong and R. Porter, eds., *Handbook of Industrial Organization, Volume 3* (Amsterdam: Elsevier, 2007, pp.1845-1886).

Bertrand, M. and F. Kramarz (2002). Does entry regulation hinder job creation? Evidence from the French retail industry. *Quarterly Journal of Economics 117*(4), 1369–1413.

Bresnahan, T. F. and P. C. Reiss (1990). Entry in monopoly markets. *Review of Economic Studies 57*(4), 531–553.

Cheshire, P. and S. Sheppard (2004). Land markets and land market regulation: Progress towards understanding. *Regional Science and Urban Economics 34*(6), 619–637.

Chung, W. and A. Kalnins (2001). Agglomeration effects and performance: A test of the

Texas lodging industry. *Strategic Management Journal 22*(10), 969–988.

Conlin, M. and V. Kadiyali (2006). Entry-deterring capacity in the Texas lodging industry. *Journal of Economics & Management Strategy 15*(1), 167–185.

Dela Cruz, T. (2003). Developers overcome obstacles for desirable projects. *Hotel & Motel Management 218*(14), 26.

Doraszelski, U. and M. Satterthwaite (2010). Computable markov-perfect industry dynamics. *RAND Journal of Economics 41*(2), 215–243.

Evans, A. W. The land market and government intervention. in P. Cheshire and E. S. Mills, eds., *Handbook of Regional and Urban Economics, Volume 3* (Amsterdam: Elsevier, 1999, pp.1637-1669).

Glaeser, E. L., J. Gyourko, and R. Saks (2005). Why is Manhattan so expensive? Regulation and the rise in housing prices. *Journal of Law and Economics 48*(2), 331–369.

Glaeser, E. L. and B. A. Ward (2009). The causes and consequences of land use regulation: Evidence from Greater Boston. *Journal of Urban Economics 65*(3), 265–278.

Gyourko, J., A. Saiz, and A. A. Summers (2008). A new measure of the local regulatory environment for housing markets: The Wharton Residential Land Use Regulatory Index. *Urban Studies 45*, 693–729.

Kalnins, A. (2004). An empirical analysis of territorial encroachment within franchised and company-owned branded chains. *Marketing Science 23*(4), 476–489.

Mazzeo, M. J. (2002). Product choice and oligopoly market structure. *RAND Journal of Economics 33*(2), 221–242.

McConnell, V., M. Walls, and E. Kopits (2006). Zoning, TDRs and the density of development. *Journal of Urban Economics 59*(3), 440–457.

McMillen, D. P. and J. F. McDonald (1991a). A simultaneous equations model of zoning and land values. *Regional Science and Urban Economics 21*(1), 55–72.

McMillen, D. P. and J. F. McDonald (1991b). Urban land value functions with endogenous zoning. *Journal of Urban Economics 29*(1), 14–27.

Nishida, M. (2012). Estimating a model of strategic network choice: The convenience-store industry in Okinawa. mimeo, Johns Hopkins University, 2012.

OECD. Land use restrictions as barriers to entry. Best Practice Roundtables on Competition Policy, 2008.

Powers, T. F. *Introduction to Management in the Hospitality Industry,* 4th ed. New York: Wiley, 1992.

Quigley, J. M. Regulation and property values: The high cost of monopoly. in G. K. Ingram and Y. Hong, eds., *Land Policies and Their Outcomes* (Lincoln Institute of Land Policy, 2007, pp.46-66).

Quigley, J. M. and S. Raphael (2005, May). Regulation and the high cost of housing in California. *American Economic Review 95*(2), 323–328.

Ridley, D. B., F. A. Sloan, and Y. Song. Retail zoning and competition. mimeo, Duke University, 2010.

Ryan, S. (2012). The costs of environmental regulation in a concentrated industry. *Econometrica 80*(3), 1019–1061.

Saiz, A. (2010). The geographic determinants of housing supply. *Quarterly Journal of Economics 125*(3), 1253–1296.

Sullivan, E. T. (2000). Antitrust regulation of land use: Federalism's triumph over competition, the last fifty years. *Washington University Journal of Law and Policy 3*, 473–512.

Train, K. *Discrete Choice Methods with Simulation.* Cambridge: Cambridge University Press, 2003.

