Maximum or Minimum? Strategic Patterns of the Lodging Industry*

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Abstract

Two-dimensional Hotelling models predict that firms choose to maximally differentiate on one dominant characteristic and minimally differentiate on the other dominated characteristic. When consumers have more choices, firms tend to improve all dimensions. This study uses lodging tax data from the Texas Comptroller of Public Accounts to examine the joint choices of geographic location and product positioning (or brand) by multi-unit hotel operators at different market boundary levels. First, our findings suggest that greater distance between own hotels is associated with less product differentiation, which implies a max-min equilibrium. Second, considering the coexistence of horizontal and vertical differentiation, we obtain a higher likelihood a hotel will be of the same quality tier as its nearest neighbor the nearer the neighbor; while a farther distance to nearest neighbor increases the degree of quality differentiation in the scenario of vertical differentiation. This implies both min-max and max-max equilibria are obtained. Third, owners with properties at different levels of quality are more likely to add new properties that are higher quality, while more geographically differentiated portfolios add lower quality properties at the margin. We obtain a max-min equilibrium. Therefore, our findings provide insights into the strategic motivations of multi-unit owners and, within their decisions, the relevant dominance of place versus market position.

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Keywords: Multi-unit owners, two-dimensional Hotelling model, horizontal differentiation, vertical differentiation, location choice

I. Introduction

This study examines the joint choices of geographic location and product positioning (or brand) by multi-unit operators in the US lodging industry. Multi-unit owners in the lodging industry can operate two distinct product market strategies: horizontal or vertical differentiation. On the one hand, *horizontal differentiation* means that the product variant is defined as the operating brand at a given quality, or amenity, level.[1] Multi-unit owners might simultaneously operate several same-tier/cross-chain hotels; e.g., Holiday Inn, Comfort Inn, and Hampton Inn. These hotel brands all rate as the upper midscale tier but they belong to different hotel chains. On the other hand, multi-unit owners might operate multiple cross-tier/same-chain hotels. This product portfolio is called *vertical differentiation* because the product variant is defined as the quality, or service tier, type. For instance, a multi-unit owner may simultaneously operate hotels that are named Hilton, Hilton Garden Inn, and Hampton Inn. These hotel brands rate from the upper upscale tier to the upper midscale tier, and belong to Hilton Worldwide family.

What does the market look like in the presence of horizontal or vertical differentiation? Will multi-unit owners cluster or disperse their establishments? Will multi-unit owners undertake diversified product positioning in different markets? Or will they cater to a particular subset of consumers? Does the current portfolio of hotels influence the quality choice of new hotels? Multi-unit owners' choices of location and brand are considered the two-dimensional horizontal model, while their choices on location and quality are considered the two-dimensional horizontal and vertical model. The literature on two-dimensional Hotelling models concludes that firms choose to maximally differentiate on one characteristic and minimally differentiate on the other (Ansari et al., 1998; Irmen and Thisse, 1998; Neven and Thisse, 1990). Equilibrium profits will be higher under this configuration because differentiation on one characteristic weakens price competition on the other characteristic.

Irmen and Thisse (1998) further implied that firms choose to maximally differentiate on the dominant characteristic, the one that matters most to consumers. We argue that, assum-

ing the geographic location is the dominant characteristic and the brand is the dominated characteristic, the model implies that multi-unit owners will structure their establishment portfolios to be geographically differentiated while choosing less differentiated brands. Alternatively, if the geographic location is the dominated characteristic and the brand is the dominant characteristic, the model implies that multi-unit owners will locate their establishments near one another in a geographic space while choosing highly differentiated brands.

If multi-unit owners build a new establishment in the geographic market where competitors and their incumbent establishments are present, the owners must choose the geographic distance of the new establishment relative to competitors and incumbents. This dynamic raises an interesting question: Does the new establishment locate close to competitors or close to incumbents of the same owner?

Empirical studies on two-dimensional Hotelling models are limited. Netz and Taylor (2002) and Iyer and Seetharaman (2008) examined the relationship between geographic location and product differentiation in the retail gasoline industry. Netz and Taylor (2002) found that retailers become more differentiated on service offerings as geographic differentiation increases. The researchers obtained a max-max equilibrium in which firms maximally differentiate themselves on both characteristics. Iyer and Seetharaman (2008) found that, however, retailers are more likely to differentiate service levels as the distance decreases between establishments. Iyer and Seetharaman's (2008) findings were consistent with the existing literature on two-dimensional Hotelling models, where firms maximally differentiate themselves on one dimension and minimally differentiate on the other dimension. Watson (2009) found that, in the retail eyeglass industry, retailers sell varied styles of eyeglasses and retail establishments are adjacent to each other. Elizalde (2013) analyzed the movie theater market and showed a trade-off between the geographical location and the set of movies. To the best of our knowledge, no empirical studies on two-dimensional Hotelling models have focused on the lodging industry.

This study offers a test of the prediction using unique and detailed data from the Texas

lodging industry at a multi-unit owner level to examine the relationship between a hotel's product positioning and location choice at different market boundary levels. We observe the full population of hotels in Texas, which allows a direct comparison between horizontal and vertical differentiation on the location pattern, rather than relying on the observations of one family of hotel chains. Moreover, the data include establishment characteristics such as the number of rooms, sales, operating name or brand, location information (address, city and zip code, and geographic coordinates), and ownership information. This study controls for differences in the quality, or amenity level, of hotel brands using hotel brand service levels (e.g., "economy," "midscale," "upper midscale," "upscale," "upper upscale," and "luxury") defined by STR Global, a lodging industry research organization, by matching business name responses with the STR Global classification list.

The Texas lodging industry provides an ideal setting to examine our research questions for several reasons. First, hotel owners may compete in a large number of geographically distinct markets. Our study analyzes the portfolio of hotel owners at different market boundary levels, such as state-level, MSA-level, and establishment-level. Second, hotels offer mainly a single product, a stay in a room. Unlike other industries in which product differentiation is difficult to measure, this research can accurately capture the heterogeneity in product/service quality among hotels, based on their quality, or amenity, segments. Third, the ownership structure of multi-unit owners is common in the Texas lodging industry. Fourth, unlike retailers or firms in other service industries, hotel chain companies usually operate multiple hotels or have multiple hotel brands across geographic markets. Multiple hotel brands target different consumer segments, and each brand also has multiple establishments across geographic markets. Finally, the Texas lodging industry is a significant sector of the economy. According to a 2018 report from the American Hotel & Lodging Association, the total number of hotels in Texas is up to 5,144 establishments with approximately 458,000 rooms collectively. The Texas lodging industry creates 632,735 jobs and contributes $51 billion to the Texas economy.

Hotels seek to reduce competition and increase the market power by offering unique price/quality combinations to a particular segment of customers (Mazzeo, 2002). Studies have highlighted that customers are more likely to choose one particular segment of hotels than be loyal to one specific brand (Skogland and Siguaw, 2004). Hotels rarely change segments as chain companies endeavor to create and maintain their reputations by offering consistent amenities and services (Rushmore and Baum, 2001). Therefore, the empirical setting allows us to clearly examine the relationship between product heterogeneity and geographic location pattern.

Using data on the location and attributes of all the hotels in Texas, our study focuses on how the geographic portfolio affects the degree of product portfolio in different market boundary levels. First, at the state-level, our results show a significant negative relationship between product differentiation and geographic differentiation. The findings suggest greater distance is associated with less product differentiation, consistent with the max-min hypothesis that differentiates more on one dimension and less on the other dimension. Second, at the MSA-level, we obtain that geographic differentiation may increase the degree of product differentiation in the portfolio, which means that a max-max equilibrium is attained. Third, on the one hand, at the establishment-level, we obtain a higher likelihood an establishment will be of the same quality tier the nearer its nearest neighbor in the scenario of horizontal differentiation, which implies a min-max equilibrium. On the other hand, our results show that a farther distance to nearest neighbor increases the degree of quality differentiation in the scenario of vertical differentiation, which also implies a max-max equilibrium. Fourth, the results from the relationship between horizontal/vertical differentiation and the distance to the nearest portfolio member are similar with those for the nearest neighbor. We also obtain a max-max equilibrium.

Finally, we also analyze what strategic motivation drives the dynamic quality choice of the marginal hotel. On the one hand, we obtain a positive relationship between incumbent portfolio product differentiation and higher quality new members. Our results suggest that

owners with properties at different levels of quality are more likely to add new properties that are higher quality. On the other hand, our findings show that more geographically differentiated portfolios add lower quality properties at the margin. Our explanations are portfolios with greater geographic differentiation are more likely to add hotels at lower quality tiers, which generally operate at lower price-points and compete more directly on price rather than differentiated amenity attributes. More geographically concentrated portfolios add higher quality hotels that compete more directly on amenities and operate at higher price-points, and presumably margins. Similarly, portfolios that are already more differentiated in quality add higher quality hotels at the margin. Both of these results are generally consistent with the two-dimensional Hotelling results of competing on the higher margin attributes.

