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ABSTRACT

Opaque Selling: Static or Inter-Temporal Price Discrimination?*

We study opaque selling in the hotel industry using data from Hotwire.com. An opaque room discloses only the star level and general location of the hotel at the time of booking. The exact identity of the hotel is disclosed after the booking is completed. Opaque rooms sell at a discount of 40 percent relative to regular rooms. The discount increases when hotels are more differentiated. This finding is consistent with static models of price discrimination. No support was found for predictions specific to inter-temporal models of opaque selling.

JEL Classification: L0, L15 and L83
Keywords: inter-temporal price discrimination, opacity, opaque selling and product differentiation

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1 Introduction

Opaque selling is the practice of offering travel inventory such as hotel rooms, airline tickets, or car rentals at discounted prices while hiding the identity of the supplier until after the purchase has been completed. Opaque selling represents a large fraction of online travel agents' (OTA) business and it is also one of OTA's most profitable segments (HSMAI, 2012). There are several theories explaining why companies may offer opaque goods (e.g. Fay, 2008; Shapiro and Shi, 2008; Jerath et al., 2010). There is, however, no empirical evidence on opaque selling. This paper is a first step toward filling this gap.

We collect information on opaque rooms offered in Hotwire, the largest OTA using posted prices. At the time of purchase, or booking day, a buyer choosing the opaque option knows the general location of the hotel and its star rating but discovers the hotel's name and exact location only after the purchase has been completed. The purchase is non-refundable, non-changeable and non-transferable. The dataset covers multiple markets, booking days, and travel nights with more than ten thousand prices for opaque and regular offers. The main purpose to this paper is to document how the level of discount for opaque rooms depends on measures of hotel differentiation and on the time to expiry (number of days between the night of travel and the day the booking is made).

One would expect opaque rooms to cost less than regular ones. Given the choice, consumers prefer having the option to select their preferred hotel. The average opaque room in the sample costs 40 percent less than equivalent regular offers. The observation that many travelers do not choose the opaque rooms suggests that they must put a large premium on the option to choose a hotel.

The main rationale for opaque selling is that it allows firms to price discriminate between the consumers who are sensitive to product differentiation (buy regular rooms) and those who aren't (buy opaque rooms). The expected quality of the opaque room is known. Product differentiation is associated with the unknown location and identity of the opaque hotel. Models vary in their emphasis but they all share the prediction that the opaque discount should increase with the extent of product differentiation (Fay, 2008; Shapiro and Shi, 2008; Jerath et al., 2010). To investigate this prediction, we distinguish two notions of differentiation that are relevant in the hotel industry. Hotels are differentiated by location. It is argued that hotels in airport areas are less differentiated because location is less important there than for non-airport areas. As expected, the opaque discount (percentage price difference between opaque and regular rooms) in airport locations is 12.2 percentage points lower than in non-airport ones. We also look at the size of the area covered within a given opaque offer. Since location is an important aspect of differentiation for non-airport hotels, we expect that the opaque discount should decrease with area size. In fact, the opaque discount decreases by 1.3 percent as the longest distance between any two points within an opaque area increases by one mile.

Hotels are also differentiated by traveler segments. We compare the opaque discount in cities that cover many traveler segments and those that cover smaller subsets. For example, Palm Springs, Las Vegas and Chicago all cater to tourist and leisure travelers, but Las Vegas also caters to convention travelers, and Chicago caters both to convention travelers and business travelers as well. We expect product differentiation to play a more important role in cities that cater to additional traveler segments. Seven cities were selected that serve four subsets of traveler segments. The focus was on pairs of cities that have nested subsets of segments. As expected, we find that the opaque discount is higher in the city that serves large sets of traveler segments.

Some authors have argued that opaque pricing also has an inter-temporal price discrimination dimension (Jerath et al., 1010). Hotels offer opaque rooms only close to the expiry date to sell distressed inventory to the consumers who are not sensitive to product differentiation. Opaque rooms are not available early on when rooms are sold to the consumers who care about product differentiation. Rooms are available *only* close to the expiry date *and* if there is excess inventory. The evidence does not support this hypothesis. Opaque room availability in our sample does not change over the last two weeks prior to the expiry date.

As follows, Section 2 reviews theories of opacity and discusses two hypotheses. Section 3 presents the industry, data, and empirical framework. Section 4 discusses the results and Section 5 offers conclusions.