Wu, J. and S.-H. Cho (2007). The effect of local land use regulations on urban development in the Western United States. *Regional Science and Urban Economics 37*(1), 69–86.

A Appendix: Other Data

Demographic data is from the decennial census and *the Regional Economics Information System*, provided by the Bureau of Economic Analysis. This demographic data includes population, per capita personal income and area. The number of establishments is obtained from *County Business Patterns* provided by the Census Bureau. These establishments include any business unit that has physical locations in corresponding counties. Examples include supermarkets, factories, business offices, restaurants and hotels. I also construct dummy variables for each county's access to the Interstate Highway System along with its access to commercial airports from road maps and the Internet. Construction cost data comes from *Means Square Foot Costs* provided by RSMeans.

B Appendix: Derivation of the Choice Probabilities

This appendix derives the choice probabilities when a hotel chain's decision problem is written as

$$\max\left(\Pi\left(1,\mathbf{s}\right)+\upsilon_1,\ \Pi\left(0,\mathbf{s}\right),\ \Pi\left(-1,\mathbf{s}\right)+\upsilon_2\right).$$

I omit all subscripts for simplicity. While this model is quite similar to the standard multinomial logit model, the lack of a stochastic shock in a particular choice (i.e., $a = 0$) gives rise to different forms of the choice probabilities. The derivation is quite similar to that of the standard multinomial logit model shown in, for example, Train (). For notational purpose, I first rewrite this problem as

$$\max\left(g_1+\upsilon_1,\ g_0,\ \upsilon_{i2}\right)$$

where

$$\begin{aligned}
g_1 &= \Pi\left(1,\mathbf{s}\right)-\Pi\left(-1,\mathbf{s}\right) \\
g_0 &= \Pi\left(0,\mathbf{s}\right)-\Pi\left(-1,\mathbf{s}\right).
\end{aligned}$$

The probability that hotel chains choose no change is

$$\begin{aligned}
\Pr\left(a=0\right) &= \Pr\left(g_0>\upsilon_2 \text{ and } g_0>g_1+\upsilon_1\right) \\
&= F\left(g_0\right)\cdot F\left(g_0-g_1\right) \\
&= \exp\left(-e^{-\left(g_0+\bar{\gamma}\right)}\right)\cdot\exp\left(-e^{-\bar{\gamma}-\left(g_0-g_1\right)}\right) \\
&= \exp\left(-e^{-\left(g_0+\bar{\gamma}\right)}\left(1+e^{g_1}\right)\right),
\end{aligned}$$

where $\bar{\gamma}$ is Euler's constant (i.e., $\bar{\gamma}\approx 0.57722$).

The probability that hotel chains choose to close a hotel is

$$\begin{aligned}
\Pr\left(a=-1\right) &= \Pr\left(\upsilon_2>g_0 \text{ and } \upsilon_2>g_1+\upsilon_1\right) \\
&= \int_{-\infty}^{\infty} 1\left(\upsilon_2>g_0\right)\cdot F\left(\upsilon_2-g_1\right)dF\left(\upsilon_2\right) \\
&= \int_{-\infty}^{\infty} 1\left(\upsilon_2>g_0\right)\exp\left(-e^{-\left(\upsilon_2-g_1+\bar{\gamma}\right)}\right)\exp\left(-\left(\upsilon_2+\bar{\gamma}\right)\right)\exp\left(-e^{-\left(\upsilon_2+\bar{\gamma}\right)}\right)d\upsilon_2 \\
&= \int_{g_0}^{\infty}\exp\left(-e^{-\left(\upsilon_2+\bar{\gamma}\right)}\left(e^{g_1}+1\right)\right)e^{-\left(\upsilon_2+\bar{\gamma}\right)}d\upsilon_2.
\end{aligned}$$

Denoting $t = e^{-(\upsilon_2+\bar{\gamma})}$, I have $d\upsilon_2 = -\frac{dt}{e^{-(\upsilon_2+\bar{\gamma})}} = -\frac{dt}{t}$.

