Technological Change as Reflected in Hotel Property Prices

John B. Corgel

School of Hotel Administration

Cornell University

Ithaca, NY 14853

e-mail: jc81@cornell.edu

Abstract

This paper investigates the effects of age on the sale prices of hotel real estate. Value erosion of commercial property due to the passage of time may be offset by renovation, although substantial follow-on investment usually occurs several years following construction. Obsolescence produces value losses during the post-construction period prior to new investment that result from technological change (Colwell & Ramsland, 2003). A hedonic model is specified to allow age to measure the effects of obsolescence in hotel prices. Although the long-run obsolescence rate for hotel properties of 1.93%/year aligns closely with the rate estimated elsewhere for retail properties, the path of obsolescence through time shows some marked departures. Contrary to the theory and the empirical results from the retail real estate market, hotel prices do not reveal much more obsolescence in the years immediately following construction than later. Also, the age and sale price relation turns positive nearing the third decade of the lives of hotels indicating a vintage effect. Thus, a V-shaped obsolescence function emerges that either may be explained by a fixed-cost renovation expenditure function or a vintage effect produced by the demand for surviving assets. A series of tests of hotel brand-specific obsolescence rates reveals considerable variation in these rates among seasoned properties, perhaps an indication of a convex renovation expenditure function and sequential follow-on investment.

Keywords: Property prices, Hotel real estate, Economic depreciation

Introduction

Economic depreciation of real estate, “the reduced ability of an asset to generate future cash flows (Blazenko & Pavlov, 2004, p.57)”, occurs as properties naturally age and as market conditions change. Physical deterioration increases operating expenses and obsolescence “results when older things function as when they were new but otherwise lose their appeal or usefulness” (Margolis, 1981, p.91). The many studies of capital asset depreciation performed during the past four decades greatly advanced the stock of knowledge about how real estate loses its ability to produce future service or cash flows over time and how to empirically measure the rate of economic depreciation.[1] Because of the implications for investment management, housing policy, tax policy, and capital allocation to the real estate sector, refinements in the approaches for isolating components of economic depreciation continue to appear in the literature (e.g., Clapp & Giacotto, 1998).

Recently, Colwell and Ramsland (2003) demonstrate how technological change, as the underlying cause of property obsolescence, affects the value of retail real estate. They show that, even during the years immediately following construction, changing technologies produce obsolescence. Because cures (i.e., renovations) seldom occur early in the life of properties, obsolescence may be observed during this interval without the offsetting effects of capital expenditures. Such results give rise to empirical specifications for measuring the extent of value changes among aging properties due to the introduction of new technology. Retail real estate represents a property type with considerable vulnerability to technological change. Hotel properties stand out as another segment of the real estate industry with similar vulnerability. This paper extends the work of Colwell and Ramsland (2003) to hotels. Extensions include minor modifications to their theory and an expanded empirical analysis using a database consisting of thousands of hotel property transactions.

[1] The many studies of capital asset depreciation performed during the past four decades greatly advanced the state of knowledge about how real estate loses its ability to produce future service or cash flows over time and about how to empirically measure the rate of economic depreciation. For a review of the early housing literature, see Malpezzi, Ozanne, and Thibodeau (1987). An updated review appears in Smith (2004). Dixon, Crosby, and Law (1999) provide the most recent discussion of research on the economic depreciation of commercial property.

Colwell and Ramsland (2003) find empirical support for the main hypothesis derived from theory. The rate of functional obsolescence during the initial 16 years (i.e., up to a breakpoint) following construction of 1.7%/year exceeds the long-run rate of 0.9%/year. These estimates are viewed as confirmation that functional obsolescence driven by a constant rate of technological change can be directly observed early in the life of properties without the complicating influences of follow-on capital investment. Because the obsolescence function estimated with retail property data has a kink instead of a V-shape, they reject the assumption of a fixed-cost renovation expenditure function in favor of a variable-cost function. They also find no evidence of variation in the rates of functional obsolescence among seasoned properties, which leads to the conclusion that the form of the renovation expenditure function is not increasing, and convex.

The hotel data yield quite different results. While the estimated rate of functional obsolescence for hotels of 1.93%/per year closely aligns with the retail property estimate during the initial period following construction, the breakpoint separating this initial period from the remaining life occurs in the 28th year. Survey data indicate that substantial follow-on investment in existing hotels begins in year 10. After the breakpoint, estimates using alternative methods confirm that the age and sale price relationship becomes positive (0.7%/year). Thus, a V-shaped obsolescence function emerges from then hotel data that could be explained either by a fixed-cost renovation expenditure function or a vintage effect (Goodman & Thibodeau, 1995) driven by the demand for surviving assets. Finally, a series of tests of hotel brand-specific obsolescence rates reveals considerable variation in these rates among seasoned properties, perhaps an indication of a convex renovation expenditure function and sequential follow-on investment.

The paper begins with a section describing the susceptibility of hotel real estate to technological change. In Optimal Property Configurations, the relevant theoretical arguments are presented. Data and Method describes the data and empirical methods introduced to estimate obsolescence rates in hotel real estate. Estimation procedures and results appear in Estimation and Results. Conclusion contains the conclusions from this study.

Technological Change and Hotel Properties

Hotels fundamentally differ from other commercial real estate in that most of the space rental involves personal use instead of use for the sale of goods and services.[2] Nevertheless, the large volumes of customers that regularly pass through the spaces making consumption decisions represent similarities across retail and hotel real estate that make both property types particularity vulnerable to technological change. Colwell and Ramsland (2003) identify three categories of technological change in retail real estate: physical (e.g., building materials and security cameras), contractual (e.g., percentage leases and CMBS debt), and process (e.g., live demonstrations) innovations.

Hotels experienced similar innovations during the past few decades. From a design perspective, suite-style rooms increased in number relative to traditional rooms, exterior-corridor hotels almost disappeared in favor of interior corridors, atrium entrances gained popularity, and the movement toward more wired and wireless environments has been a design focal point. Contractually, numerous advancements have occurred to strengthen management and franchise relationships. The manner in which food and beverage service delivery has evolved to more self-service, particularly in the mid-price segment, represents an example of process change in hotels.

Elevated concerns about hotel obsolescence extend beyond maintaining shares in increasingly competitive markets with declining information costs to reasons related to the widespread separation between ownership and management. Few hotels with more than twenty rooms are owned and managed by the same entity. Owners control capital allocation while managers oversee capital spending. Agency problems associated with expenditures for repairs, maintenance, and replacement of personal property items appear small by comparison to issues involving capital intensive renovations when substantial portions of income-generating spaces are removed from service for extended periods.

Concerns of owners and managers about how much money should be spent and reserved to keep hotels competitive prompted two surveys of hotel capital expenditures during the past 10 years by the

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[2] Restaurants, meeting rooms, and banquette facilities generate 15 percent of hotel revenues in the typical full-service hotel and less than 5 percent in limited-service hotels.

International Society of Hospitality Consultants (ISHC, 1995, 2000). The ISHC asked questions about actual expenditures for the following purpose [2000, p.2]:

- Updating design and décor
- Curing functional and economic obsolescence, thereby extending both the physical and economic life of the asset
- Complying with franchisors' brand requirements
- Technological improvements
- Product changes to meet market demands
- Adhering to government regulations, and
- Replacing all short and long lived building components due to wear and tear.

Unfortunately, neither report separates out expenditures by purpose.[3] The 2000 report, however, provides aggregate expenditures by hotel type, ownership category, and age of property. A summary of these expenditures appears in Table 1. Not surprisingly, expenditures at full-service hotels exceed those at limited-service hotels and expenditures in hotels with public-company associations exceed those of private-companies. Expenditures patterns by age of all hotels, as shown in Panel B, confirm that relatively small amounts are spent during the initial 5 years following construction. Expenditures and the variance of expenditures increase steadily thereafter. In addition, expenditures tend to be concentrated at points in the property life cycle when renovations occur (e.g., year 10).

Finally, brand affiliation with recognized hotel companies, such as Hilton and Marriott, imposes filters on property obsolescence from technological change. These companies incur substantial monitoring costs to prevent properties from becoming obsolete. Consequently, responses to changes in technology occur fairly rapidly, incrementally, and also uniformly across brands within the same

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[3] The report presents detail on expenditures at various locations within the hotel (e.g., lobby) and for specific items (e.g., wall coverings).

company and across competing companies. These conditions create a unique environment relative to other property types for technological change to manifest as obsolescence.