2 Theory review

All explanations for opaque selling are based on a price discrimination argument. The general idea is that by adding an opaque product, firms change market segmentation and can increase the price of regular offers. The argument that adding a product can improve price discrimination is well-known in the bundling and damaged-goods literature (Deneckere and McAfee, 1996). The novelty of opaque pricing is that the new product is a lottery over products that were already offered by competing firms (Fay and Xie, 2008). Therefore, opaque selling mixes elements of price discrimination and competition with differentiated products (Stole, 2007). There are static and dynamic models of opaque selling. Shapiro and Shi (2008) propose a static model of price discrimination. Jerath et al. (2010) and Wang et al.

(2009), on the other hand, emphasize that opaque selling is used in industries carrying last minute distressed inventories. They propose a model of inter-temporal price discrimination under demand uncertainty.

According to Shapiro and Shi, opaque selling "enables service providers to price discriminate between those customers who are sensitive to service characteristics and those who are not" (p. 803). The introduction of opaque selling increases competition for the price-sensitive customers (a decrease in profits) but reduces competition on the customers who are service sensitive (an increase in profits). They show that opaque selling can be profitable even in the absence of market expansion due to a reduction of competition on the high margin segment.[3] Product differentiation is defined within a spatial model as the distance between two adjacent products located on a circle. A key prediction of Shapiro and Shi is that the difference between the price of regular and opaque rooms should increase with the level of product differentiation (Proposition 3, p. 815).

Jerath et al. add a dynamic dimension to the static models of opaque selling. Consumers sort both inter-temporally and across regular and opaque rooms. Price-sensitive consumers wait for last minute opaque rooms that are available only when some hotels have distressed capacity due to a low demand realization. Service-sensitive consumers buy early because they may not obtain their preferred product in the late market. Jerath et al. show that opaque selling dominates last-minute sales when product differentiation is important. This is because opaque selling diverts fewer regular sales, relative to last-minute discounting of distressed

[3] Jerath et al. also discuss a static version of their model in which opaque selling has a market-expansion effect. In practice, both effects (market segmentation and market expansion) may be at play.

inventory, away from the full-price offers. According to the inter-temporal model, opaque offers should be available (a) only close to the expiry date and (b) not all the time.

3 Case study and data

3-1 Online travel agency, opaque pricing and Hotwire[4]

Opaque pricing is offered by online travel agency (OTA). The North American OTA market is highly concentrated as four companies, along with their subsidiaries, collectively hold more than 97 percent market share: Expedia (expedia.com, hotwire.com), Sabre Holdings (Travelocity.com, Lastminute.com), Orbitz Worldwide (orbitz.com, cheaptickets.com) and Priceline. The two main models of opaque selling are Priceline's "name your own price"® and Hotwire's "hot rates." The main distinction is that Hotwire has posted prices while Priceline's consumers make bids that Priceline may accept or reject.

This paper focuses on Hotwire because one can observe and collect opaque prices only for posted prices. Hotwire offers both regular rooms, as other OTAs, and opaque rooms. Opaque rooms display only partial information including the general area within a city, the star level and some amenities. It does not reveal the hotel's exact location, brand, or name. The prices of opaque rooms are much lower than the prices of regular offers—up to a 50% discount rate according to Hotwire.

Online travel agencies have successfully developed opaque selling in North America and also worldwide. TravelClick reports that the opaque segment represents six percent of hotel reservations for major hotel brands. Typically, OTAs work under a merchant model. A hotel enters the rate at which it wants to offer a room on Hotwire and the inventory available at

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[4] Much of the information discussed in this section is drawn from a teaching case (Courty and Liu, 2012).

that rate. The OTA receives a commission once a booking is made but it makes no commitment on inventory and takes no risk over unsold capacity. Online travel agencies charge substantial fees for their services. According to HSMAI (2012), OTA commissions in 2011 were approximately 17 percent for regular hotel rooms and 40 percent for opaque bookings.

Hotwire has eight star and half-star categories and it uses its own ratings to rank hotels (averaging the ratings on other travel sites and then making adjustments based on customer feedback).[5] An opaque room also comes with an approximate percentage discount off the regular price. With this information, a consumer should have a fairly good idea of the value to expect from the opaque room. There was no evidence of systematic consumer complaints regarding discrepancies between value promised and the hotel delivered. According to MarketMetrix, Hotwire is ranked the highest in customer satisfaction on hotel travel websites from 2006 to 2010.