$$\begin{aligned}
\Pr(a=-1) &= \int_{e^{-(g_0+\bar{\gamma})}}^{0} \exp\left(-t\left(e^{g_1}+1\right)\right) t \left(-\frac{dt}{t}\right) \\
&= \int_{0}^{e^{-(g_0+\bar{\gamma})}} \exp\left(-t\left(e^{g_1}+1\right)\right) dt \\
&= \left[\frac{e^{-t(e^{g_1}+1)}}{-\left(e^{g_1}+1\right)}\right]_0^{e^{-(g_0+\bar{\gamma})}} \\
&= \left(1-\exp\left(-e^{-(g_0+\bar{\gamma})}\left(1+e^{g_1}\right)\right)\right)\cdot\frac{1}{e^{g_1}+1} \\
&= \left(1-\Pr(a=0)\right)\cdot\frac{1}{e^{g_1}+1}.
\end{aligned}$$

Finally, the probability that hotel chains choose to open a new hotel (i.e., $a=1$) is

$$\begin{aligned}
\Pr(a=1) &= 1-\Pr(a=-1)-\Pr(a=0) \\
&= 1-\left(1-\Pr(a=0)\right)\frac{1}{e^{g_1}+1}-\Pr(a=0) \\
&= \left(1-\Pr(a=0)\right)\cdot\frac{e^{g_1}}{e^{g_1}+1}.
\end{aligned}$$

Summarizing the results, if $h \in \{1,\cdots,6\}$,

$$\begin{cases}
\Pr(a=-1) = \left(1-\exp\left(-e^{-(g_0+\bar{\gamma})}\left(1+e^{g_1}\right)\right)\right)\cdot\frac{1}{e^{g_1}+1} \\
\Pr(a=0) = \exp\left(-e^{-(g_0+\bar{\gamma})}\left(1+e^{g_1}\right)\right) \\
\Pr(a=1) = \left(1-\exp\left(-e^{-(g_0+\bar{\gamma})}\left(1+e^{g_1}\right)\right)\right)\cdot\frac{e^{g_1}}{e^{g_1}+1}
\end{cases}$$

or

$$\begin{cases}
\Pr(a=-1) = \left(1-U(s)\right)\cdot\frac{1}{1+\exp(\Pi(1,\mathbf{s})-\Pi(-1,\mathbf{s}))} \\
\Pr(a=0) = U(s) \\
\Pr(a=1) = \left(1-U(s)\right)\cdot\frac{\exp(\Pi(1,\mathbf{s})-\Pi(-1,\mathbf{s}))}{1+\exp(\Pi(1,\mathbf{s})-\Pi(-1,\mathbf{s}))},
\end{cases}$$

where

$$U(s) = \exp\left(-e^{-(\Pi(0,\mathbf{s})+\bar{\gamma})}\left(e^{\Pi(-1,\mathbf{s})} + e^{\Pi(1,\mathbf{s})}\right)\right).$$

If $h = 0$, hotel chains cannot close a hotel and hence $\Pi(-1, \mathbf{s}) \to -\infty$. As a result, the choice probabilities are written as

$$\begin{cases} \Pr(a = -1) = 0 \\ \Pr(a = 0) = \exp\left(-e^{\Pi(1,\mathbf{s})-\Pi(0,\mathbf{s})-\bar{\gamma}}\right) \\ \Pr(a = 1) = 1 - \exp\left(-e^{\Pi(1,\mathbf{s})-\Pi(0,\mathbf{s})-\bar{\gamma}}\right). \end{cases}$$

If $h = 7$, hotel chains cannot open a hotel and hence $\Pi(1, \mathbf{s}) \to -\infty$. As a result, the choice probabilities are written as

$$\begin{cases} \Pr(a = -1) = 1 - \exp\left(-e^{-(\Pi(0,\mathbf{s})-\Pi(-1,\mathbf{s})+\bar{\gamma})}\right) \\ \Pr(a = 0) = \exp\left(-e^{-(\Pi(0,\mathbf{s})-\Pi(-1,\mathbf{s})+\bar{\gamma})}\right) \\ \Pr(a = 1) = 0. \end{cases}$$

Table 15: Transition Function Estimates

	Dependent Variables		
	(1)	(2)	(3)
	State-Wide Sales	Population	Establishments
Lagged Dep. Var.	0.992	0.998	0.932
	(0.020)	(0.005)	(0.125)
Estimator	OLS	Arellano and Bond (1994)	

Notes: N=63 for sales and 490 for establishments and population. Standard errors are in parentheses. All dependent variables are in log. Estimates and standard errors for quarter dummy (for (1)) and year dummies (for (2) and (3)) are suppressed.