This research is organized as follows. The next section introduces a literature review on location theory, which focuses mainly on the two-dimensional Hotelling model. The theoretical background and hypotheses are developed in section III. The data is introduced in section IV and section V outlines an empirical model and results. The section VI concludes the research.

II. Literature Review

Hotelling (1929) integrated spatial (product) differentiation into market models and suggested that firms have incentives to minimally differentiate on location, given the assumptions of homogeneous goods, uniformly distributed consumers, and linear transportation costs. Subsequent works have demonstrated that almost any equilibrium configuration can be obtained based on the assumptions of the model such as the distribution of consumer locations, the elasticity of demand, the form of the transport cost, and consumer heterogeneity. Eaton and Lipsey (1975) showed that, if the distribution of consumers is nonuniform, the location of firms will be more concentrated, rather than a dispersed distribution. Relaxing the assumption of inelastic demand, Smithies (1941) mitigated the incentive for firms to minimally differentiate on location because, if they move too far from the endpoints of

the market, firms will lose consumers. D'Aspremont et al. (1979) claimed that, under the assumption of quadratic transportation cost, the best strategy of two firms is to locate as far away from each other as possible in an equilibrium of maximal differentiation. Meanwhile, de Palma et al. (1985) introduced consumer heterogeneity and claimed that minimal differentiation could be attained if the magnitude of demand is large enough.[2]

Regarding the location decision, firms face two opposite incentives which may generate mixed results. Firms have incentive to position their products close to competitors to capture more consumers. This situation represents the *market share effect* (Pinske and Slade, 1998). Working against this incentive, however, is the fact that reducing spatial or product differentiation leads to greater competition in the price dimension; thus, a firm has an incentive to locate farther from its competitors to reduce price competition. This scenario is called the *market power effect*. The equilibrium, clustering or differentiation, may be obtained depending on the assumption of the model. Irmen and Thisse (1998) characterized the theoretical literature as being more supportive of dispersion than clustering, suggesting that the market power effect dominates the market share effect.

Hotelling' model (1929) assumed that each firm has a single plant or product. However, there is no reason that a firm should not open several plants or sell several products to exercise more consumer surplus. Lancaster (1990) mentioned three main potential influences on a firm's choice of product variety: (1) the existence of inter-product economics on the production side; (2) the potential for increasing demand by offering more varieties; (3) the use of product variety for strategic purposes. Now, the firm must consider not only the location but also the number of plants or products. The bundling of products brings greater sales and profits because it allows firms to reach new consumers. In addition, because it is increasingly difficult to maintain or increase profitability levels, the firm has an incentive to stabilize its market position and relative price separation. By offering significantly more services than its competitors, a firm can maintain that position. Firms must decide on both price and the positioning of their offerings on more than one dimension. As a result,

Hotelling's conclusion must be modified when considering the introduction of more than one dimension.

When firms have discretion over the levels of more than one dimension, several configurations are possible, ranging from firms choosing the same level on all dimensions (no differentiation, i.e., min-min), to firms choosing as much separation as possible on all dimensions (maximal differentiation, i.e., max-max), and to firms choosing an *in-between* degree of differentiation (e.g., maximal differentiation on one dimension and minimal differentiation on the other, i.e., max-min; or maximal differentiation on one dimension and partial differentiation on the other, i.e., partial-max).

Differentiated products can be a set of products located at various places, which can be a combination of various levels of characteristics. The degree of product differentiation can be expressed in two separate ways (Lancaster, 1990). First, horizontal differentiation suggests there is no consensus ranking among consumers of the primary characteristics of the products. Differences between products are more subjective than objective. Consumers will buy the closest product in terms of the distance function to their preferred product, even if their most preferred version is unavailable. Second, vertical differentiation occurs when the there is a consensus ranking among consumers of the product's characteristics, as in the case of quality. Consumers desire high-quality products more than low-quality products when the prices of both products are the same.

Many studies have examined the horizontal case. Ben-Aliva et al. (1989) and de Palma et al. (1985) added a second dimension of horizontal differentiation. In other words, products that are offered at distinct locations have different brand specifications. Firms choose their location but not the brands they sell. Product differentiation is endogenous in the location dimension but exogenous in the brand dimension. The researchers showed that the collocation of firms is more likely when the transport cost, market size, and number of firms are smaller, and when the heterogeneity of tastes is larger. Similar findings are provided by Ansari et al. (1998), Irmen and Thisse (1998), and Tabuchi (1994). Their explanation is

that, if firms can differentiate on brands, the firms then have incentive to choose collocation because price competition is softened through product differentiation. Thus, when each characteristic can be weighted differently from the others–for example, when a dominant characteristic exists–then maximum differentiation occurs alongside the dominant characteristic. According to Irmen and Thisse (1998), differentiation in one dimension is enough to reduce price competition among firms and to allow firms to benefit from the advantage of locating in the central point of all other dimensions.

Other research has studied the two-dimensional vertical differentiation model. Hauser (1988) and Vandenbosch and Weinberg (1995) studied a model with two vertical characteristics (referring to quality) and found max-min product differentiation equilibria. If two quality dimensions are used to define a product specification, only one of the dimensions will be used to differentiate; the other will be equal across firms. In other words, in equilibrium, two firms tend to choose positions that will represent maximal differentiation on one dimension and minimal differentiation on the other dimension. Both firms want to have the highest quality, but the strategic force means only one firm will achieve that quality level. The firm unable to choose the highest quality position differentiates its product by choosing the minimum quality on one dimension because of the demand force. Therefore, this choice reduces price competition while maintaining a sufficient high-quality level for the differentiating firm's product to appeal to consumers.

The stream of research has assumed constant marginal costs of production. Studies have ignored the possibility that selecting a product position not only produces demand and competitive implications but also affects costs. In many product categories, the higher-quality provision typically comes with higher production costs. Lauga and Ofek (2011) considered the effect of quality costs on firms' differentiation strategies. When the cost to provide quality is too high, firms use only one attribute to differentiate their products–maximal differentiation on one dimension and minimal differentiation on the other, attaining a max-min equilibrium. In addition, firms always differentiate along the dimension with the greater

attribute range. As for the dimension with the smaller range, along which they collocate, firms either choose the highest quality level or the lowest quality level possible, depending on whether the marginal costs of quality provision are low or intermediate, respectively. However, for larger quality provision costs, firms differentiate their products on both dimensions; this dynamic creates a maximal differentiation equilibrium in which one firm chooses the highest quality level on both attributes while its competitor offers the lowest quality level on both attributes (Prince and Simon, 2015). A max-max equilibrium is thus attained.

There is less research examining both the two-dimensional horizontal and vertical models. For example, Dos Santos Ferreira and Thisse (1996) and Neven and Thisse (1990) investigated a two-dimensional model with horizontal differentiation (variety) and vertical differentiation (quality). The researchers showed in both studies that a max-min equilibrium exists in which firms never choose to fully differentiate on both dimensions.

The literature above concludes that either vertical or horizontal differentiation can be used to mitigate price competition and therefore facilitate clustering among firms. The generalization of the research is that price competition will be relaxed when there is sufficient differentiation on location, quality, or variety. If sufficient product differentiation holds in the dominant non-locational attribute, firms can collocate in the center of the market because it is unnecessary to differentiate in the geographic space. When other attributes are insufficiently differentiated, however, firms need to locate far from their competitors in order to reduce the intensity of price competition.

Yet few empirical studies have focused on the relationship between multidimensional product differentiation and location choice, and how the product and location decisions of firms are jointly affected by some fundamental characteristics of local markets. For example, Elizalde (2013) and Thomadsen (2007) showed that firms' incentives to differentiate depend on market size. In large markets, firms increase their profits by moving toward the edges of the market, whereas in small markets, firms increase profits by moving toward the market center. That is, a large-town-size favors maximum location differentiation, while a small-

town-size favors minimum location differentiation. Iyer and Seetharaman (2008) found that those closely located retailers who face sufficient income dispersion across consumers in a local market may differentiate on product design and pricing strategies. Watson (2009) found that if the incumbent faces relatively little local competition, with few or no proximate competitors, shifting a rival to join the incumbent from elsewhere in the market is more likely to lead to an expansion in the incumbent's product range. Netz and Taylor (2002) found that gasoline stations tend to locate further from competitors when the number of gasoline stations, the fraction of the market served by non-branded gasoline stations, and the fraction of the market that is the same brand as the center, increase in a given market. The finding in Netz and Taylor (2002), however, is inconsistent with the result from the multidimensional differentiation model. They found that gasoline stations increase spatial differentiation as differentiation in other attributes increases, which implies a max-max equilibrium.