Optimal Property Configurations

Following Colwell and Ramsland (2003), a linearly increasing cost-to-build function and a concave present

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INSERT TABLE 1 HERE

This table was developed from the findings of two surveys of hundreds of hotel owners conducted by the International Society of Hospitality Consultants (1995, 2000). These results include the percent of total revenues spent for capital items by hotel type, ownership category, and age of property. Repairs and maintenance expenditures are not in the totals

value function are assumed.[4] Both cost and value originate from quantities of property attribute set x. Thus, C(x) represents the cost of placing a new property in service with x attributes, such that,

$$C'(x) > 0 \text{ and } C''(x) = 0 \tag{1}$$

The present value of future net income increases at a diminishing rate in *x*. Let *V (x)* represents the current value of property in service with quantities of x attributes. This means that,

$$V'(x) > 0 \text{ and } v''(x) < 0 \tag{2}$$

The equilibrium solution involves determining the property attribute configuration, x*, that maximizes net present value. The first-order condition where marginal present value equals marginal cost is given by,

$$V'(x^*) = C'(x^*) \tag{3}$$

Also, net present value must equal zero to reduce the likelihood of supply cascades. Thus,

$$V(x^*) = C(x^*) \tag{4}$$

[4] Colwell and Ramsland (2003) state that the assumption of a linear cost function represents a theoretical convenience.

The present value and cost functions reach a point of tangency at the optimal property configuration given the assumption that the cost function is less concaved than the value function. Obsolescence and positive 'vintage' effects appear as movements in either direction from the optimal configuration. Goodman and Thibodeau (1995) note that a vintage effect occurs in the housing market when some unmeasured quality characteristic correlates with the year of construction such that prices can vary either up or down with the age of the property. New optimal configurations arise, therefore, either because of shifts in the cost curve due to changes in input prices and technology or due of shifts in the present value curve from demand-related re-pricing of attributes and changes in expenses associated with owning the attributes.

Figure 1, Panel a shows the optimal configuration of a new property, x^*, at the intersection of $C(x)$ and $V(x)$. An increase in costs resulting from advancements in technology, for example, shifts the cost curve to $C(x_1)$ producing optimal configuration X_1^*. The higher rent earned from properties with

INSERT FIGURE 1 HERE

Fig. 1 Optimal property configurations with alternative cost and value functions. Note: This figure shows optimal property configurations found at the intersection of alternative linear cost functions and a concaved present value function. The shift of the cost function from *C(x)* to *C*(x_1) in panel **a** represents an advancement in technology. The shift of the value function in panel **b** may be due to market repricing (positive) of attributes, thus indicating 'vintage effect'

X_1^* relative to X^* translates into price differential $p_1^* > p^*$. Most seasoned properties continue to operate with obsolete configuration x* prior to renovation.

Unanticipated market changes manifests into different configurations for older relative to new properties. Typically, older property configurations produce lower valuations than newer property configurations and the increment of depreciated value reflects the extent of seasoned property obsolescence. A portion of this obsolescence comes from technological change, while the balance comes from other forms of obsolescence (i.e., physical, location) described in the real estate appraisal literature (Appraisal Institute, 2003). To isolate the contribution of technological change to obsolescence, empirical specifications need to include conditioning variables that account for the other determinants of economic depreciation.

This relatively simple process of property obsolescence becomes more complicated if the present value curve shifts, for example, due to demand-related re-pricing of *x* attributes. Panel b of Fig. 1 shows an upward shift of the present value function from $V(x)$ to $V(x_1)$ without technological change. An increase in the demand for seasoned properties with x_2 attribute means that these properties command p_2, where $p_2 > p^*$. These properties benefit from a positive vintage effect.

Renovation and Repositioning

Defenses against obsolescence come in the form of capital infusions for renovation and repositioning. Renovations involve investments to maintain competitive positions, while capital expenditures for repositioning move properties into different market segments. With no lease friction and a considerable number of recognized hotel market segments along the continuum of room rates, hotel repositioning often occurs relative to other commercial real estate.

Capital flows intermittently for renovations across all property types, but likely with greater frequency for retail and hotel real estate. These investments may not eliminate all accrued obsolescence. To gain an appreciation for this outcome, let's assume that an existing property has obsolete configuration x_3 and the recent purchaser of the asset desires to invest amount *i* to improve the configuration. Further, *i* expenditures are assumed to be linear and entirely variable (i.e., no fixed costs). Again, following Colwell and Ramsland (2003) the optimal building configuration, x_i, occurs at the point where the marginal benefits of *i* expenditures equal the marginal costs. That is,

$$V'(x_i) = c'(x_i - x_3). \tag{5}$$

When the obsolescence is removed from seasoned properties to the extent profitable, then no incremental functional obsolescence will be observed. Notwithstanding, small cross-sectional variances will persist in levels of obsolescence and prices of seasoned properties because the properties that require either renovation or repositioning will only receive these treatments when needed.

By assuming that the marginal cost of eliminating obsolescence exceeds the marginal cost to create new operating properties,

$$C'(x) < c'(x - x_3) \tag{6}$$

then expenditure level i will not remove all obsolescence, such that

$$x_i < x^* \tag{7}$$

Consequently, properties with remaining obsolescence after i expenditures will operate with less than optimal configurations and carry different prices than new properties and seasoned properties not receiving i expenditures. Panel a in Fig. 2 introduces the cost function $c(x - x_3)$ to remove obsolescence with x3 attributes and demonstrates the pricing differentials $p_3 < p_i^*$ and $p_i^* < p^*$. Thus, properties should sell for more after the removal of 'curable' functional obsolescence, but not as much as new properties because they have not experienced substantial incurable obsolescence and because the marginal cost of eliminating obsolescence is assumed to exceed the marginal cost to create new operating properties.

Colwell and Ramsland (2003) extend these arguments to the case of a linear expenditure function for renovation that consists of fixed costs. This case appears in Panel b of Fig. 2. The graphic demonstrates an outcome following renovation to x_i in which a seasoned property with x_5 attributes exhibits less functional obsolescence than the less obsolete property with attributes x_4. The cost of renovation exceeds the value increment for property x_4 (i.e., $p_i^* - p_4$), but the more obsolete property x_5 can be renovated profitable to x_i given the value increment $p_i^* - p_5$. This outcome is similar to the case in which the vintage effect appears in the market pricing of seasoned properties, but without an upward shift in $V(x)$, as shown in Fig. 1, Panel b.

If the expenditure function is increasing and convex, then renovations to remove curable obsolescence do not occur all at once. This means that seasoned properties will not be renovated to the same level and will exhibit considerable variation in obsolescence. Investment behaviors designed to combat obsolescence have various complications. Wong and Norman (1994), for example, show that retail mall renovations may be delayed by unanticipated changes in capital market, space market, and input pricing. Williams (1997) finds that more frequent and less extensive re-investments in property redevelopment produce greater values.

The process by which technological change produces obsolescence, that in turn reduces the cash flows and values of seasoned properties relative to new properties, appears straightforward given the hypothesis that technological changes increase the optimal attribute set at a fairly constant rate. The survey data in Table 1 show that hotel capital expenditures occur at low and fairly constant rates during most of the initial decade following construction. After that point, expenditures become more temporally concentrated. Newer properties accrue obsolescence without offsetting renovations until some critical point.