C Appendix: Transition Functions Estimation

This brief appendix documents the specification of the transition functions of exogenous market characteristics $\mathbf{x}_{1mt}$ and reports the estimates. This vector consists of three components: (i) population, (ii) the number of establishments and (iii) state-level sales of mid-scale hotels. I specify the modeling of the first two components as AR1 with market-specific fixed effects as well as time-specific fixed effects. I estimate this dynamic panel model using the estimator proposed by Arellano and Bond (1991). For the state-wide sales, I employ a simple AR1 model and estimate its parameters by running the OLS. Table 15 reports the estimates of these models.

D Appendix: Implementing Forward Simulations

The steps below explain how to calculate (10) by simulation.

1. Fix a market m and a hotel chain i.

2. Simulate a series of exogenous time-variant market specific variables over T periods for N_S times by using the AR1 models obtained in the first stage. Let $\{\widetilde{\mathbf{x}}^n_{m\tau}\}^T_{\tau=1}$ denote

its nth series. For the initial value $\widetilde{\mathbf{x}}_{m1}^{n}$, use the corresponding value in the raw data at the initial sample period in market m.

3. Simulate chain i's cost shocks $(\tilde{\upsilon}_{1im\tau}^{n}, \tilde{\upsilon}_{2im\tau}^{n})$ over T periods Ns times by generating random draws from the Type I extreme value distribution whose mean is normalized to be zero and whose variance is equal to $\frac{\pi^2}{6}$.

4. Generate chain i's N_I alternative policies by perturbing the observed policy function obtained in the first stage. I implement this perturbation as follows: first I generate N_I vectors, $\left(\gamma^1, \cdots, \gamma^{N_I}\right)$ of i.i.d. random draws from the standard normal. The length of γ^k is equal to the number of the parameters of the policy functions. Second, I perturb the estimates of the observed policy function by multiplying $\left(1 + .005\gamma^k\right)$ to their parameter estimates.

5. For every $k \in \{1, 2, \cdots, N_I\}$, simulate chain i's expected revenue $\left\{\widetilde{ER}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$, the number of hotels it operates $\left\{\tilde{h}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$, its entry and exit decisions $\left\{\tilde{a}_{im\tau}^{k,n}\right\}_{\tau=0}^{T}$ and its private cost shocks $\{\tilde{\upsilon}_{1im\tau}^{n}, \tilde{\upsilon}_{2im\tau}^{n}\}_{\tau=0}^{T}$ Ns times when σ_{im}^{k} decides its choice while its rivals' decisions are based on the observed policies $\left\{\sigma_{-im}^{0}\right\}$.

   (a) At the beginning of the nth simulation, set the initial state $\widetilde{\mathbf{s}}_{m1}^{k,n} = \left(\widetilde{\mathbf{h}}_{m1}^{k,n}, \widetilde{\mathbf{x}}_{m1}^{n}\right)$. For the initial value $\widetilde{\mathbf{h}}_{m1}^{k,n}$, use the corresponding value in the raw data at the initial sample period in market m.

   (b) Simulate the choice of all hotel chains at period one $\widetilde{\mathbf{a}}_{im1}^{k,n}$ by using σ_{im}^{k} and $\{\tilde{\upsilon}_{1im1}^{n}, \tilde{\upsilon}_{2im1}^{n}\}$ for chain i's choice, and σ_{-im}^{0} for the choices of the other chains. Update the state variables $\widetilde{\mathbf{s}}_{m2}^{k,n} = \left(\widetilde{\mathbf{h}}_{m2}^{n}, \widetilde{\mathbf{x}}_{m2}^{n}\right) = \left(\widetilde{\mathbf{h}}_{m1}^{k,n} + \widetilde{\mathbf{a}}_{m1}^{k,n}, \widetilde{\mathbf{x}}_{m2}^{n}\right)$. I need to simulate chain i's choice by using $\{\tilde{\upsilon}_{1m1}^{n}, \tilde{\upsilon}_{2m1}^{n}\}$ so that I can calculate the entry and exit costs chain i actually incurs. In contrast, I can simulate the other chains' choices by directly using the choice probability based on σ_{-im}^{0}, since further steps do not require the entry and exit costs these chains incur.