What the consumer does not know at the time of booking is the exact hotel that will be obtained within a given value category and general geographical area. This information is important for the consumers who care about exact location or about specific hotel attributes. Consumers may be able to make some inferences regarding the hotels they are likely to obtain in an opaque booking. Hotwire lists some hotel suppliers on its website although it claims that “Hotel brands are provided as examples only. Hotwire does not guarantee you will stay in one of the hotels listed above.” Hotwire also posts regular (non-opaque) rooms

[5] Hotel ratings were collected from Hotwire and TripAdvisor for the sample of 110 hotels. The correlation between the two is 93.7 suggesting a small difference between the two ratings.

that match the description of opaque rooms. In the cities we study, there are on average four regular hotels posted in the non-opaque section of Hotwire for each opaque room.

Opaque selling on Hotwire differs from the way opaque pricing is captured in the theoretical models discussed earlier. In theoretical models, consumers believe at the time of the booking that they will obtain one of the hotels that participate (in equilibrium) in opaque pricing. Using these beliefs, Shapiro and Shi compute a measure of differentiation between the goods that fall within an opaque room. They also compute the opacity of an opaque deal as the number of goods included in the deal. Hotwire, however, does not reveal the set of hotels that participate in a specific opaque booking. Still, the information presented in the regular section of Hotwire can be used to derive reasonable belief on opacity and differentiation as will be explained shortly.

3-2 Data

Price and availability information was collected for opaque and regular offers in seven U.S. cities. To select the cities, we used two rankings of the top 25 cities for general business travel and for convention travel. Hotel demand is composed of these two business segments in addition to tourist/leisure (T/L) travelers. These seven cities cover four types of markets: (a) Chicago and Washington, D.C. are highly ranked for both business and convention travel. These cities are called *ALL* because they cover all traveler types. (b) Las Vegas and Orlando are highly ranked only for convention travel. These cities are called *CONV+T/L* because they cover convention and tourist/leisure travelers. (c) New York is highly ranked only for business travel. It is called *BUS+T/L*. (d) Palm Springs and Honolulu are not part of either ranking. They cater only to T/L.[6]

The two sources of price and availability data are the Hotwire website and individual hotel websites. The regular section of Hotwire is similar to that of other non-opaque OTAs. Opaque rooms are for a given geographical area and star category. Each city is divided into areas (see Figure 1). The number of areas in the sample varies from 20 in Chicago to six in Palm Springs. Hotwire categorizes hotels from one to five stars with also 2.5, 3.5 and 4.5 stars. Hotwire typically displays multiple opaque star categories in each area. The average number of opaque rooms within a city is 36 in the sample.

In each city, data was collected for four or five of the most popular areas (areas with the largest number of opaque rooms) with two or three different star levels chosen in each area. There are 65 types of opaque rooms in our sample covering 32 different areas and seven star categories. Out of the 32 areas, six were designated as airport areas in Hotwire. The star levels represented in the sample vary from two to five stars with half star increments. For convenience, 2 and 2.5 star offers were pooled into low quality; 3 and 3.5 into medium quality; and 4, 4.5 and 5 into high quality. Appendix 1 describes in detail the 65 types of opaque rooms in the sample.

For each type of hotel room, hotels were randomly selected in Hotwire's regular section that matched the area and star level of the opaque room. For example, consider an opaque

[6] Chicago and Washington, D.C are ranked first and third in both rankings respectively. Las Vegas is ranked second for convention and 19th for business travel. Orlando is ranked fourth for convention and 20th for business travel. New York is ranked fourth for business travel and 20th for convention travel. http://www.hotel-online.com/News/PR2005_1st/Feb05_HabitsTracked.html

room for a four star hotel in the area denominated *Empire State Building* in New York. The hotels in Hotwire's regular section that belong to the Empire State Building area were sorted and then two four-star hotels in that area were chosen: The Empire Hotel and Lowes Regency Hotel. In the end, 110 hotels cover the majority of the 65 opaque rooms in the sample.[7]

Price information for opaque rooms was collected from Hotwire. The price information for regular offers was collected from the hotels' own websites. For each hotel, the price was noted for a standard room for two adults staying one night. When this room category was sold out, the room was considered unavailable. The reason the prices of regular offers was taken from the hotels' own websites, rather than from the regular section in Hotwire, is because hotels are not always represented on the regular section of hotwire.[8]

A *travel night* is defined as the night when one plans to travel and a *booking day* as the day when the booking is made. It was important that the dataset contain information on future travel nights holding the booking day constant and also for the same travel night booked on different days. The sampling design is displayed in Table 1. Price information was collected over a 10-day period. Each day, prices for seven travel nights were collected on a rolling window. An important consideration was how far in advance to start collecting prices. The trade-off is between having a long advance booking day history and enough data to identify changes over that history. Because the goal of this paper was to investigate discount

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[7] It was not always possible to randomly select two hotels per opaque room. There are 32 opaque rooms with two hotels, 21 rooms with one hotel, eight rooms with three hotels, and four rooms with none.