Data and Method

The data used for estimation consist of nearly 4,000 hotel real estate sales that occurred throughout the US from January 1996 through early 2004. Information about property sale prices and characteristics

INSERT FIGURE 2 HERE

Fig. 2 Optimal property configuration following renovation. Note: Panel **a** of this figure introduces the cost function $c(x - x_3)$ for renovation to remove obsolescence from properties with x_3 attribute set. The graphic demonstrates that these expenditures will not remove all obsolescence, assuming costs are entirely variable and the marginal cost of renovation exceeds the marginal cost of new construction. Resulting price differentials $(\mathrm{p}^* - \mathrm{p}_\mathrm{i}^*)$ and $(\mathrm{p}_3 - \mathrm{p}_\mathrm{i}^*)$ also are shown. Panel **b** demonstrates an outcome following renovation to x_i in which a seasoned property with x_5 attributes exhibits less functional obsolescence than a newer property with attributes x_4. The cost of renovation exceeds the price increment for the property with x_4 (i.e., $\mathrm{p}_\mathrm{i}^* - \mathrm{p}_4$), but the more obsolete property with x_5 can be renovated profitable to x_i given the price increment $\mathrm{p}_i^* - \mathrm{p}_5$.

come from a database managed by the PKF Hospitality Research. This firm obtains hotel transaction information through subscriptions with CoStar and Hotel Brokers International. Transactions data also come from industry publications, news reports, and the firm’s consultants. This firm researches sales to verify and to fill in missing information. Demographic data, such as ZIP code level population and per capita income, come from CACI.

INSERT TABLE 2 HERE

This table presents descriptive statistics for a sample of 3,810 hotel real estate sales in the US that occurred from 1996 through the first half of 2004. Symbols for variables are provided and property prices are rounded to the nearest million dollars. Sources: CoStar, Hotel Brokers International, and PKF Hospitality Research

The selection criteria applied to these data include the removal of full-service properties with less than 75 rooms, limited-service properties with less than 20 rooms, and remaining hotels with sale prices less than $500,000.[5] Conference center and resort hotels are merged into the appropriate full-service market segment categories. Finally, only hotels with a nationally recognized brand affiliation (i.e., affiliated hotels) remain in the sample after screening out properties with no affiliation and those with regional brands. This step ensures cross-sectional consistency in the sample with respect to maintenance, repairs, and to a lesser extent, renovation. For reasons related to goals of maintaining national brand integrity and homogeneity, franchise agreements require hotel owners to abide by fairly common sets physical quality standards within each segment to retain affiliations.[6]

Variable definitions and summary statistics appear in Table 2. Transactions are evenly distributed by the year of sale and across the dominant market segments. Each property has been assigned to a particular market segment. Full-service hotels include deluxe, luxury, upscale, and midscale with food and beverage segments with the balance being limited-service hotels. While some firms make these assignments based on room rate, the firm supplying these data defines hotel market segments according to brand homogeneity, and thus, like-collections of property characteristics. About two-thirds of the transactions involved hotels in the 0–10 and 11–20 year old age groups, although every age cohort up to 40 years has at least 400 transactions.

[5] Full-service hotels have integrated food and beverage that generate approximately 15% of total revenue while limited-service hotels generate nearly all revenue from the sale of room nights.

[6] Monitoring of these standards occurs through regular inspections and an institutional process known as the Property Improvement Program (PIP). If a hotel has been 'PIPed', then the property meets all of the current standards of the sponsoring company. This event ordinarily involves technology and other physical upgrades, all except extensive renovations.

Sale prices exhibit considerable variation from the mean of $12.4 million, as indicated by the large standard deviation and broad range. For estimation purposes sale price is scaled by the number of rooms to form a price-per-room variable with a reduced variance. The problem with using the number of rooms either as a scalar or a conditioning variable stems from the lack of consistency across hotels in the quantity of space as well as the quality of the room.[7] The transaction database contains the published room rate for double occupancy. This rate overstates the actual average daily rate, but is positively and highly correlated with realized average daily rate.[8] If directly introduced into a hedonic price equation, the published room rate may provide an effective control for quantity and quality differences across rooms and coincidently account for the effects of missing and unobserved property characteristics. Published room rate, however, correlates closely with other explanatory variables, such as the age of the property, and with the disturbance term.

A two-step instrumental variable approach is employed to retain useful information in the published rate. The first stage involves running the following regression:

$$\mathrm{In}(\mathrm{R_i}) = \lambda + \mathrm{f}\big(\mathrm{MS_1}, \dots, \mathrm{MS_J}; \mathrm{S_1}, \dots, \mathrm{S_J};\ \mathrm{T_1}, \dots, \mathrm{T_K}\big) + \gamma_1 \mathrm{RM_i} + \gamma_2 \mathrm{PI_i} + \gamma_3 \mathrm{A_i^2} + \mathrm{u}_i \tag{8}$$

where $\ln(R_i)$ is the natural log of published room rate, f is a function of MS_j $(j = 1,2, \dots J)$ hotel market segments (fixed effect), $S_j(j = 1,2, \dots J)$ States (fixed effect), and $T_k(k = 1,2, \dots K)$ year-of-sale for the ith property (subscripts suppressed). The number of rooms, RM, and the per capita income, PI, of in the ZIP code in which the ith property is located also appear along with the age of the property, A, and age squared, A^2.

The error term from the estimation of Eq. 8, u_i, becomes orthogonal to this set of potential conditioning variables in the hotel price equation, but if introduced into the price equation will produce

[7] The standard physical space measure in hotel markets is the ‘room’. Square footage information th at would eliminate the quantity consistency issue usually is not available.
[8] Due to seasonal variation in room rates, industry analysts generally make cross-sectional comparisons using an annualized rate. Thus, when a hotel sale occurs and the room rate is identified that rate will be an annual average. The published rates in these data are annual averages of seasonal rates cited in travel guides. Annualized published rate and ADR are highly correlated (about 0.9), differing mostly by a scale factor.

bias estimates due to the correlation with the error term of the estimated price equation. This problem differs from Murphy and Topel's (1985) generated regressor problem in that the desired information from the first step comes from the error term and not from the predicted published rate.

The second step involves creating the instrument from u_i that reduces estimation bias. Two alternative approaches suggested by Kennedy (1998) are employed for specifying the instrumental variable, $\hat{R_i}$. The first alternative involves ranking u_i by size, with the instrument defined as the rank order of u_i. The second alternative requires that u_i be divided into two groups separated by the median value. The instrument takes on the value −1 for observations equal to and less than the median and the value +1 for observations greater than the median.

Hedonic Price Equation

The general form of the pricing model represents hotel property sale price as a function of property attributes, X_i, and overall property depreciation. That is,

$$P_i = f(X_i, \text{Overall Depreciation}) \tag{9}$$

Real estate appraisers divide overall depreciation into three categories—physical deterioration (i.e., normal wear and tear), external obsolescence (i.e., location or economic), and functional obsolescence. Property age accounts for the price effects due to functional obsolescence when controls appear in the estimating equation for condition and location, such that

$$P_i = f(X_i, \text{Condition}, \text{Location}, \text{Age}) \tag{10}$$

The data base lacks specific details on property attributes beyond the number of rooms and the year of construction. Controls for different sets of property characteristics must be introduced through a fixed effects treatment of the nine market segments and an indicator variable for properties with all-suite rooms. As mentioned earlier, market segment designations are assigned according to cross-sectional consistence of property attributes. Also, the size of the hotel, a characteristic that often account for 30% or more of the variation in hotel sale prices, enters on the left side of the estimating equation through the price-per-room variable.[9] Thus,

$$(\mathrm{P_i}/\mathrm{RM_i}) = \mathrm{f}(\mathrm{x_i}, \mathrm{Condition}, \mathrm{Location}, \mathrm{Age}) \tag{11}$$

Adjustments for condition occur in two ways. First, limiting the sample to nationally-affiliated hotels provides in-sample consistency for physical condition. This does not mean that every affiliated property has exactly the same level of deferred maintenance, only that the level of deferred maintenance neither typically nor grossly exceeds other properties of the same brand and segment. Differences among non-homogeneous brands are picked up by the market segment variable. Second, the instrument, $\hat{R_i}$, derived from the published room rate contains information related to the condition of the property.

Colwell and Trefzger (1994) find that locational obsolescence does not necessarily depend on the presence of an externality, but instead results from the misallocation of land in the general case. They suggest an empirical specification for estimating locational obsolescence that requires both land value and building cost, neither of which are available. In the regressions run by Colwell and Ramsland (2003), locational obsolescence is introduced through a location quality scale variable developed by real estate experts who rated each retail mall on a one-to-ten scale depending on factors, such as the position of the mall in the market, proximity to highways, and quality of tenants. Downs (1995) provides a discussion of the causes of obsolescence in office buildings and argues that locational obsolescence is most apparent in neighborhoods and downtown areas characterized by high relative crime rates and downward shifts in incomes.