(c) Simulate a series of state variables over T periods $\left\{\widetilde{\mathbf{s}}_{m\tau}^{k,n}\right\}_{\tau=1}^{T}$ by iterating the process shown in (b) T times.

(d) Calculate chain i's expected revenue $\widetilde{ER}_{imt}^{k,n}$ by using the revenue function estimates and $\widetilde{\mathbf{s}}_{mt}^{k,n} = \left(\widetilde{\mathbf{h}}_{mt}^{k,n}, \widetilde{\mathbf{x}}_{mt}^{n}\right)$.

(e) Calculate (10).

E Appendix: Recovering the Construction Cost of a Midscale Chain Hotel

This appendix describes the procedure I follow to calculate the construction cost of a midscale chain hotel in Texas from industry sources. I limit my focus to Best Western and La Quinta since their websites provide detailed information about their prototype models (though not construction costs). Calculations proceed in three steps. I first estimate the total building square footage of their prototype hotels. I next estimate the cost per square foot cost for hotel construction in Texas. Finally, I obtain a construction cost estimate from the product of these two numbers.

My calculation of the total building square footage of a Best Western hotel and La Quinta hotel relies on the brochures they put on their websites. Among several prototypes proposed by these two chains, I look at Classic Mid-Scale Prototype for Best Western[46] and Design B Prototype for La Quinta.[47]

Best Western's floor plan shows the amount of area allocated to each function of a hotel (e.g, guest rooms and administrative). Although I am able to obtain the total building square footage of this prototype by summing up these numbers, I do not use this sum directly since this prototype seems to reflect higher standards imposed on newly constructed hotels only and hotels in my sample do not necessarily follow this higher standard. First, its

[46] http://www.bestwesterndevelopers.com/resources/classic/AS1.00.pdf
[47] http://www.lq.com/lq/about/franchise/PrototypeGuide-B.pdf

Table 16: Total Building Square Footage for a Best Western hotel

Functions		Area (Sq. Foot)
Sixty Guest Rooms		16,800
Guest Room Support	Corridors, Stairs, Guest Laundry	4,741
Administrative	Offices	545
Public Areas	Lobby, Business Center, Fitness Center	4,415
Back of House Areas	Employee Lounge, Linen, Storage	3,099
Total		29,600

The average guest rooms size is assumed to be 280 square feet.

prototype has more rooms than those in my sample (80 rooms vs. 60 rooms). Second, this prototype reflects a minimum room size requirement imposed on only new hotels (312 square feet) rather than that imposed to existing hotels (200 square feet). Based on these facts, I consider a hotel that has 60 guest rooms, each of 280 square feet. Assuming the amount of area used for other functions are not different between this prototype and existing hotels, I set a total building square footage of a Best Western hotel during my sample period to be 29,600 foot. Table 16 provides a breakdown of this calculation. For La Quinta, I use the total building square footage shown in the brochure since the capacity difference between this prototype and the sample median is relatively small (114 rooms vs. 105 rooms), and the brochure does not provide the breakdown of this total building square footage anyway. As a result, I use 55,041 square feet as the total building square footage for a La Quinta hotel.

I next calculate the square foot construction cost for a motel. RS-Means provides a square foot construction cost for various types of commercial building. Among them, I employ the one for a two-to-three story motel. To reflect locational difference of construction costs, I also employ Location Factors, a price index provided by RS-Means. Finally, I normalize this square foot cost to year 2000 dollars by employing the Turner Building Cost Index provided by Turner Construction. Following these steps, I obtain \$81.3 for the square foot cost.[48]

Finally, I multiply the obtained square foot cost by the total building square footage. As a result, I obtain \$2,407 thousand dollars ($= 81.3 \times 29,600$) as an estimate for the total construction cost of a Best Western hotel and \$4,505 thousand dollars for that of a La Quinta hotel.

[48] The breakdown of this calculation is 147.75 dollar as a square footage construction cost, .790 as a location factor and .697 as Turner Building Cost Index. Rounding generates a slight difference between the product of these three numbers and the number shown in the text.