[8] For a small subsample of observations, the regular price on Hotwire and the price on the hotel's website conditional on availability were compared. The correlation between the Hotwire price and the hotel's price is .95.

offers for last-minute distress inventory, the focus was on a two-week window prior to the travel night.[9]

Table 2 presents some summary statistics for the main variables. There are 22 travel nights and 10 booking days. Regarding availability, there are 4550 opaque observations (7 days * 10 nights * 65 opaque rooms) and 7601 regular observations.[10] Prices were collected when a room was available. This resulted in 3921 opaque prices and 6496 regular prices. The average price of an opaque room is $96.94, while the average price of a regular room is $169.71.

Opaque rooms are available about as often as regular rooms (86 versus 84 percent of the time). Table 2 also shows two other measures collected for each of the 65 opaque rooms. A measure of opacity is defined as the number of hotels that match that opaque room in the regular section of Hotwire. For example, for the 4.5 star hotels located in the Times Square area of New York, the number of 4.5 star hotels was collected through the regular section of Hotwire. Opacity varies from 0 to 9 with a median of 3. For each area, a measure of the size of the area was collected. This is a proxy for product differentiation as will be argued below. Area size is defined as the longest distance between any two locations within a given area (see Figure 1). The average area size in this sample is 3.94 miles with a standard deviation of 3.25.

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[9] Some hotels also offer large discounts far in advance for travel nights that are expected to have a low demand. These discounts fall outside the scope of this study.

[10] There are 110 regular hotels in the sample. There are 7601 regular observations instead of 7700 observations (7*10*110) because the hotel's website could not be accessed in a few instances. For example, some of the Hilton Group hotel websites encountered a problem and could not display the room rates for May 25th. This happened in 99 instances out of 7700 searches.

4 Empirical framework and results

We analyze the price and availability of opaque and regular rooms. In the price analysis, we study how the log of price varies across markets for regular and opaque rooms. We use the following specification

$$Ln(p) = \alpha + X\beta_x + Opaque*\beta_o + Opaque*X\beta_{x,o} + \varepsilon \qquad (1)$$

where p is the price of a regular or opaque room; X includes a set of product characteristics that influence prices; Opaque is a dummy equal to one if the price is for an opaque room; ε is an error term; and α, β_o, β_x, $\beta_{x,o}$ are parameters/vectors to be estimated. The variables included in X are a set of market dummies (BUS+T/L, CONV+T/L, ALL); a set of dummies for hotel quality; a dummy for airport locations; a dummy for weekend travel nights; and a set of dummies for advance booking days. A log specification for price is used because Hotwire advertises the potential savings for opaque prices as fractions of regular prices indicating that opaque prices vary proportionally to regular prices.

Specification (1) acknowledges the fact that prices may vary across markets, travel nights, and booking days. The set of variables in X accounts for these differences. Holding constant these differences, the question is whether the opaque discount depends systematically on market characteristics that influence the extent of product differentiation. Our interest is on the coefficient estimates $\beta_{x,o}$. To illustrate, consider the distinction between airport and non-airport markets. A key determinant of hotel differentiation is location. Location does not matter as much for airport hotels because all airport hotels are within a couple of minutes drive from the airport. A lower opaque discount for hotel airports is expected because differentiation plays a lesser role. The level of hotel prices may be lower (or higher) in airport areas. A control is included for this level and what matters is the difference in opaque discounts in airport relative to non-airport areas: We compare the difference between regular and opaque prices across airport and non-airport markets.

We can apply this difference in difference approach to other product characteristics keeping in mind that the identification of $\beta_{x,o}$ rests on the assumption that holding constant the demand shifters X and Opaque, the omitted variables that influence Ln(p) are orthogonal to the interaction term Opaque* X. This is the case, for example, if omitted variables have the same impact on the regular and opaque prices or if the omitted variables that influence differentially these two prices are not correlated with the variables in X. Such omitted variable problem is less a concern with our approach because we do not try to explain the level of opaque prices. Instead we are interested in how the percentage difference between the opaque and regular price depend on hotel characteristics.