While the extant research has studied industries such as the retail gasoline and movie theatre industries, to the best of our knowledge, our study is the first that shows the relationship between geographic location and product differentiation in the lodging industry. The following section develops the two-dimensional Hotelling model as it relates to the specifics of the lodging industry.

III. Horizontal and Vertical Differentiation in the Lodging Industry

A. Two-dimensional Hotelling model: geographical location and horizontal differentiation

Firms locate together at the market center when brand differentiation is large enough (Ben-Aliva et al., 1989). They maximize differentiation on one dimension, while minimizing differentiation on the other dimension (Tabuchi, 1994; Veendorp and Majeed, 1995). Elizalde (2013) found that cinemas are differentiated along two dimensions: geographical location and the set of movies exhibited. The min-max equilibrium is attained when cinemas locate close to each other and show different movies. Watson (2009) suggested that eyeglass retailers

maximally differentiate in product style and minimally differentiate in geographic location. Furthermore, firms choose to maximally differentiate on the dominant characteristic, the one that matters most to consumers (Irmen and Thisse, 1998). As sufficient differentiation power exists along some dimensions, firms will have incentives to select similar strategies with respect to some characteristics (Neven and Thisse, 1990). Different weights for the different dimensions of differentiation may result in different types of equilibrium (Ansari et al., 1998).

In the lodging industry, a hotel's location and brand are considered the two horizontal characteristics of its product. A horizontal differentiation in brands means that hotels operate at the same service-level tier but with different brand labels (and possibly different chain families) in a given geographic market. The theoretical framework above suggests that if the geographic location is the dominated characteristic and the brand is the dominate characteristic, then firms will locate close to one another in the geographic space (i.e., the minimal geographic differentiation) while choosing the same service quality using different brand names (i.e., the maximal horizontal differentiation). For instance, tourists who have limited budgets have incentives to choose lower-end hotels. The tourists are relatively indifferent to hotel chains but care about the cost they have to pay. If one of the hotels is unavailable, tourists will choose another hotel in the same industry segment even if it is operated by a different hotel chain. Therefore, we hypothesize that multi-unit owners' portfolios will minimally differentiate on the geographic location while maximally differentiating on the brand (at a given quality tier).

Hypothesis 1. *Multi-unit owners have incentives to minimize the geographic location while maximizing the horizontal product differentiation.*

B. Two-dimension Hotelling model: geographical location and vertical differentiation

Economides (1989) introduced an additional choice variable, named quality, into the Hotelling framework. Firms will differentiate along some dimensions and imitate along others. If one dimension is sufficiently dominate, firms will maximally differentiate along that dimension and minimally differentiate along all others (Irmen and Thisse, 1998). Firms may choose to minimally differentiate on the dimension of location and maximally differentiate along the quality attribute. As firms have sufficient differentiation power on the quality dimension, they will choose to locate together. This choice implies that firms put higher weights on the dimension of quality than on the dimension of distance.

Vertical differentiation in the lodging industry means that multi-unit owners operate hotels in different service-level tiers within a given territorial market. Assuming quality is the dominant discriminating characteristic, multi-unit owners would choose to put higher weights on quality because consumers care about this dimension. Such a choice implies that multi-unit owners will choose to maximize the dimension of vertical differentiation in their portfolio in order to minimize competition between hotels within the local market. At the same time, as the geographical location is the dominated characteristic, multi-unit owners will locate their hotels close to one another. This occurs because tourists with strong service-tier or brand preferences are less likely to substitute hotels across service levels unless there are no reasonable geographic alternatives. To the extent consumers do substitute service-tiers, the closet tier is more likely to be the substitute. For example, tourists and business travelers who prefer luxury hotels would prefer to choose upper-upscale hotels rather than an economy hotel, even if the higher quality hotel is farther from them when there is no room available in the luxury hotel. In this scenario, multi-unit hotels owners will collocate their properties because it helps hoteliers to capture consumers at different service (and price) points.

Hotels compete in many different markets, and against many different combinations of

competitors with differing characteristics. However, it is unclear whether quality would be one of the dimensions along which differentiation would occur. For example, hotels compete along many non-price dimensions, not just one. These include the tangible offerings such as the quality of the room and ancillary services such as a spa or dining rooms. The extant theoretical research relating quality provision to market structure has mixed predictions based on the different assumptions of models (Tseng et al., 2010). When consumers have more choices, firms have incentive to take steps to become more appealing in order to make sales. Firms tend toward improvement on all dimensions under their control. Thus, we hypothesize that multi-unit owners will maximally differentiate on the geographic location while maximally differentiating on the quality.

Hypothesis 2. *Multi-unit owners have incentives to maximize the geographic location while maximizing the vertical product differentiation.*

IV. The Data

To test the hypotheses proposed in the previous section, we use establishment-level data covering all hotel properties in the state of Texas during the period 2010 to 2017. The core of the data comes from the Texas Comptroller of Public Accounts' *Hotel Occupancy Tax Receipts* records. The Texas tax receipts data include information such as the owner's identity and address, the establishment's operating name (brand affiliation, if any) and address, number of rooms, revenue, lodging tax receipts, and the establishment's start and end (if appropriate) dates.[3] We determine longitude and latitude data for each establishment address and its owner's address, which we then use to calculate distances.[4]

We define multi-unit owner as one who simultaneously owns multiple hotels, based on the tax receipts data (e.g., establishments with the same taxpayer ID). We conduct our analysis of multi-unit owner portfolios at the state-, Metropolitan Statistical Area (MSA)-, and establishment-levels in a given year. The MSA-level analysis focuses on 25 MSAs in Texas, as defined by the U.S. Census Bureau in 2017.[5]

We identify the chain brand under which the establishment operated and the parent company with which the chain is affiliated. Table 1 summarizes hotel parent companies and their chain brands in the samples. STR Global, a lodging industry research organization, provides an objective, standardized categorization of six quality or service tiers, ranging from economy to luxury hotels.[6] We match business names with STR Global's classification list, assigning values from 1 to 6.

Insert Table 1 about here.

V. Empirical Method and Results

A. Model Specification

To identify whether a tendency towards minimal or maximal differentiation dominates, we focus on how the portfolio geographic dispersion affects the degree of product differentiation of establishments in a multi-unit owner's portfolio. Following Netz and Taylor (2002), the empirical model can be written as follows:

$$ProdDiff_{i,t} = \alpha + \beta GeoDiff_{i,t} + \gamma X_{i,t} + \delta\tau_t + \epsilon_{i,t}, \tag{1}$$

where i indexes the multi-unit owner, and t indexes the year from 2010 to 2017. $ProdDiff$ measures the degree of product, or quality, differentiation adopted by multi-unit owners. $GeoDiff$ measures the degree of spatial differentiation. X contains control variables, such as the owner's experience, the number of rooms, the number of member hotels, RevPAR, the population density, the magnitude of competition, the average distance to the owner's headquarters, the average distance of member units, the percentage of chained hotels, Gini coefficients. τ measures time fixed effects. ϵ is the unobserved variable.

The above model does not control for potential endogeneity in the choice of location in the multi-unit owner's portfolio. That is, the multi-unit owner has an ability to choose

where the hotel is located. Previous studies have shown that spatial differentiation may be affected by market characteristics (Carvell et al., 2016; Kim et al., 2020). Therefore, we test for this endogenous effect for the geographic portfolio of multi-unit owners in the sample, by running the above model as a two-stage regression with instrumental variables (IVs), using the first stage of the model:

$$GeoDiff_{i,t} = \theta_0 + \theta Z_{i,t} + \varepsilon_{i,t}, \tag{2}$$

where Z contains controls for the instrumented variable.

We apply these basic models of Equation 1 and Equation 2 at three different levels of analyses, which are state-level, MSA-level, and establishment-level. We will interpret the related dependent variables, independent variables, and control variables, for each level analysis, respectively.

Dependent Variable

First, at the state-level analysis, $State\ ProdDiff$ is represented as the multi-unit owner's product portfolio, which is calculated as the standard deviation of quality-tier values for all hotels in the owner's state-level portfolio. A value equal to zero indicates horizontal differentiation since all hotels have the same quality score. A value larger than zero indicates vertical differentiation, with larger values indicating a greater degree of vertical differentiation. Second, at the MSA-level analysis, $MSA\ ProdDiff$ is calculated as the standard deviation of quality-tier values in the multi-unit owner's product portfolio within each MSA.[7] A zero value indicates horizontal differentiation while a value larger than zero indicates vertical differentiation. A larger values indicates a greater degree of vertical differentiation. Third, at the establishment-level analysis, $Horizontal$ indicates horizontal differentiation, which is indexed as one if the focal hotel has the same quality tier with its neighbor. Vertical differentiation, denoted as $Vertical$, is calculated as the quality-tier difference between the focal

hotel with its nearest neighbor.