Location adjustments are accomplished in a general way with fixed-effects treatment of the States in which the property sale occurred. In addition, the zip code per capita income level serves as a measure of locational obsolescence. Many of the zip codes with the lowest per capita income in this data base are in and around downtown areas. Two other measures are tested. First, a dummy variable is created

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[9] See Corgel and deRoos (1994).

indicating if the sale occurred in a ZIP code with per capita incomes in the bottom 25% of the distribution. Second, the data base contains population growth rates by ZIP code, a variable that potentially contains information about internal economic changes in cities leading to locational obsolescence.

Both A and A^2 enter the equation assuming a concave relation between asset price-per-room (the log transform) and age such that the hypnotized sign of A is negative and the sign of A^2 is positive. The hedonic price equation takes the general form,

$$\ln(P_i/RM_i) = \alpha + f(MS_l, \dots, MS_J)f(S_l, \dots, S_J) + \beta_1 A_i + \beta_2 A_i^2 + \beta_3 PI_i + \beta_4 R_i^* + f(T_l, \dots, T_k) + e_i \qquad (12)$$

The coefficients on the age variables would normally indicate the rate of economic depreciation in hotels. With this specification however, they indicate the extent to which hotel properties lose value due to obsolescence. Taking the derivative of Eq. 12 with respect to A gives the rate in a given year (Malpezzi, Ozanne, & Thibodeau, 1987)

$$\frac{d(P_i/RM_i)/dA}{(P_i/RM_i)} = \beta_l + 2\beta_2 A_i \qquad (13)$$

The theory suggests that renovations do not happen until properties reach a certain level of maturity, and thus renovations cannot offset obsolescence during the early years in the life of properties. Given the assumption that technological change occurs at a constant rate over time, the pure effect of obsolescence-producing technological change can be estimated with data on the sale of younger relative to older properties. Colwell and Ramsland (2003) use a piecewise exponential approach to find the relative obsolescence rates. In addition, this sample of nearly 4,000 hotel transactions can be divided in various ways and separate regressions run to directly estimate rates across specific age intervals, particularly properties less than 10 years old.

Estimation and Results

Table 3 presents results from estimating Eqs. 8 and 12 with the entire sample of hotel property transactions. In these and subsequent regressions the entire sample is run with segment dummies and brand interaction variables instead of with sub-samples, for example full-service and limited-service hotel

INSERT TABLE 3 HERE

This table presents the results from first and second stage regressions to produce OLS estimates of the hotel hedonic price equation. In the first stage, the number of rooms, age of the property at time of sale, age squared, per capita income in the ZIP code where the property is located, a binary variable series of hotel market segments (including all-suites), a binary variable series of States where sales occurred, and a series of time indicators beginning in 1996 (omitted) and ending in 2004 are regressed on the natural log of published room rate. An instrument created from the residual term in this regression, ei, becomes a measure of omitted quality variables, $R^{\wedge}$. The second stage regression is the hedonic estimation with the natural log of price-per-room on the left side and, on the right side, $R^{\wedge}$ along with the same variables as from the first stage except the number of rooms. The coefficients and standard errors for State binary variables not shown (available on request). $n = 3{,}810$. *Significant at 0.01. Sources: CoStar, Hotel Brokers International, and PKF Hospitality Research

transactions. While full-service and limited-service continue to represent the dominate business models in the hotel industry, analysts have become increasingly interested in segment sub-group and brand performance. Thus, the decision was made to run all observations with segment dummies as controls, and by doing so, examine the relative pricing (budget segment omitted) of the various segments as indicated by the magnitudes of their coefficients. The magnitudes of the segment dummy coefficients have the expected relative sizes. In the final section, selected brand interaction variables with age are introduced to estimate specific brand obsolescence effects. The goal was to go beyond the limited-service and full-service delineations without necessarily going through them.

The right-side variables in these models explain more than 50% of the variation in the log of published room rate and the log of price-per-room. Most of the explanatory variables in the room rate equation are significant and correctly signed. All except one market segment variable in the price equation is significant at the 0.01 level. The R^ variable does not improve the overall explanatory power of the models by as much as expected.

The estimated negative and significant sign on the age coefficient and the positive and significant sign for age squared in the price-per-room equation indicate a concave relationship between asset value and age. This general pattern appears similar to economic depreciation rate patterns found for other property types.[10] Even with controls in place for physical condition and locational obsolescence, hotels on average lose value through functional obsolescence at an increasing rate. Nevertheless, the size of the coefficient on A^2 is quite small. The rate of functional obsolescence during the first year derived from the coefficients on A and A^2 in the price equation and Eq. 13 equals 1.38% $(-0.0136 + (2^*0.0001))$ per year. By the 20th year the rate becomes 1.58%. These estimates lie between the rate of obsolescence estimated by Colwell and Ramsland (2003) for shopping centers of 1% and the rate of economic depreciation of 2.7% estimated by Fisher, Smith, Stern, and Webb (2002) for apartments.

Age-related Heteroskedasticity

Goodman and Thibodeau (1995, 1996) show that building age introduces heteroskedasticity in hedonic price equations estimated with housing price data because the residual variance increases with the age of the property. They cite uneven maintenance and renovation activity throughout the life cycle as the underlying causes. The same reasoning logically applies to hotels and other commercial real estate. Standard tests for heteroskedastic variances (Breusch & Pagan, 1979; White, 1980) applied to both sets of OLS residuals indicate rejection of the homoskedastic variance hypothesis. Tests run on specific variables suggest that the age of the property is an important contributing factor to heteroskedasticity in these estimated equations.

Consequently, Eqs. 8 and 12 are re-estimated using WLS. The weighting procedure involves estimating a variance model of the form

$$|e_i| = \Phi_0 + \Phi_1 A + \Phi_2 A^2 + \Phi_3 A^3 + \Phi_4 A^3 \tag{14}$$

[10] See references in *fn*. 1.

where $|e_i|$ is the absolute value of the residual from the OLS regression. Weights are determined using the predicted value of the variance model as $l/\hat{y}$ (Goodman & Thibodeau, 1995). The WLS estimations,

INSERT TABLE 4 HERE

This table presents the results from first and second stage regressions to produce WLS estimates of the hotel hedonic price equation. In the first stage, the number of rooms, age of the property at time of sale, age squared, per capita income in the ZIP code where the property is located, a binary variable series of hotel market segments (including all-suites), a binary variable series of States where sales occurred, and a series of time indicators beginning in 1996 (omitted) and ending in 2004 are regressed on the natural log of published room rate. An instrument created from the residual term in this regression, ei, becomes a measure of omitted quality variables, $R^{\wedge}$. The second stage regression is the hedonic estimation with the natural log of price-per-room on the left side and, on the right side, $R^{\wedge}$ along with the same variables as from the first stage except the number of rooms. The weighting procedure involves estimating a variance model of the form $le_il = \Phi_0 + \Phi_1 + A + \Phi_2 A^2 + \Phi_3 A^3 + \Phi_4 A^4$ where e_i is the residual of the OLS regression. Weights are determined from the predicted value of the variance model as $1/\hat{y}$. The coefficients and standard errors for State variables are not shown (available on request). $n = 3{,}810$. * Significant at 0.01, **Significant at 0.05. Sources: CoStar, Hotel Brokers International, and PKF

presented in Table 4, yield slightly improved explanatory power of the models, but most importantly, they result in a higher rate of functional obsolescence of 1.73/year (-0.0171+(2*0.0001)) in year one.

Technological Change and Obsolescence

Colwell and Ramsland (2003) introduce a variable in their hedonic price equation to detect a breakpoint in the obsolescence function. This variable has the form $(A - \overline{A})$, where A is the age of the property at time of sale and $\overline{A}$ is a critical age. If $(A - \overline{A}) < 0$ then $(A - \overline{A}) = 0$; otherwise $(A - \overline{A})$ is a positive number. The introduction of $(A - \overline{A})$ creates a piecewise linear function in logs of the age and sale price relationship. The critical age comes from repeatedly running regressions each time with a successively greater age until R^2 reaches a maximum. They estimate a critical age of 16 years for retail. This alternative estimation procedure produces an increase in the obsolescence rate from slightly less than -1 to -1.7%. Also, $(A - 16)$ is highly significant, positively signed, and has a magnitude slightly smaller than the size of the age coefficient (i.e., 1.5%). Interpretation of these findings is taken as confirmation of two hypotheses derived from the theory. First, the functional obsolescence observable in asset prices stops at some critical age, and thereafter no additional obsolescence appears because profitable renovation has occurred to the extent profitable. Second, a higher rate of functional obsolescence occurs in the early years because renovations do not counteract obsolescence.