The availability analysis describes how availability varies with advance booking days. The specification used for availability is similar to (1)

$$Pr(A=1) = \alpha + X\beta_x + Opaque*\beta_o + Opaque*X\beta_{x,o} + \varepsilon \qquad (2)$$

where A is equal to one if the regular or opaque room is available. Again we compare opaque availability relative to regular room availability. According to the dynamic model of opaque discounts, opaque rooms should not be available in advance, and should be available, with some probability less than one, close to the travel night.

4-1 Opaque room price discount

Specification (1) is estimated using robust standard errors clustered at the level of city interacted with travel night to account for the possibility that price observations could be dependent within a city on the same travel night. Table 3 model (1) includes only the control variables X and the Opaque dummy. It gives plausible economics estimates for the main variables. Hotel prices increase with hotel quality, and are higher during weekends and in non-airport areas.

Before turning to the role of product differentiation, we discuss the coefficient of the opaque dummy which is informative in itself. Opaque prices are 40 percent—1-exp(-.504)—lower than regular prices. As discussed earlier, this is a measure of the premium for differentiation if the regular hotels in the sample are representative of the hotels consumers believe they will get with the opaque room. This is a reasonable assumption because hotels were randomly selected, to match the opaque rooms in the sample, within the subsets of hotels featured in the regular section of Hotwire. Another concern is that the availability of opaque rooms may be correlated with the level of regular price. As a robustness check, the ratio of opaque to regular price was computed for the subset of observations for which both regular and opaque rooms were available (94 percent of the 10,417 price observations in the sample). The average discount computed that way is 36 percent. Both figures suggest that buyers of regular rooms are willing to pay a substantial premium for differentiation.

Column 2 adds product characteristics interacted with the opaque dummy. The coefficient on these interacted variables measures how the opaque discount varies with each characteristic. The interest is on characteristics that are proxies for product differentiation. Holding quality constant, hotels are primarily differentiated by location. As discussed above, we expect location to matter less in airport markets. Consistent with this hypothesis, the log of opaque price increases by .13 in airport areas relative to non-airport areas and the coefficient estimate is highly significant. The difference is economically important. The opaque discount is 12.2 percent lower —1-exp(-.13)— in airport relative to non-airport locations.

A traveler who considers buying an opaque hotel knows only the general area where the hotel will be located (see Figure 1). Say the traveler would like to stay in a given location within that area. Not knowing where the opaque hotel is located is less important if the area is small. Any hotel within the area must be fairly close to the traveler's preferred location. This is not the case for large areas. The traveler may end up far from her favorite location. We expect the opaque discount to be higher in larger areas. The variable area size interacted with the opaque dummy captures this effect. Area size is an indicator for the distance a traveler should expect the opaque hotel to be from her preferred location. We set area size to zero for airport locations to account for the fact that area size matters less for airport areas as argued above (including these observations does not change the results). Increasing area size by one mile increases the opaque discount by about 1.3 percent and the coefficient is highly significant.

Both measures of differentiation based on physical location (airport and area size) are consistent with the theory. These two measures, however, should be distinguished from an identification viewpoint. Area size is chosen by Hotwire (subject to constraints imposed by geography and neighborhood boundaries) while the airport dummy is exogenous. The price of regular rooms decrease by 1.2 percent as area size increases by one mile (coefficient for area size not interacted). It is not clear what mechanism is at play and whether it influences the interpretation of the coefficient estimate for area size interacted with opacity.

Hotels are also differentiated on the basis of characteristics (other than location) that appeal differently to different consumers. To implement this in practice, note that the seven cities in the sample serve four different subsets of submarkets of travelers: convention, business, both convention and business, or neither convention nor business. The hypothesis is that hotel differentiation within a city is higher in cities that serve more submarkets. This is because hotels specialize to appeal to specific submarkets by investing in amenities that appeal to the chosen submarket. To illustrate, hotels targeting business travelers are more likely to have more than one business center; hotels targeting conventions, a fancier ballroom; and hotels targeting leisure travelers, a spa. If hotels specialize, one would expect that hotels located in cities serving more submarkets to be more differentiated. Palm Springs and Honolulu are low differentiation cities because these towns serve mostly tourist and leisure travelers. Differentiation is higher in cities that also serve business travelers or convention travelers. Differentiation is highest in cities that serve both business and convention travelers, in addition to tourist and leisure travelers. In total, we can make four pair wise comparisons of cities that contain nested subset of submarkets. Using tourist and leisure cities (T/L) as the omitted city category, log opaque prices are lower in cities that cater, in addition to tourist and leisure traveler, also business travelers (-.129) or convention ones (-.08). The former coefficient is highly significant. Log opaque prices are still lower in cities that serve all submarkets of travelers (-.185). Moreover, the differences are economically important.