Independent Variable

Geographic differentiation has been examined as a potential factor to influence product differentiation of incumbents (Baum and Haveman, 1997; Fischer and Harrington, 1996; Freedman and Kosova, 2012; Mazzeo, 2002; Urtasun and Gutierrez, 2006). The degree of spatial differentiation, $GeoDiff$, is measured as the average nearest distance between each of the owner's hotels.[8] A smaller value of the average nearest geographic distance means that hotels are more closely located, or collocated, to one another. To compute the geographic distance, we use the longitude and latitude information of each hotel in the multi-unit owner's portfolio. The shortest line between nearest hotels is captured for each hotel in the portfolio and then used to calculate the average value as the independent variable.

First, at the state-level analysis, $State\ GeoDiff$ is the mean value of the nearest distance among each establishment in the multi-unit owner's state-geographic portfolio. Second, at the MSA-level analysis, $MSA\ GeoDiff$ is calculated as the average nearest distance among hotels owned by the multi-unit owner within each MSA. Third, at the establishment-level analysis, $Nearest\ Neighbor\ Distance$ is calculated as the distance between the focal hotel and its nearest neighbor. We also calculate the nearest distance between the focal hotel and its neighboring portfolio member, named $Nearest\ Member\ Distance$.

Control Variables

Firm-related variables. Owners' characteristics might influence the product position of establishments to their incumbents. Establishment age is measured by the difference between the start and end years in the Texas Comptroller's data.[9] Then, the maximum age of hotels with the same multi-unit owner is defined as the owner's experience. More experienced multi-unit owners may have had a preemptive advantage to choose a *better* product position as they may have become available. RevPAR, calculated as revenue divided

by occupancy, is a common performance measure in the lodging industry (Kim and Lin, 2021). Room capacity is used to be a proxy for the size of hotels (Lee and Jang, 2015; Lin and Kim, 2020). Portfolio size is the number of establishments the multi-unit owner operates in given a market boundary. The distance to the owner's headquarters is a potential factor to influence how multi-unit owners choose their product portfolio (Baum and Haveman, 1997; Combs and Ketchen, 2003; Freedman and Kosova, 2012; Kalnins and Lafontaine, 2004, 2013; Kaufmann and Dant, 1996; Perryman and Combs, 2012). Multi-unit owners who operate multiple high-end hotels are more likely to venture farther from the owner's headquarters, believing they can be successful (Kalnins and Lafontaine, 2013; Kosova and Sertsios, 2018).

For the state-level analysis, we calculate *Experience* to capture how many years the multi-unit owners operate hotels in the lodging industry. *Mean RevPAR* is the average value of the total accommodation revenue per available rooms of multi-unit owners. *Mean Rooms* is the mean value of the number of rooms offered by multi-unit owners for accommodation, indicating the size of a multi-unit owner. *Portfolio Size* is the number of establishments operated by multi-unit owners in Texas. *Mean Owner Distance* is the average distance between each hotel to its headquarters, which is aggregated to the multi-unit owner's level.

For the MSA-level analysis, *Experience* measures the maximal number of years after opening for multi-unit owners in the MSA. *Mean RevPAR* is calculated as the the mean value of the total accommodation revenue per available rooms in the multi-unit owner's portfolio in each MSA. *Mean Rooms* is the average number of rooms offered by multi-unit owners. *Portfolio Size* is the number of establishments owned by multi-unit owners in each MSA.

For the establishment-level analysis, *Age* is the number of years of operations for the hotel. *RevPAR* is defined as the total room revenue per available rooms of hotels. The room capacity, named as *Rooms*, is the number of rooms offered by hotels for accommodation. *Portfolio Size* is the number of hotels owned by multi-unit owners. The *Rival's Quality/Member's Quality* and *Rival's Rooms/Member's Rooms* may influence the deci-

sion making of focal hotels. *Distance to Owner* is the distance between a focal hotel and its owner.

Market-related variables. Population density may affect multi-unit owners' incentives to enter the market. A higher population density in a market may create higher potential demands, which may attract more hotels to enter the market. We collect the population for each MSA from the American Community Survey (ACS). The population density is expressed as the average number of people per square mile of land area. Household income Gini is calculated by the number of IRS returns and adjusted gross income by income strata at each market boundary. The percentage of chained hotels and the number of competitors are possible factors to affect how multi-unit owners choose their product portfolio (Baum and Haveman, 1997; Combs and Ketchen, 2003; Freedman and Kosova, 2012; Kalnins and Lafontaine, 2004, 2013; Kaufmann and Dant, 1996; Perryman and Combs, 2012). Hotel density is used to measure the magnitude of competition in a market boundary. We calculate the hotel density as the number of hotels divided by a market boundary.

First, at the MSA-level analysis, *Population Density* is calculated as the mean value of individuals per square mile of land area in each MSA. *MSA Gini* is measured by the number of returns and adjusted gross incomes by income strata in each MSA. The percentage of chained hotels, named as *Percent Chained Hotels*, and *Hotel Density* are calculated as the number of chained hotels and competitors divided by each MSA area size, respectively.

Second, at the establishment-level analysis, *Population Density* is calculated as the average number of people per square mile. *Income Gini* is measured the number of returns and adjusted gross incomes by income strata. *Percent Chained Hotels* and *Hotel Density* are calculated as the number of chained hotels and neighboring hotels divided by each market boundary, respectively.

We apply these basic models of Equation 1 and Equation 2 at three different levels of analysis. First, we looks at portfolios.

B. State-level Analysis

We first created multi-unit owner portfolios at the state level, meaning owners with more than one hotel anywhere in the State of Texas, identifying 922 state-wide multi-unit owners. We calculate portfolio measures for $ProdDiff$ and $GeoDiff$ for each portfolio as defined above. We define control variables for owner experience ($Experience$), mean revenue per room ($Mean\ RevPAR$) and mean capacity ($Mean\ Rooms$) at the portfolio level to reflect size and value of operations, and number of establishments ($Portfolio\ Size$) in the portfolio. Finally, we calculate the mean distance to the owner's address ($Mean\ Owner\ Distance$), since the literature frequently uses distance to the owner as a proxy for managerial agency costs.

Table 2 provides summary statistics for the state-level portfolio sample. The average product differentiation is 0.66 while the average mean nearest distance is 70.72 miles. The average owner had almost 10 years' experience and just over five hotel locations. Hotels in the average portfolio include 683 rooms and have a mean revenue per room ($RevPAR$) of \$282.81. The mean distance from portfolio hotels to the owner's address was just over 401 miles.

Insert Table 2 about here.

Table 3 presents results from four regression models. Column (1) reports a fixed-effects panel regression (STATA xtreg) with robust standard errors clustered by the multi-unit owner. The coefficient on $GeoDiff$ is negative and significant, suggesting greater distance is associated with less product differentiation, consistent with the max-min hypothesis that differentiates more on one dimension and less on the other. Column (2) reports results for a linear regression with multiple fixed-effect models (STATA reghdfe), without fixed effects for year and multi-unit owner. Like the fixed-effect panel model, the coefficient on $GeoDiff$ is negative and significant with a similar value. Neither of these models accounts for potential endogeneity in the quality and location decision.

Insert Table 3 about here.

Columns (3) and (4) report results for instrumental variable (IV) regressions using two-stage least squares (2SLS) and generalized method of moments (GMM) estimation procedures, respectively. In both models, $GeoDiff$ is instrumented by *Experience* and *Experience*-squared. The 2SLS model is estimated with robust variance-covariance estimators. For both models, the null hypothesis of exogenous variables is rejected at the 1% level with Chi-squares of 44.26 and 44.89, respectively. Tests for over-identification fail to reject the null, both with Hansen's J Chi-squares of 2.29. The two models yield comparable results. The relationship between $GeoDiff$ and $ProdDiff$ is significant, negative, and has a absolute value almost twice those in the first two regressions. In addition, the IV regressions find a significant negative relationship between the number of hotels in the portfolio and product differentiation. Given the limited range of quality tiers and the preponderance of hotels in the lower four quality tiers, this result is perhaps not surprising. The IV regressions also find a small but significant positive relationship between product differentiation and the portfolio's average hotel size and mean distance from the owner.

Overall, the state-level results are consistent with the hypothesis that multi-unit owners will adopt a max-min strategy between product differentiation and geographic differentiation. All four models find a significant, negative relationship between the mean distance to the nearest portfolio member and the degree of quality differentiation.