The procedure just described is replicated with hotel property data. The results from estimating the price equation with $(\mathrm{A}-\overline{\mathrm{A}})$ appear in the first two columns of Table 5.[11] A single critical value of 28 years was found. The highly significant coefficient of the age variable increases slightly from -0.0171 to -0.0193 and the highly significant coefficient on $(\mathrm{A}-\overline{\mathrm{A}})$ equals 0.0259. These results indicate that functional obsolescence is observable for a much longer period in the hotel market than the retail market. In addition, the rate of functional obsolescence is marginally greater before, compared to after, the critical year.

Finally, a positive vintage effect is detected following the critical year of approximately 0.7%. The second piece in the kinked slope of the age and sale price relationship is found by taking the sum of the coefficients on $(\mathrm{A}-\overline{\mathrm{A}})$ and age (i.e., 0.0259+(−0.0193)=0.0066). By contrast, the Colwell and Ramsland (2003) results establish a continuation of price erosion beyond the critical year. Separation of the sample into two parts — one containing transactions of properties less and equal to 28 years and the other with transactions greater than 28 years—then re-estimating the original WLS equation confirms this result with only minor differences in magnitudes. These estimates are shown in columns three through six of Table 5.

Separate estimates shown in the last two columns of Table 5 are prepared for properties operating in the first decade following construction in an attempt to isolate the rate of functional obsolescence prior to renovation. The estimated coefficient on the age variable equals −0.0037, but is not significant at the 0.05 level. The magnitudes and significance levels of other conditioning variables in the equation appear quite close to the estimates shown in Tables 4 and 5.

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[11] The A^2 variable is omitted from this regression to allow the $(\mathrm{A}-\overline{\mathrm{A}})$ to pick up changes in the slope of the age and sales price relationship.

INSERT TABLE 5 HERE

This table presents the results from regressions to produce WLS estimates of the hotel hedonic price equation by the same method described in the previous table. Results appear for four different regression analyses. The first set of results come from estimating an equation that includes the variable, $\mathrm{A}-\overline{\mathrm{A}}$. This variable determines if a piecewise age linear function exists in age. The critical value comes from repeatedly running regressions each time with a successively greater age until R^2 is maximized. The second set of results rely on a reduced sample that contains only hotel properties whose ages are less than and equal to $\overline{\mathrm{A}}=28$. The third set of results rely on a reduced sample that contains only hotel properties whose ages are greater than $\overline{\mathrm{A}}=28$. The final set of results rely on a reduced sample that contains only hotel properties whose ages are from 0–10 years. The coefficients and standard errors for State variables are not shown (available on request). $n=3{,}810$ for the first regression, $n=3{,}075$ for the second regression, $n=735$ for the third regression, and $\mathrm{n}=1{,}274$ for the fourth regression. *Significant at 0.01, **Significant at 0.05. Sources: CoStar, Hotel Brokers International, and PKF Hospitality Research

INSERT FIGURE 3 HERE

Fig. 3 Functional obsolescence and hotel property prices. Note: The true path of the hotel property functional obsolescence function has three possible shapes shown in this figure. The dashed line indicates a slightly concave shape throughout the entire life of the asset with an average rate of −1.73%/year. The obsolescence function displayed using a dotted line was estimated assuming a piecewise linear function in logs of the age and sale price relationship and results in a kink at the critical age equal to 28 years. The early segment is linear or slightly concave and the second segment is upward sloping indicating a positive vintage effect. An obsolescence function also is hypothesized from the regression results using the subsample of properties with ages 0–10 years. Using the estimated size of the age coefficient −0.3% suggests a very modest slope in the initial decade, an acceleration of the rate of functional obsolescence during the next 18 years, then a slight positive slope in the age sale price relationship thereafter

The Path of Functional Obsolescence

The path of functional obsolescence for hotel properties can now be traced using the results from hedonic price equation estimations with alternative age specifications. As shown in Fig. 3, the true path has three possible forms. First, the dashed line indicates a slightly concave shape throughout the entire life of the asset with an initial rate of −1.73%/per year. This shape is suggested from the WLS estimates obtained using the entire sample without a critical age variable included. Second, the obsolescence function displayed using a dotted line was estimated assuming a piecewise linear function in logs of the age and sale price relationship and results in a kink at the critical age equal to 28 years. The early segment is either linear or slightly concave and the second segment is upward sloping indicating a positive vintage effect.

An obsolescence function also is hypothesized from the regression results using the sub-sample of properties with ages 0–10 years. Neither the coefficient on A nor A^2 age are significantly different from zero in this regression. The estimated size of the age coefficient of approximately −0.3% suggests a very modest slope in the initial decade, an acceleration of the rate of functional obsolescence during the next 18 years, then a slight positive slope in the age sale price relationship thereafter.

Obsolescence and Hotel Brands

Brand affiliation represents a unique feature of hotels relative to other commercial real estate and is often cited as a reason why some hotels outperform others. The 3,810 property sample of hotel transactions includes a broad range of affiliated properties. For example, the full-service hotel category consists of

INSERT TABLE 6 HERE

This table presents the results from regressions to produce WLS estimates of the hotel hedonic price equation by the same method described in previous tables. Ten interaction variables appear in the model, each measured as age time the selected brand (1,0). The brands tested include Hilton ($n = 100$), Holiday Inn ($n = 230$), Marriott ($n = 82$), Sheraton ($n = 69$), Westin ($n = 21$), Best Western ($n = 202$), Comfort Inn ($n = 172$), Courtyard ($n = 84$), Hampton Inn ($n = 174$), and Hilton Garden Inn ($n = 21$). The coefficients and standard errors for State variables are not shown (available on request). $n = 3{,}810$. *Significant at 0.01, **Significant at 0.05. Sources: CoStar, Hotel Brokers International, and PKF Hospitality Research

brands as diverse in quality as Ritz Carlton, Clarion, Four Seasons, and Holiday Inn. The market segment conditioning variables account for difference in quality as does the instrument developed from the published room rate. Nevertheless, questions remain as to whether brands have price effects, and specifically for the purposes of this study, do hotels with different brands, but similar seasoning, become functionally obsolete at the same rate?

To answer this question, a series of brand affiliation and age interaction variables are included in the hedonic equation. Ten well-known brands are tested including the following five full-service and five limited-service hotel brands: Hilton (*n*=100), Holiday Inn (*n*=230), Marriott (*n*=82), Sheraton (*n*=69), Westin (*n*=21), Best Western (*n*=202), Comfort Inn (*n*=172), Courtyard (*n*=84), Hampton Inn (*n*=174), and Hilton Garden Inn (*n*=21). Table 6 presents the regression analysis with the interaction variables. The inclusion of the interaction variables cause only slight changes to the coefficient values of the age variables and conditioning variables from results provided in Table 3.

Several of the interaction variables are estimated with coefficients significantly different from zero. These coefficients are interpreted as the brands' rate of functional obsolescence. Specifically, the Holiday Inn interaction variable suggests that these properties experience a positive vintage effect of approximately 0.6%/year. Other brands with positive and significant coefficients are Courtyard (1.47%) and Hampton Inn (1.34%). The Marriott variable (0.5%) and Westin variable (0.5%) are significant at the 0.10 level. Brands with normal rates of functional obsolescence include Hilton (−0.6%), and Sheraton (−1.1%). In the absence of theory about the price effects of affiliation, these estimates support the notion that rates of functional obsolescence vary across brands in the hotel market holding other factors constant. The results further suggest that renovation occurs sequentially and not to the extent profitable, leading to cross-sectional variation in observed obsolescence among seasoned hotel properties.

Conclusion

The capital asset literature from recent decades provides the theoretical foundation of empirical specifications for estimating rates of economic depreciation. For the most part, these rates have been needed by tax and housing policymakers. As the commercial real estate markets become more contractually sophisticated, the demand increases among owners and managers for details about the component drivers of depreciation, the process by which properties lose value and the ability of assets to generate cash flow over time. The focus of recent literature on commercial properties has been on obsolescence and the cures for obsolescence, such as renovation, rather than on repairs and maintenance as defenses against the physical components of depreciation.