C. MSA-level Analysis

While the state-level analysis is consistent with our hypotheses, one might expect pricing competition pressures to be more relevant on a more local market scale. Hotels in Houston, for instance, are not directly competing with hotels in Dallas for the marginal customer, so the strategic value of differentiating may be smaller over as expansive a geography as the State of Texas. Moreover, local market characteristics may also have an influence on multi-unit owners' quality-location decisions.

To examine the local market effect, we repeat the basic analysis using MSA-level portfolios. We identify multi-unit owners as those owning more than one hotel in a given MSA. Since some multi-unit owners own more than one hotel in more than one MSA, the number of multi-unit MSA portfolios in the state is larger than the number of state-level portfolios.[10] In addition to the portfolio characteristics calculated at the state-level, we add local market characteristics as controls in the MSA analysis. Namely, we include the MSA's population density (*Population Density*), the density of hotels in the MSA (*Hotel Density*), the percentage of hotels in the MSA that belong to a chain brand (*Percent Chained Hotels*), and a *MSA Gini* coefficient measuring income inequality in the MSA.[11] Table 4 provides summary statistics for the MSA-level variables.

Insert Table 4 about here.

Table 5 presents results from four regression models. Column (1) reports a panel regression (STATA xtreg) with year fixed effects and robust standard errors clustered by the multi-unit owner. Unlike the state results, the coefficient on $GeoDiff$ is positive and significant, but a very small value. The only other (weakly) significant coefficient estimate is for the Income Gini, which is as expected since higher income inequality would suggest demand for more quality differentiation in hotels. However, the model diagnostics suggest that the model performs poorly. Column (2) reports results for a linear regression with multiple fixed-effects (STATA reghdfe), with fixed effects for year, MSA, and multi-unit owner. Like the fixed-effect panel model, the coefficient on $GeoDiff$ is positive and significant, but small, and no other coefficient estimates are statistically significant. Neither of these models accounts for potential endogeneity in the quality and location decision.

Insert Table 5 about here.

Columns (3) and (4) report results for instrumental variable (IV) regressions using two-stage least squares (2SLS) and generalized method of moments (GMM) estimation procedures, respectively. In both models, $GeoDiff$ is instrumented by $Experience$ and $Portfolio$

Size. The 2SLS model is estimated with robust variance-covariance estimates. For both models, the null hypothesis of exogenous variables is rejected at the 1% level with Chi-squares of 22.27 and 18.02, respectively. Tests for over-identification only weakly reject the null at the 10% level, both with Chi-squares of 2.82. The two models yield comparable results. The relationship between $GeoDiff$ and $ProdDiff$ is significant and positive, and with values much larger than the first two MSA regressions, but still smaller than the magnitude of the negative coefficients found at the state level. In addition, the IV regressions find a significant negative relationship between portfolio quality differentiation and the percentage of chained hotels in the MSA. No other controls have significant coefficients of any meaningful magnitude.

The small, positive relationship between geographic differentiation and quality differentiation in the multi-unit portfolio seems consistent with our Hypothesis (2), which claims that firms have incentives to differentiate on all dimensions because firms have an incentive to take steps to become more appealing in order to make sales. Several factors may be confounding these effects. The MSA is a rather arbitrary geographic boundary to impose on a multi-unit owner's portfolio strategy. MSAs vary greatly in size (as measured by square miles) and the boundaries between any two MSAs may be closer to one another than any two hotels within either MSA. In some cases, MSAs are geographically contiguous. While imposing the MSA boundaries allows us to clearly identify local market characteristics, it may not well reflect the relevant geography for owners' price competition concerns.

D. Establishment-level Analysis

To get a fine-grained perspective, we conducted an analysis at the individual establishment level. To test the hypothesis about quality differentiation and geographic differentiation, we estimate the regressions, using whether the establishment is of the same quality tier as its nearest competitor (horizontal differentiation) or a different quality tier (vertical differentiation) as the measure of product differentiation. The variable $Horizontal$ is a bi-

nary variable equal to 1 if the observation hotel has the same quality tier as its neighbor. The variable $Vertical$ is the absolute value of the difference between the observation hotel's quality tier and that of its neighbor.

Summary statistics of the establishment level data and relevant variables are in Table 6. There are over 33,400 hotel-year observations over the 2010-2017 period. The average age of hotel was 9 years, operating on average 95 rooms with revenue per room of $279. Density, chain hotel penetration, and income Gini are all calculated at the MSA level. *Rival's Quality* and *Rival's Rooms* reflect the quality and size of the nearest neighbor hotel. Given we focus only on hotels in MSAs, the distance to nearest neighbor is small; the average distance to nearest neighbor is only 0.28 miles and the maximum is roughly 3 miles. Consequently, it may be reasonable to assume a high degree of competition between hotels in the local market, when based on price, quality tier, and both.

Insert Table 6 about here.

Quality Differentiation and Distance to Nearest Neighbor.—We ran three specifications for both the $Horizontal$ and the $Vertical$ differentiation measure: a linear multiple-fixed-effects regression and two IV regressions, using 2SLS and GMM, respectively, as in the previous sections. Table 7 shows results for all six specifications when comparing the hotel to its nearest neighbor, regardless of ownership. For a given location and the existence of incumbent competitors, the min-max strategy would suggest that owners choose a quality tier conditioned on the distance to and degree of price competition with incumbent competitors. Consequently, we would expect a negative coefficient on $Nearest\ Neighbor\ Distance$ for the $Horizontal$ regressions, since direct price competition is weakened by distance; and a positive coefficient for the $Vertical$ regressions, since quality differentiation is higher valued in dispersed distribution. We control for the quality tier ($Rival's\ Quality$) and room capacity ($Rival's\ Rooms$) of the nearest neighbor, as well as controls for local market characteristics.

Insert Table 7 about here.

Column (1) presents the results of the linear multiple-fixed-effects regression (reghdfe) with year, MSA, and brand family fixed effects. The coefficients on the distance to nearest neighbor have the expected negative sign, but are not statistically significant (at traditionally acceptable levels). The IV regressions results, however, show large, statistically significant results with expected negative signs. Columns (2) and (3) show a strong negative relationship between *Horizontal* and distance to nearest neighbor, meaning a higher likelihood an establishment will be of the same quality tier the nearer its nearest neighbor. That effect is mitigated to an extent by the presence of other chain brand hotels. A higher percentage of chain-affiliated hotels reduces the likelihood that a hotel will be of the same quality tier as its nearest neighbor. In both models the distance to nearest neighbor is instrumented by distance to the establishment's owner and the quality tier of the nearest neighbor. In both cases, the assumption of exogenous variables is rejected at the 1% level and the test for over-identification fails to reject the null. The percent of chained hotels has a negative influence on horizontal differentiation.

Column (4) presents the results of the linear multiple-fixed-effects regression (reghdfe) with year, MSA, and brand family fixed effects. The coefficients on the distance to nearest neighbor have the expected positive sign. Columns (5) and (6) show a strong positive relationship between $Vertical$ and distance to nearest neighbor, meaning that a farther distance to nearest neighbor increases the degree of quality differentiation, since $Vertical$ measures the magnitude of the difference in quality tiers between the hotels. An interesting findings is that there is a positive relationships between vertical differentiation and the percent of chained hotels in the market. These contradict the results in Columns (2) and (3). A higher percentage of chained hotels further increases the difference in quality between a hotel and its nearest neighbor.

One possible explanation for these results versus our hypothesized results is the potential for agglomeration economies in heterogeneous sub-markets of an MSA. As noted above, distance to nearest neighbor is small (no more than three miles) in our sample, a significantly

smaller radius than the geography of an MSA. An unequal spatial distribution of income and population across an MSA may result in sub-markets that specialize or attract specific price-points (and associated quality tiers) to those hyper-local markets. Consequently, local market characteristics may dominate in the owners' portfolio decision.

Quality Differentiation and Distance to Nearest Portfolio Member.—To consider the owner's portfolio strategy more specifically, we rerun the previous models using *Nearest Member Distance* rather than *Nearest Neighbor Distance*. Here *Horizontal* and *Vertical* are defined similarly to the nearest neighbor, but relative to the quality tier of the nearest portfolio member hotel. *Member's Quality* and *Member's Rooms* reflect the quality and size of the nearest other member of multi-unit owner's portfolio. Table 8 shows the results for the six regression specifications considering nearest-member effects. Once again, Columns (1) and (4) present the results of linear multiple-fixed-effects regressions for *Horizontal* and *Vertical* respectively. Columns (2) and (3) present IV regression results for *Horizontal* and Columns (5) and (6) report IV regression results for *Vertical* as above.

Insert Table 8 about here.

The results of all models are consistent with those for the nearest neighbor in terms of the effects of distance and product differentiation, but the magnitudes of the coefficients are smaller by orders of magnitude, suggesting little consequence regardless the statistical significance. While the distance to nearest member seems to have little economic effect, the quality of the nearest neighbor is also significant and mitigates the effect of distance. Having a higher quality member-neighbor increases the likelihood that the observed location will share that quality tier and lowers the difference in quality tiers between locations. Interestingly, the percentage of chained hotels has an opposite effect in these models to those in the nearest neighbor models. A higher percentage of chained hotels increases the likelihood a hotel shares the same quality tier as its nearest portfolio neighbor and reduces the size of difference in quality tiers between these two hotels. As with the earlier results, the size and significance

of all these effects are largest in the IV regressions, which also include fixed effect controls for year, MSA, and brand family.

In summary, the establishment-level analysis of a hotel's strategy relative to its nearest neighbor and its nearest portfolio member is not consistent with the traditional theoretical result that geographically proximate hotels will increase the difference in their quality to avoid direct price competition. Rather, the geographic distance results suggest that hotels that are closer together are of the same, or more similar, quality than hotels that are farther apart within the local (MSA) market. At the owner-portfolio level, the quality of neighboring hotels in the portfolio appears to be positively related (higher quality increasing homogeneity in Columns (3) and (4)), with greater homogeneity at higher quality levels (reduced difference in quality as neighbor quality increase in Columns (5) and (6)).

E. New Member Quality

All of the previous analysis is static in nature, comparing portfolio attributes and individual hotel attributes while holding time constant. But what about the marginal hotel in the portfolio? What strategic motivation drives the dynamic quality choice of the marginal hotel? To examine this last question, we identify all new hotels added to a multi-unit owner's portfolio over the 2010 to 2017 period. This includes the creation of multi-unit portfolios as a single-unit owner adds additional properties. Table 9 shows the summary statistics for this sub-sample of establishments. There are 400 new portfolio properties added over the course of the eight-year period. On average, the portfolio geographic differentiation ($GeoPortfolio$) is 26 miles and the average portfolio includes just over five properties. Portfolio product differentiation ($ProdPortfolio$) is defined as the standard deviation in property quality tier levels, as in the state- and MSA-level analyses.

Insert Table 9 about here.

We run two sets of regressions to examine whether and how incumbent portfolio product differentiation and portfolio geographic differentiation influence the choice of quality for the

new location ($EntrantQuality$). We use Equation (3) as the base regression framework:

$$EntrantQuality_{i,t} = \alpha + \beta Portfolio_{i,t-1} + \gamma X_{i,t} + \delta \tau_t + \epsilon_{i,t}, \tag{3}$$

where $Portfolio_{i,t-1}$ includes the lagged value of the portfolio $i's$ $ProdPortfolio$ and $GeoPortfolio$, and X includes portfolio and local market controls as in the previous models. As before, we run three specifications for each of the portfolio's differentiation variable: a multiple-fixed effects linear regression with errors clustered multi-unit owners, and 2SLS and GMM IV regression models with year and MSA fixed effects. Table 10 contains the results for all six specifications.

Insert Table 10 about here.

Columns (1) through (3) report the effect of portfolio quality differentiation on the quality of the new member. There is a positive and statistically significant relationship between incumbent portfolio product differentiation and higher quality new members, suggesting that owners with properties at different levels of quality are more likely to add new properties that are higher quality, although the IV regressions suggest that owner's experience has a small negative effect on the quality of new hotels, all else equal. The remaining results for the portfolio quality regressions are mixed, but generally suggest a slight negative effect of portfolio size on new member quality and a positive effect of the percent of chain-affiliated hotels in the MSA.

Columns (4) through (6) report on the effect of portfolio geographic differentiation, or dispersion, on the quality of new member. The results are mixed across specifications, but we believe the best results continue to be the IV regression models in Columns (5) and (6). As in our previous analyses, we can strongly reject the hypothesis of exogenous regressors. Instrumenting portfolio attributes use the lagged values of the portfolio's average hotel size ($Rooms$) and revenue per room ($Mean\ RevPAR$), we cannot reject the null for the test

of over-identification. Focusing on the results in Columns (5) and (6), more geographically differentiated portfolios may add lower quality properties at the margin. Consistent with the quality differentiation results in Columns (2) and (3), there is a negative relationship between portfolio size and new member quality and a positive relationship between the percent of chained hotels and new member quality. Likewise, mean distance to portfolio owner has a positive and significant, those small, effect on new member quality.

How do these results relate to our original hypotheses? Portfolios with greater geographic differentiation are more likely to add hotels at lower quality tiers, which generally operate at lower price-points and compete more directly on price rather than differentiated amenity attributes. More geographically concentrated portfolios add higher quality hotels that compete more directly on amenities and operate at higher price points, and presumably margins. Similarly, portfolios that are already more differentiated in quality may add higher quality hotels at the margin. Both of these results are generally consistent with the two-dimensional Hotelling result of competing on the higher margin attribute.

VI. Conclusion

The literature on the two-dimensional Hotelling model concludes that firms choose to maximally differentiate on the dominant characteristic and minimally differentiate on the dominated characteristic. This implies max-min or min-max equilibria. On the other hand, the extant theoretical research relating quality provision to market structure has mixed predictions. Firms may compete in many different markets and against many different combinations of competitors with differing characteristics. Firms have incentives to maximally differentiate on the dominant characteristic, the one that matters most to consumers. When consumers have more choices, firms have incentives to take steps to become more appealing in order to make sales. Firms tend toward improvement on all dimensions under their control. This implies a max-max equilibrium.

This study examines the interplay of spatial differentiation and product market differ-

entiation among hotels in Texas at different market boundary levels, controlling for fixed effects, with and without controlling for the endogenous selection problem, by analyzing panel data from the Texas Comptroller of Public Accounts for the period of 2010 to 2017. Rather than the trade-off among firms, our study focuses on how the geographic portfolio affects the degree of product portfolio at a multi-unit owner. Moreover, we also investigate whether and how incumbent portfolio product differentiation and portfolio geographic differentiation influence the quality choice of the new member.

First, we find that, at the state-level, the results show a significant negative relationship between product differentiation and geographic differentiation. This finding suggests greater distance is associated with less product differentiation, consistent with the max-min hypothesis that differentiates more on one dimension and less on the other dimension. Second, at the MSA-level, we find that geographic portfolio may increase the degree of product portfolio differentiation, which means that a max-max equilibrium is attained. Third, at the establishment-level, on the one hand we obtain a higher likelihood an establishment will be of the same quality tier the nearer its nearest neighbor in the scenario of horizontal differentiation, which implies a min-max equilibrium. On the other hand, the findings show that a farther distance to nearest neighbor increases the degree of quality differentiation in the scenario of vertical differentiation, which also implies a max-max equilibrium. Fourth, the results from the relationship between horizontal/vertical differentiation and the distance to the nearest member are similar with those for the nearest neighbor. We therefore obtain a max-max equilibrium.

Finally, we also analyze the quality choice of the marginal hotel in a portfolio. On the one hand, we obtain a positive relationship between incumbent portfolio product differentiation and higher quality new members. The results suggest that owners with properties at different levels of quality are more likely to add new properties that are higher quality. On the other hand, our findings show that more geographically differentiated portfolios add lower quality properties at the margin. Our explanations are portfolios with greater geo-

graphic differentiation are more likely to add hotels at lower quality tiers, which generally operate at lower price-points and compete more directly on price rather than differentiated amenity attributes. More geographically concentrated portfolios add higher quality hotels that compete more directly on amenities and operate at higher price-points, and presumably margins. Similarly, portfolios that are more already more differentiated in quality add higher quality hotels at the margin. Both of these results are generally consistent with the two-dimensional Hotelling results of competing on the higher margin attributes.

This study makes several contributions to the two-dimensional Hotelling model literature. First, this research introduces the concept that horizontal and vertical differentiation can coexist in one industry. While previous studies of the two-dimensional Hotelling model have not distinguished between these kinds of differentiation, the distinction is important because the two types of differentiation are compositionally different, so they provide theoretically different implications. Each differentiation can have a different magnitude/weight on one dimension. Horizontal differentiation dominates on the location portfolio dimension, while vertical differentiation dominates on both portfolio dimensions. The traditional concept of the two-dimensional Hotelling model may be unclear when researchers fail to consider the presence of both differentiation strategies in one industry.

Second, the results show that the location decision of multi-unit firms is more complex than previous studies have suggested. The location pattern of multi-unit firms varies based on their product positioning. This situation implies that multi-unit firms could strategically choose their different location patterns–for instance, to minimize geographic pattern in the presence of horizontal differentiation and to maximize geographic patterns in the presence of vertical differentiation. This study shows that min-max and max-max are both possible equilibria. As a result, our findings show that different types of product differentiation are important factors in the location decisions of multi-unit firms.