Functional obsolescence follows from technological change and it is reasonable to assume that technological change occurs at a constant rate. In studies of how technological change manifests into obsolescence and how renovation cures obsolescence, retail properties have received the most attention. Hotels operate in similar competitive environments as retail properties and therefore represent an alternative research setting. Although the long-run obsolescence rate for hotel properties of 1.93%/year aligns closely with the rate estimated elsewhere for retail properties (1.7%/year), the paths of obsolescence through time show some marked departures. Contrary to the theory and the empirical results from the retail real estate market, hotel prices do not reveal substantially more obsolescence in the years immediately following construction than later. Also, the age and sale price relation turns positive nearing the third decade of the lives of hotels indicating a vintage effect. Hotels operate in a unique contractual environment without leases and with management and franchise agreements. These arrangements may create differences in the rate of technological transfer to hotels relative to other property types.

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Table 1 Hotel capital expenditure patterns

Panel A—Average annual capital expenditures by property and ownership types		
Category	1995 study	2000 study
Full-service hotels	6.9%	6.1%
Limited-service hotels	3.7%	5.5%
Suite hotels	N/A	4.9%
Public company association	N/A	6.1%
Private company	N/A	4.6%
Panel B—Range of average annual capital expenditures for all hotels, by age		
Years/age	Minimum (%)	Maximum (%)
1	1.65	4.51
2	1.72	3.29
3	1.43	3.15
4	1.31	3.64
5	3.21	6.23
6	4.80	6.77
7	4.15	5.85
8	3.60	5.23
9	4.83	7.01
10	8.43	11.94
15	3.35	5.72
20	2.37	8.68
25	5.05	10.24