Third, the empirical analysis of the lodging industry shows a trade-off between two main dimensions of differentiation: the distance among hotels and the quality diversifica-

tion of product portfolios. The test of the max-min equilibrium predicted by the theoretical two-dimensional model tries to prove that both the existing trade-off relationship and the evidence supports the existence of the equilibrium. Incorporating the maximum and minimum differentiation on both location and product positioning dimensions, we find support for both min-max and max-max equilibria, given the geographic location as the first dimension and the product positioning as the second dimension. The results imply that the weight of variables where the portfolio is maximally differentiated is important to identify the dominant characteristic. The application of location equilibrium with the degree of product positioning suggests that more geographical proximity may imply an increased incentive for vertical differentiation.

Fourth, by analyzing how strategic motivation drives the quality choice of the marginal hotel, the results suggest that owners with properties at different levels of quality are more likely to add new properties that are higher quality. Moreover, our findings show that more geographically differentiated portfolios add lower quality properties at the margin. The results provide an extension of the two-dimensional Hotelling model to the relationship between incumbent portfolios and entrant quality choices.

Lastly, the results of this study ultimately suggest there are managerial implications for hotel operators to better understand the complexities associated with the portfolio dominance between location and product positioning. When hotel operators construct product positioning from one specific quality segment of hotels, the location portfolio of hotels is dispersed. When hotel operators construct product positioning from the same quality segment of hotels, the location portfolio of hotels is clustering. The portfolio, minimal location and maximal product positioning can achieve economies of scale and scope, and derive the benefits from intra-agglomeration. Hence, hotel operators may consider leveraging location versus product positioning at the beginning stage of their businesses.

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Notes

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[1]For ease of exposition, we use "quality" to describe service or amenity tiers, not as a subjective measure of performance. We recognize that lower quality tier establishments may provide high quality service, and vise versa.

[2]See Ben-Akiva et al. (1989), Gabszewicz and Thisse (1979), Wauthy (1996) and others for one dimensional models.

[3]Other studies using this data set include Chung and Kalnins (2001), Conlin and Kadiyali (2006), Hollenbeck (2016), Kalnins (2004), Kalnins and Chung (2004, 2006), Kim and Lin (2021), Lin and Kim (2020, 2021), McCann and Vroom (2010), Suzuki (2013), and Yang and Mao (2017).

[4]In STATA, the command geodist can be used to calculate the shortest distance between two hotels by using the hotels' longitude and latitude information.

[5]The 25 MSAs in Texas are Abilene, Amarillo, Austin-Round Rock,Beaumont-Port Arthur, Brownsville-Harlingen, College Station-Bryan, Corpus Christi, Dallas-Fort Worth-Arlington, El Paso, Houston-The Woodlands-Sugar Land, Killeen-Temple, Laredo, Longview, Lubbock, McAllen-Edinburg-Mission, Midland, Odessa, San Angelo, San Antonio-New Braunfels, Sherman-Denison, Texarkana, Tyler, Victoria, Waco, and Wichita Falls.

[6]STR Global's service quality tiers are Economy, Midscale, Upper Midscale, Upscale, Upper Upscale, and Luxury.

[7]It is important to note that the number of multi-unit owners changes based on the level of

analysis. For instance, some state-level multi-unit owners have individual hotels in different MSAs. Consequently, while they would be considered multi-unit owners at the state-level, they would not be included as multi-unit owners in the MSAs where they own only one property.

[8]In the literature, this is referred to as distance-based agglomeration. An alternative is statistics-based agglomeration measures (i.e., U.S. states, U.S. metropolitan statistical areas, U.S. census division, or U.S. zip code).

[9]This is not the same as the age of the property or facility, but how long the incumbent owner has been the tax entity for the establishment.

[10]It may also be the case that some state-level portfolio owners drop out of the MSA analysis because they own more than one hotel, but only one hotel in any given MSA. We do not document those lost portfolios.

[11]The Gini coefficient was calculated by the authors from IRS data on number of returns and adjusted gross income by income strata at the county level.

Table 1: Hotel companies in samples

Hotel Company	Chain Brands
Best Western Company	Best Western, Best Western Plus, Best Western Premier
Choice Hotels International	Ascend Collection, Cambria Suites, Clarion, Comfort Inn, Comfort Suites, Econo Lodge, MainStay Suites, Quality Inn, Rodeway Inn, Sleep Inn, Suburban Extended Stay, WoodSpring Suites
Drury Hotel	Drury Inn, Drury Inn & Suites, Drury Plaza Hotel, Drury Suites, Pear Tree Inn
G6 Hospitality	Motel 6, Studio 6
Hilton Worldwide	Conrad, Curio Collection, Double Tree, Embassy Suites, Hampton Inn, Hampton Inn & Suites, Hilton, Hilton Garden Inn, Home2 Suites by Hilton, Homewood Suites
Hyatt Hotel Corporate	Grand Hyatt, Hyatt, Hyatt House, Hyatt Place, Hyatt Regency
Intercontinental Hotels Group	Candlewood Suites, Crowne Plaza, Holiday Inn, Holiday Inn Club Vacations, Holiday Inn Express, Hotel Indigo, InterContinental, Kimpton, Staybridge Suites
Marriott International	aloft, Autograph Collection, Courtyard, Delta, element, Fairfield Inn, Four Points, Gaylord, JW Marriott, Le Meridien, Luxury Collection, Marriott, Renaissance, Residence Inn, RItz-Carlton, Sheraton, Springhill Suites, St Regis, TownePlace Suites, W Hotel, Westin
Radisson Hotel Group	Country Inn & Suites, Park Inn, Radisson
Red Lion Hotels Corporation	America's Best Value Inn, Country Hearth Inn, GuestHouse Inn, Red Lion Hotels
Red Roof Inn	Red Roof Inn
Wyndham Worldwide	AmericInn, Baymont Inn & Suites, Days Inn, Hawthorn Suites, Howard Johnson, Knight Inn, La Quinta Inn & Suites, Microtel Inn & Suites, Ramada, Super 8, Travelodge, Tryp, Wyndham, Wyndman Garden, Wingate

Table 2: State-level Portfolio Summary Statistics

	Mean	SD	Min	Max	N
State ProdDiff	0.66	0.79	0.00	4.24	922
State GeoDiff	70.72	96.76	0.00	569.01	922
Experience	9.97	8.19	1.00	48.00	922
Mean RevPAR	282.81	514.00	0.00	4,563.27	922
Portfolio Size	5.41	12.96	2.00	95.00	922
Mean Rooms	683.86	1,551.78	46.00	12,287.00	922
Mean Owner Distance	401.76	457.29	0.00	1,604.88	922

Table 3: Estimates of State-level Portfolios

	State-Level Portfolios			
	(1)	(2)	(3)	(4)
GeoDiff	-0.010***	-0.010**	-0.019***	-0.019***
	(0.003)	(0.004)	(0.006)	(0.006)
Experience	0.080	0.048		
	(0.080)	(0.061)		
Mean RevPAR	-0.000	0.000	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Portfolio Size	0.127	0.059	-0.096***	-0.091***
	(0.099)	(0.079)	(0.026)	(0.026)
Mean Rooms	-0.001	-0.001	0.001***	0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
Mean Owner Distance	0.009*	0.011	0.001**	0.001**
	(0.005)	(0.007)	(0.000)	(0.000)
Constant	-0.355	-3.458	1.908***	1.923***
	(2.133)	(2.688)	(0.354)	(0.352)
Year FE	Y	N	Y	Y
Family company FE	Y	N	Y	Y
Observations	922	899	922	922
Log-likelihood	723.316	577.098		
Pseudo R-squared				

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

Table 4: MSA-level Portfolio Summary Statistics

	Mean	SD	Min	Max	N
MSA ProdDiff	0.48	0.75	0.00	4.24	1,019
MSA GeoDiff	28.82	37.19	0.00	229.52	1,019
Experience	10.40	8.23	1.00	48.00	1,019
Mean RevPAR	842.04	1,222.62	0.00	4,563.27	1,019
Portfolio Size	3.69	4.12	2.00	26.00	1,019
Mean Rooms	2,592.71	3,897.74	46.00	12,287.00	1,019
Population Density	514.79	278.68	17.21	834.23	1,019
Hotel Density	222.03	110.06	15.19	441.53	1,019
Percent Chained Hotels	0.01	0.03	0.00	0.33	1,019
MSA Gini	0.61	0.05	0.50	0.73	1,019

Table 5: Estimates of MSA-level Portfolios

	MSA-Level Portfolios			
	(1)	(2)	(3)	(4)
MSA GeoDiff	0.001***	0.002***	0.007***	0.006***
	(0.000)	(0.001)	(0.002)	(0.002)
Experience	-0.000	-0.001		
	(0.000)	(0.000)		
Ln(Mean RevPAR)	-0.000	-0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Portfolio Size	-0.011	0.005		
	(0.012)	(0.009)		
Mean Rooms	0.000	-0.000	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Population Density	-0.000	-0.000	0.003	0.003
	(0.000)	(0.001)	(0.003)	(0.003)
Hotel Density	0.000	-0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.002)	(0.002)
Percent Chained Hotels	-0.645	-0.824	-37.647***	-36.925***
	(0.651)	(2.304)	(6.092)	(6.095)
MSA Gini	0.177*	-0.006	-0.047	-0.115
	(0.102)	(0.320)	(2.330)	(2.275)
Constant	0.340***	0.565*	2.030	2.053
	(0.099)	(0.291)	(1.352)	(1.321)
Observations	1,019	1,006	1,019	1,019
Log-likelihood	2,466.883	579.194		

* p<0.1, ** p<0.05, *** p<0.01. Year and MSA fixed-effect coefficients are omitted for brevity but available from the authors on request.