Figure 1

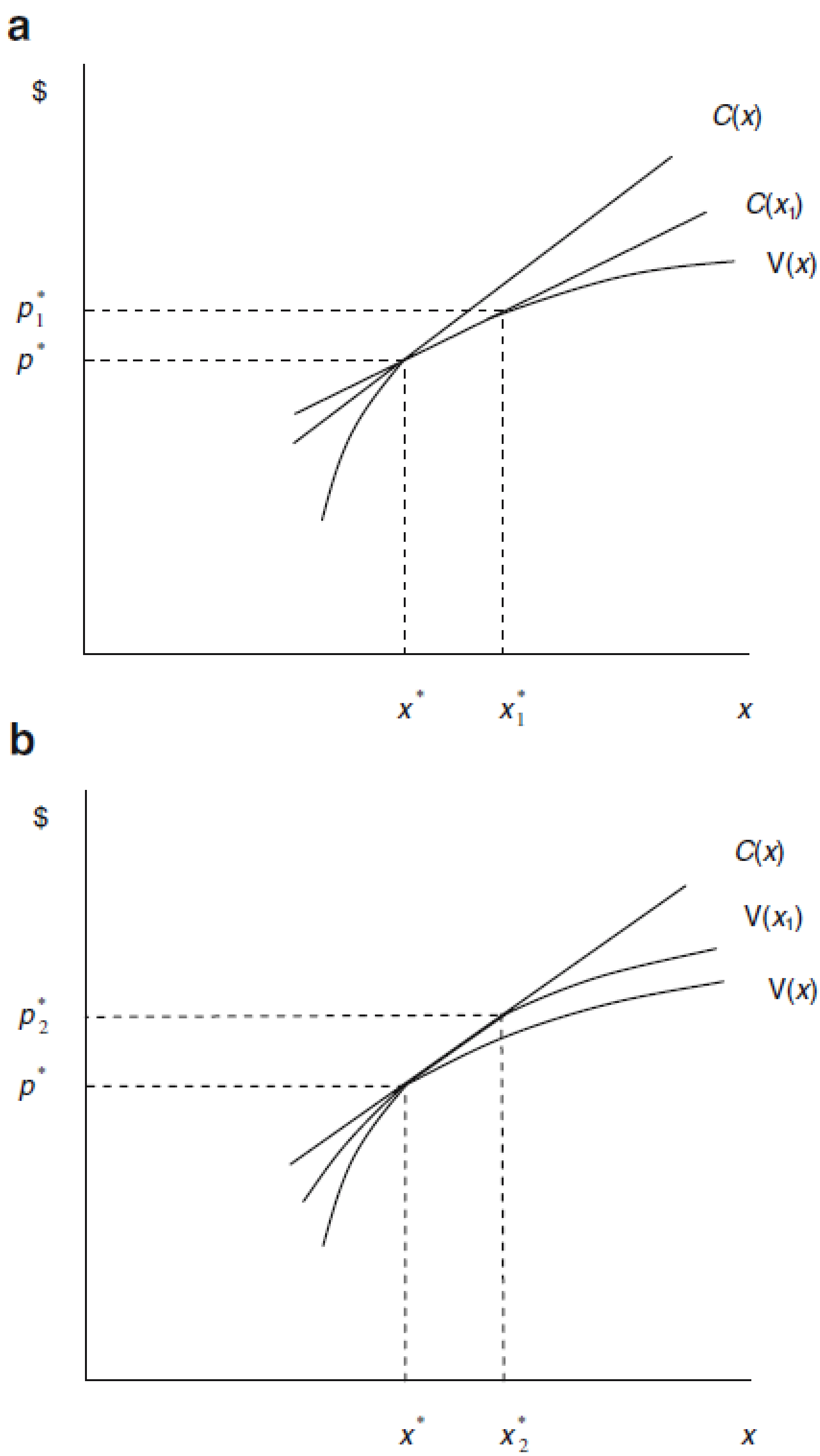

Figure 2

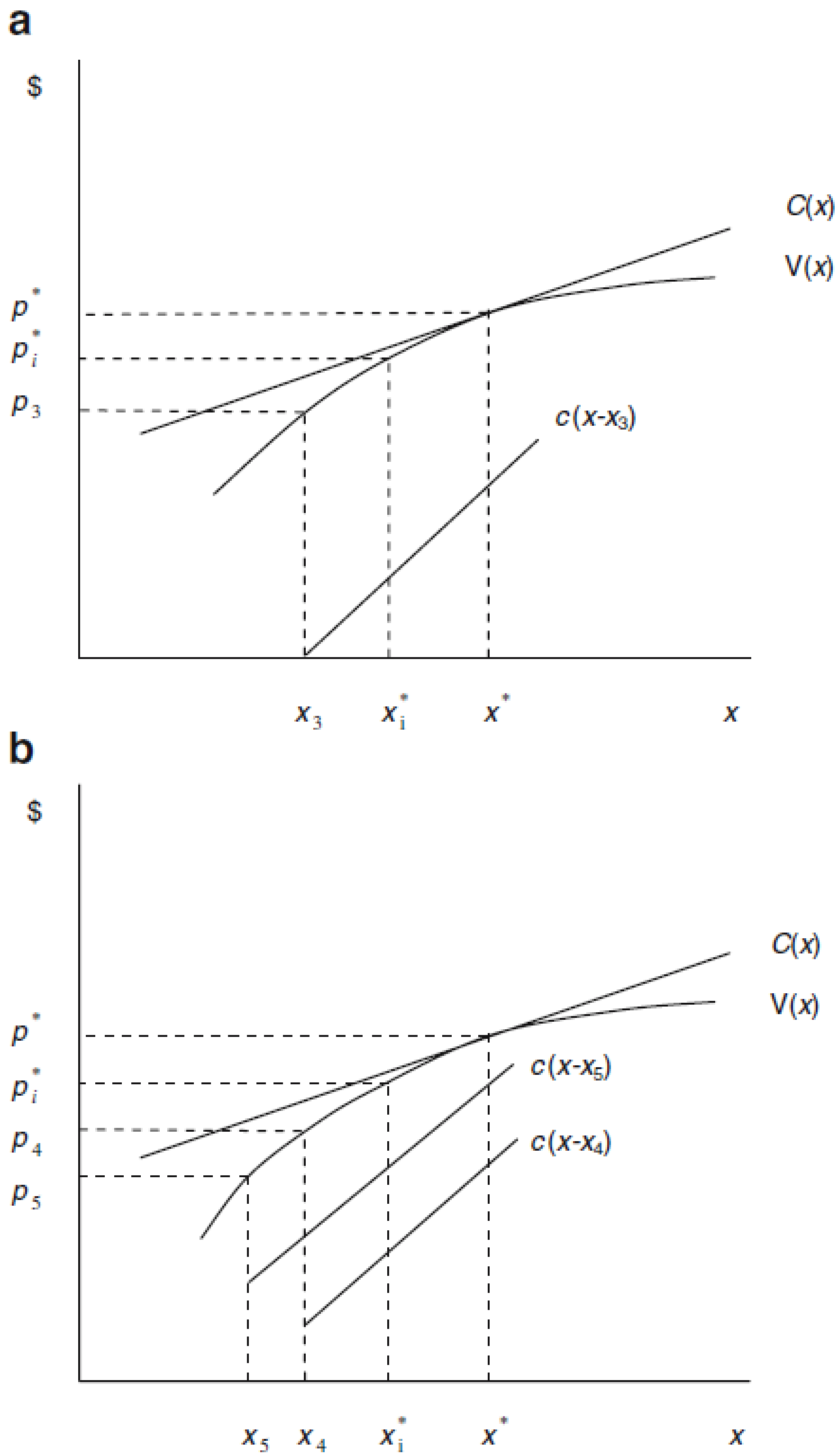

Table 2 Descriptive statistics for hotel property transaction sample

Panel A—Statistics for selected variables

Variable	Symbol	N	Mean	σ	Minimum	Maximum
Sale price	P	3,810	$12.4 M	$24.6M	$.5M	$365M
Number of rooms	RM	3,810	167	155	20	2940
Age	A	3,810	18	15	1	202
Published room rate	R	3,810	$94.18	$61.23	$19	$950
Per capita income	PI	3,810	$26,572	$13,799	$6,428	$148,052

Panel B — Statistics by Category

Category	Sale price Symbol	N	Mean	σ	Minimum	Maximum
Market segment						
Deluxe	DEL	44	$105M	$73.7M	$8.5M	$355M
Luxury	LUX	409	$46.3M	$45.9M	$1.8M	$365M
Upscale	UPS	400	$19.7M	$15.1M	$1.2M	$96M
Upper-tier Extended Stay	UES	92	$12.4M	$7.6M	$1.2M	$74.5M
Midscale W/ F&B	MW	753	$7.1M	$7.6M	$.6M	$80M
Lower-tier Extended Stay	LES	237	$5.1M	$3.9M	$.6M	$26.7M
Midscale W/Out F&B	MWO	800	$4.8M	$3.8M	$.5M	$52M
Economy	ECO	586	$3.2M	$3.5M	$.5M	$5.3M
Budget	BUD	489	$2.5M	$1.6M	$.5M	$10.5M
Age category						
0–10 years	N/A	1,274	$12.4M	$21.6M	$.5M	$275M
11–20 years	N/A	1,237	$12.1M	$23M	$.5M	$355M
21–30 years	N/A	694	$11.9M	$25.5M	$.6M	$321M
31–40 years	N/A	404	$8.5M	$23.3M	$.5M	$365M
Over 40 years	N/A	201	$23.3M	$42M	$.5M	$243M
Year of sale						
1996	T96	462	$14.2M	$21.4M	$.5M	$198M
1997	T97	499	$15.1M	$23.1M	$.5M	$190M
1998	T98	404	$17.5M	$29.9M	$.7M	$197M
1999	T99	372	$12.1M	$25.8M	$.5M	$275M
2000	T00	502	$10.2M	$26.4M	$.5M	$365M
2001	T01	407	$9.9M	$23M	$.6M	$250M
2002	T02	390	$8.2M	$17.9M	$.6M	$214M
2003	T03	463	10.9M	$22.9M	$.5M	$321M
2004	T04	311	13.1M	$30.9M	$.5M	$355M

Table 3 OLS results for all hotels

Dependent variable		ln(R)		ln(P/RM)	
Variable	Label	Cofficient	Std. Error	Cofficient	Std. Error
RM	Number of rooms	0.0003*	0.0001	N/A	N/A
A	Age at date of sale	−0.0044*	0.0006	−0.0136*	0.0010
A^2	Age squared	0.0001*	0.0001	0.0001*	0.0001
R^	Published rate instrument	N/A	N/A	0.1593*	0.0084
PCI	ZIP Per Capita Income	0.0001	0.0001	0.0001*	0.0001
DEL	Deluxe	1.6515*	0.0512	2.0625*	0.0838
LUX	Luxury	1.0512*	0.0251	1.1848*	0.0363
UPS	Upscale	0.7878*	0.0232	0.8098*	0.0370
UES	Upper-tier Extended Stay	0.8375*	0.0255	1.0491*	0.0423
MW	Midscale W/ F&B	0.4922*	0.0193	0.2402*	0.0318
MWO	Midscale W/Out F&B	0.3815*	0.0188	0.2972*	0.0314
LES	Lower-Tier Extended Stay	0.2821*	0.0358	0.2080*	0.0598
ECO	Economy	0.1396*	0.0195	0.0404	0.0325
AS	1=all suites	0.2146*	0.0228	0.3068*	0.0381
T97	1=sold in 1997	−0.0230	0.0214	0.1498*	0.0337
T98	1=sold in 1998	0.0319	0.0214	0.2152*	0.0358
T99	1=sold in 1999	−0.0139	0.0221	0.1852*	0.0370
T00	1=sold in 2000	−0.0460*	0.0255	0.1634*	0.0343
T01	1=sold in 2001	−0.0736*	0.0217	0.1665*	0.0363
T02	1=sold in 2002	−0.0029*	0.0220	0.1193*	0.0368
T03	1=sold in 2003	0.1027*	0.0298	0.1122*	0.0351
T04	1=sold in 2004	0.1668*	0.0232	0.1330*	0.0389
C	Intercept	3.9940*	0.1196	10.2236*	0.1998
(S_1,...,S_J)	States	See note		See note	
R^2	Adjusted	0.6386		0.5343	
RMSE	Root Mean Square Error	0.3091		0.5167	

Table 4 WLS results for all hotels

Dependent variable		$\ln(R)$		$\ln(P/\text{RM})$	
Variable	Label	Cofficient	Std. Error	Cofficient	Std. Error
RM	Number of rooms	0.0003*	0.0001	N/A	N/A
A	Age at date of sale	−0.0056*	0.0007	−0.0171*	0.0012
A^2	Age squared	0.0001*	0.0001	0.0001*	0.0001
R^	Published rate instrument	N/A	N/A	0.1534*	0.0083
PCI	ZIP Per Capita Income	0.0001	0.0001	0.0001*	0.0001
DEL	Deluxe	1.6414*	0.0521	2.0296*	0.0840
LUX	Luxury	1.0464*	0.0251	1.1722*	0.0358
UPS	Upscale	0.7865*	0.0230	0.8131*	0.0364
UES	Upper-tier Extended Stay	0.8289*	0.0251	1.0261*	0.0412
MW	Midscale W/ F&B	0.4941*	0.1924	0.2537*	0.0318
MWO	Midscale W/Out F&B	0.3794*	0.0187	0.2983*	0.0309
LES	Lower-tier Extended Stay	0.2821*	0.0352	0.1904*	0.0583
ECO	Economy	0.1397*	0.0194	0.0300	0.0367
AS	1=all suites	0.2113*	0.0224	0.2931*	0.0367
T97	1=sold in 1997	−0.2218	0.0197	0.1467*	0.0330
T98	1=sold in 1998	0.0314	0.0213	0.2145*	0.0352
T99	1=sold in 1999	−0.1143	0.0220	0.1808*	0.0364
T00	1=sold in 2000	−0.0450**	0.0240	0.1643*	0.0339
T01	1=sold in 2001	−0.0735*	0.0216	0.1709*	0.0357
T02	1=sold in 2002	0.0002	0.0219	0.1231*	0.0364
T03	1=sold in 2003	0.1061*	0.0209	0.1193*	0.0365
T04	1=sold in 2004	0.1688*	0.0232	0.1387*	0.0387
C	Intercept	4.0086*	0.1187	10.2624*	0.1968
$(S_1,\ldots,S_J)$	States	See note	–	See note	–
R^2	Adjusted	0.6383	–	0.5347	–
RMSE	Root Mean Square Error	0.3075	–	0.5113	–

Table 5 Regression analysis: technological change and obsolescence

Dependent variable—ln(P/RM)									
Variable	Label	Critical Age ($\overline{A}$)		Ages<=$\overline{A}$		Ages>$\overline{A}$		Ages<=10 years	
		Cofficient	Std. error	Cofficient	Std. error	Cofficient	Std. error	Cofficient	Std. error
A	Age at date of sale	−0.0193*	0.0011	−0.0191*	0.0042	0.0087*	0.0041	−0.0037	0.0167
A^2	Age squared	N/A	N/A	−0.0001	0.0001	−0.0001	−0.0001	−0.0001	−0.0015
$A-\overline{A}$	Age minus critical Age	0.0259*	0.0019	N/A	N/A	N/A	N/A	N/A	N/A
R^	Published rate instrument	0.1494*	0.0082	0.1475*	0.0089	0.1440*	0.0204	0.1386*	0.0131
PCI	ZIP Per Capita Income	0.0001*	0.0001	0.0001**	0.0001	0.0001	0.0001	0.0001	0.0001
DEL	Deluxe	1.9661*	0.0834	1.9832*	0.0921	1.6737*	0.1964	1.9102*	0.1286
LUX	Luxury	1.1673*	0.0354	1.1589*	0.0378	1.2388*	0.1037	1.2729*	0.0616
UPS	Upscale	0.8145*	0.0361	0.8238*	0.0388	0.7726*	0.0975	0.9932*	0.0591
UES	Upper-tier Extended Stay	0.9912*	0.0408	0.9826*	0.0426	1.1571*	0.2149	1.0831*	0.0561
MW	Midscale W/ F&B	0.2803*	0.0316	0.2869*	0.0358	0.2785*	0.0725	0.4715*	0.0637
MWO	Midscale W/Out F&B	0.2881*	0.0306	0.3000*	0.0327	0.2075**	0.0875	0.4170*	0.0493
LES	Lower-tier Extended Stay	0.1613*	0.0578	0.1613*	0.0614	0.0775	0.1842	0.3355*	0.0735
ECO	Economy	0.0474	0.0320	0.0214	0.0353	0.0853	0.0777	0.0690	0.0580
AS	1=all Suites	0.2735*	0.0363	0.2660*	0.0371	0.3725	0.2134	0.2573*	0.0447

T97	1=sold in 1997	0.1514*	0.0326	0.1460*	0.0341	0.2875*	0.1112	0.1596*	0.0482
T98	1=sold in 1998	0.2204*	0.0348	0.2164*	0.0371	0.2821*	0.1001	0.2783*	0.0525
T99	1=sold in 1999	0.1794*	0.0360	0.1756*	0.0387	0.2488**	0.1070	0.2832*	0.0542
T00	1=sold in 2000	0.1694*	0.0335	0.1610*	0.0362	0.2276**	0.0915	0.2699*	0.0532
T01	1=sold in 2001	0.1787*	0.0353	0.1848*	0.0381	0.1945**	0.0982	0.2320*	0.0564
T02	1=sold in 2002	0.1234*	0.0360	0.1093*	0.0395	0.1974**	0.0926	0.2793*	0.0577
T03	1=sold in 2003	0.1270*	0.0343	0.1269*	0.0374	0.1414	0.0899	0.2442*	0.0559
T04	1=sold in 2004	0.1450*	0.0382	0.1414*	0.0427	0.1887**	0.0927	0.3333*	0.0657
C	Intercept	10.3375*	0.1948	10.3552*	0.1963	9.5755*	0.5601	9.8508*	0.3309
$(S_1,\ldots,S_J)$	States	See note		See note		See note		See note	
R^2	Adjusted	0.5451		0.5426		0.5698		0.5274	
RMSE	Root Mean Square Error	0.5055		0.4933		0.5321		0.4550	

Figure 3

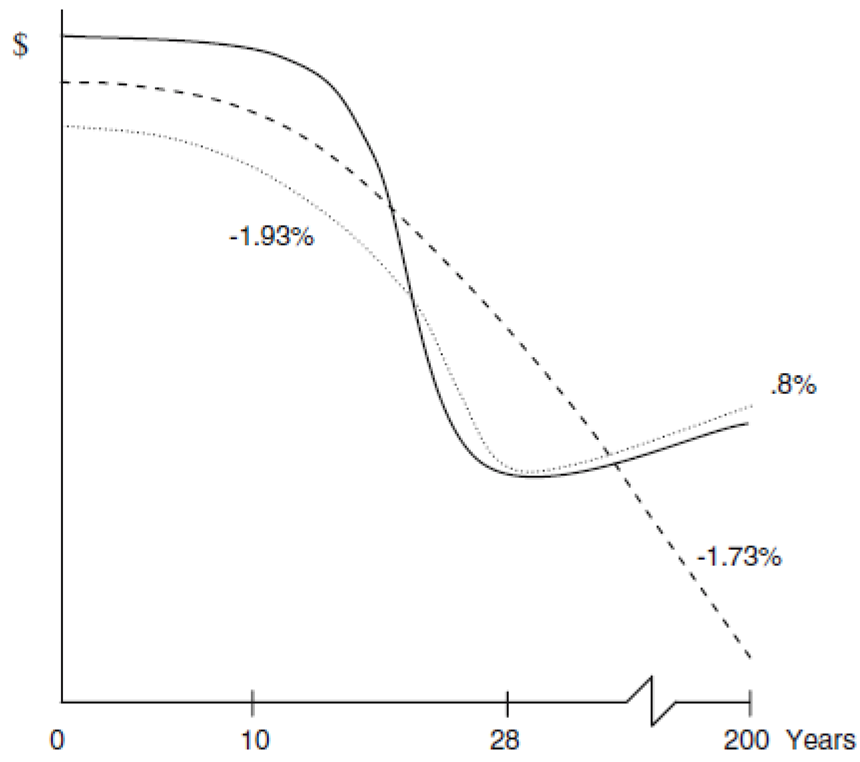

Table 6 Regression analysis: brands and obsolescence

Dependent variable—ln(*P*/RM)			
Variable	Label	Cofficient	Std. Error
A	Age at date of sale	−0.0181*	0.0013
A^2	Age squared	0.0002*	0.0001
R^	Published rate instrument	0.1467*	0.0084
PCI	ZIP Per Capita Income	0.0001**	0.0001
DEL	Deluxe	2.0317*	0.0835
LUX	Luxury	1.2094*	0.0461
UPS	Upscale	0.7914*	0.0371
UES	Upper-tier Extended Stay	1.0216*	0.0409
MW	Midscale W/ F&B	0.1999*	0.0355
MWO	Midscale W/Out F&B	0.2691*	0.0334
LES	Lower-tier Extended Stay	0.1845*	0.0570
ECO	Economy	0.0409	0.0322
AS	1=all Suites	0.3080*	0.0373
T97	1=sold in 1997	0.1518*	0.0327
T98	1=sold in 1998	0.2185	0.0350
T99	1=sold in 1999	0.1846*	0.0362
T00	1=sold in 2000	0.1779*	0.0338
T01	1=sold in 2001	0.1801*	0.0355
T02	1=sold in 2002	0.1340*	0.0362
T03	1=sold in 2003	0.1271*	0.0346
T04	1=sold in 2004	0.1446*	0.0385
IHIL	Hilton * Age	−0.0059**	0.0024
IHOL	Holiday Inn *Age	0.0060*	0.0017
IMAR	Marriott * Age	0.0050	0.0027
ISHR	Sheraton * Age	−0.0107*	0.0033
IWES	Weston * Age	0.0052	0.0031
IBW	Best Western * Age	0.0021	0.0019
ICOM	Comfort Inn *Age	−0.0018	0.0028
ICOU	Courtyard * Age	0.0147**	0.0054
IHAM	Hampton Inn * Age	0.0134*	0.0038
IHGI	Hilton Garden Inn * Age	0.0169	0.0148
C	Intercept	10.2760*	0.1957
$(S_1,\ldots,S_J)$	States	See note	
R^2	Adjusted	0.5412	
RMSE	Root Mean Square Error	0.5077	