Table 6: Establishment-level Summary Statistics

	Mean	SD	Min	Max	N
Horizontal Differentiation	0.16	0.37	0.00	1.00	33,453
Vertical Differentiation	1.11	1.20	0.00	6.00	33,453
Nearest Neighbor Distance	0.28	0.40	0.00	2.99	33,453
Age	8.90	6.71	1.00	58.00	33,453
RevPAR	279.45	904.66	0.00	9,478.16	33,453
Portfolio Size	1.83	3.45	1.00	26.00	33,453
Rooms	94.67	94.10	20.00	1,840.00	33,453
Rival's Quality	1.66	1.53	0.00	6.00	33,453
Rival's Rooms	95.46	98.78	20.00	1,840.00	33,453
Population Density	474.60	288.83	5.24	834.23	33,453
Hotel Density	212.86	117.33	3.19	441.53	33,453
Percent Chained Hotels	0.01	0.05	0.00	1.00	33,453
Distance to Owner	205.23	388.55	0.00	2,974.06	33,453
Income Gini	0.61	0.05	0.44	0.78	33,453

Table 7: Establishment-level Nearest Neighbor Analysis

	Horizontal Differentiation			Vertical Differentiation		
	(1)	(2)	(3)	(4)	(5)	(6)
Nearest Neighbor Distance	-0.051	-4.234***	-4.250***	0.366*	4.338***	4.377***
	(0.040)	(0.676)	(0.677)	(0.188)	(1.485)	(1.491)
RevPAR(t-1)	-0.000	-0.000***	-0.000***	0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portfolio Size	-0.003	-0.017***	-0.017***	-0.002	0.015	0.016
	(0.007)	(0.005)	(0.005)	(0.017)	(0.010)	(0.010)
Rooms	0.000	-0.001***	-0.001***	0.002**	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Rival's Quality	0.028			0.027	0.159***	0.160***
	(0.018)			(0.085)	(0.016)	(0.016)
Rival's Rooms	-0.000***	-0.001***	-0.001***	0.001**	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Population Density	0.000*	0.000	0.000	-0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.002)	(0.002)
Hotel Density	-0.000	-0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Percent Chained Hotels	0.634***	-1.241***	-1.250***	-0.360	2.857***	2.874***
	(0.245)	(0.347)	(0.348)	(1.096)	(0.593)	(0.595)
Distance to Owner	0.000			0.000		
	(0.000)			(0.001)		
Household Income Gini	-0.029	0.134	0.142	0.010	-0.497	-0.505
	(0.059)	(0.865)	(0.868)	(0.149)	(1.022)	(1.028)
Age				0.005		
				(0.010)		
Constant	0.067	1.574***	1.576***	0.650**	-0.815	-0.825
	(0.067)	(0.543)	(0.545)	(0.254)	(0.772)	(0.777)
Observations	32,719	33,453	33,453	32,719	33,453	33,453
Log-likelihood	14,516.15			-19,678.02		

* p<0.10, ** p<0.05, *** p<0.01. Year, MSA, and brand family fixed-effect coefficients are omitted for brevity and available from the authors.

Table 8: Establishment-level Nearest Member Analysis

	Horizontal Differentiation			Vertical Differentiation		
	(1)	(2)	(3)	(4)	(5)	(6)
Nearest Member Distance	-0.000**	-0.003***	-0.003***	0.000	0.007***	0.006***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Age	-0.002			-0.000		
	(0.004)			(0.012)		
RevPAR(t-1)	-0.000	-0.000***	-0.000***	0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Portfolio Size	-0.002			-0.009		
	(0.006)			(0.018)		
Rooms	0.000	0.000***	0.000***	0.003**	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Member's Quality	0.029*	0.033***	0.032***	-0.040	-0.080***	-0.094***
	(0.016)	(0.009)	(0.010)	(0.105)	(0.029)	(0.031)
Member's Rooms	0.000	0.000***	0.000**	0.002	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Population Density	0.000	0.000	0.001	0.000	-0.000	0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)
Hotel Density	-0.000	-0.000	-0.001	0.000	0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Percent Chained Hotels	1.239*	2.881***	3.117***	-1.376	-6.548***	-3.886*
	(0.634)	(0.427)	(0.896)	(2.841)	(1.105)	(2.255)
Distance to Owner	0.000	0.000***	0.000***	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Household Income Gini	-0.012	-0.335	-0.090	-0.500	-0.412	2.364
	(0.345)	(0.846)	(1.178)	(0.685)	(2.002)	(2.886)
Constant	-0.035	0.723	0.314	0.651	0.058	-4.569
	(0.268)	(0.487)	(1.455)	(0.993)	(1.157)	(3.731)
Observations	5,318	5,319	5,319	5,318	5,319	5,319
Log-Likelihood	-1,795.40			-7,205.25		

* p<0.10, ** p<0.05, *** p<0.01. Year, MSA, and family fixed-effect coefficients are omitted for brevity but available from the authors on request.

Table 9: New Member Summary Statistics

	Mean	SD	Min	Max	N
EntrantQuality	2.29	1.41	0.00	6.00	400
ProdPortfolio	0.46	0.62	0.00	4.24	400
GeoPortfolio	26.55	33.41	0.00	157.00	400
Experience	5.43	6.90	1.00	42.00	400
Rooms	2,400.93	2,609.54	40.00	7,730.00	400
Mean RevPAR	789.80	656.85	5.71	1,822.05	400
Portfolio Size	5.62	4.80	2.00	17.61	400
Population Density	577.06	235.09	17.12	828.86	400
Hotel Density	228.34	96.58	15.19	472.58	400
Percent Chained Hotels	0.01	0.03	0.00	0.30	400
Mean Distance to Owner	579.46	466.44	0.01	1,665.60	400
Household Income Gini	0.61	0.04	0.51	0.68	400

Table 10: Establishment-level New Member Analysis

	EntrantQuality					
	(1)	(2)	(3)	(4)	(5)	(6)
ProdPortfolio	0.174**	1.820***	2.117***			
	(0.070)	(0.426)	(0.785)			
GeoPortfolio				0.021***	-0.041***	-0.029
				(0.006)	(0.013)	(0.018)
Experience		-0.078***	-0.084**		-0.013	-0.004
		(0.023)	(0.034)		(0.022)	(0.027)
Rooms	0.000			0.000*		
	(0.000)			(0.000)		
Mean RevPAR	-0.003**			-0.003***		
	(0.001)			(0.001)		
Portfolio Size	0.044**	-0.088***	-0.091*	0.031**	-0.221***	-0.209***
	(0.018)	(0.028)	(0.051)	(0.014)	(0.032)	(0.030)
Population Density	0.005	0.011	-0.001	0.001	-0.006	-0.009***
	(0.009)	(0.015)	(0.002)	(0.007)	(0.019)	(0.003)
Hotel Density	0.006*	-0.003	0.004	0.002	0.003	0.012
	(0.003)	(0.008)	(0.006)	(0.002)	(0.010)	(0.008)
Percent Chained Hotels	22.208**	183.45***		14.341	274.60***	
	(8.731)	(52.637)		(10.501)	(52.684)	
Mean Distance to Owner	-0.005	0.001***	0.001***	-0.011**	0.001*	0.001**
	(0.007)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)
Household Income Gini	-3.941	7.971		-3.290*	7.015	
	(2.708)	(10.255)		(1.870)	(12.292)	
Constant	5.532	-6.515	1.293	11.795***	-5.147	7.670***
	(5.039)	(5.988)	(1.611)	(3.967)	(7.354)	(1.994)
Observations	378	400	400	378	400	400
Log-likelihood	-170.01			-166.09		

* p<0.10, ** p<0.05, *** p<0.01. Year and MSA fixed effect coefficients are omitted for brevity and available from the authors.