The variable opacity offers a final opportunity to look at product differentiation. For a given opaque room, we measure opacity as the number of regular hotels offered on Hotwire that match that opaque offer.[11] If hotels are differentiated in other dimension than the ones

[11] Opacity is measured as the number of hotels displayed on Hotwire matching a given opaque room on a given booking day and travel night. The concern was that these choices (of booking day and travel night) may influence the results. As a robustness check, opacity was collected on three different dates for three different travel nights. The correlation between the three measures is high (.66 when two weekday nights are compared and .57 and .43 when a weekend and weekday night are compared) and the coefficient estimate for opacity does not change

we already control for (which is very likely) we would expect that the opaque discount should increase with opacity. This is because the travelers who care about a single hotel face more uncertainty as opacity increases. In fact, Table 3 column 3 shows that the opaque discount increases by 3.7 percent for each additional hotel in an opaque offer.[12] Because model 3 holds area size, city type, and airport constant, the interacted opacity variable captures the other dimensions of hotel differentiation that are not captured by these variables. Another concern is that opacity could be correlated with local market competitiveness (higher opacity means more hotels competing). But column 3 controls for opacity non-interacted. The small and insignificant coefficient estimate is inconsistent with the competition hypothesis. Only the price of opaque room depends on opacity. Consumers are willing to pay less when it involves facing more uncertainty about the product they may receive (higher opacity).

4-2 Opaque room availability

Table 4 presents the results of specification (2) estimated using a linear probability model. The results are robust using a logit or probit model (not reported here). Consider model two. The variables Advance Booking Days * Opaque computes the availability of opaque rooms as a function of advance booking days (ABD). Advance booking days have been grouped in three categories: three or five days, seven or nine days, and 11 or 13 days.

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when the opacity measure is changed. The results reported use the average value of opacity over these three dates.

[12] This result is consistent with one of the equilibria derived in Shapiro and Shi. They derive two types of opaque equilibria, and show that an exogenous change in opacity increases the opaque premium only in the profit-inferior equilibrium. In the profit-superior equilibrium, the opaque premium does not depend on opacity. This is because the model rules out substitution from the regular to the opaque segment. In a general model where opaque rooms divert sale from regular offers, one would expect that opacity would increase the opaque discount.

The omitted category corresponds to the last day the travel night is available (ABD=1). All coefficients are very small and insignificant. The availability of opaque rooms is constant over the last 13 days before a room expires.

According to the inter-temporal price discrimination hypothesis, one would have expected (a) less availability in opaque rooms 13 days in advance (b) an increase in availability of opaque rooms close to the travel night. This is not the case. We find a high availability of opaque room 13 days in advance and no increase closer to the travel night.

Hotwire also publishes the number of opaque and regular offers per city for each future travel night. This number was collected for all cities on each booking day and night listed on Table 1 (490 observations). We tried a specification explaining how opaque and regular offers vary with ABD. Again no effect of ABD on opaque rooms was found after controlling for a number of variables (see Appendix 2). The availability of opaque rooms does not decrease with ABD. This approach covers a much greater number of opaque rooms than are in Table 4 but the data is aggregated at the city level.

One may argue that opaque rooms are available in advance because the discount is smaller. This is a generalized version of the inter-temporal price discrimination hypothesis. Time of purchase still segments the market between the consumers who are sensitive to product attribute and those who aren't but segmentation is achieved by varying the size of the opaque discount over time rather than by varying availability. To check whether this is the case, the value of the coefficient estimates for ABD*Opaque in specification (1) were examined. Table 3, models 2-4, show that the opaque discount is slightly lower 11 to 13 days in advance and constant afterwards. This contradicts the inter-temporal price discrimination hypothesis. The opaque discount is higher—instead of lower—further in advance.

Casual evidence indicates that the availability of opaque rooms mirrors the availability of regular rooms. A coarse measure of room availability was computed as follows. For each of the 4270 opaque rooms in the sample, we say that a regular hotel room was available for that opaque room if at least one of the hotels matching the opaque room has availability. This is coarse because the sample only contains a small subset of the hotels that match each opaque room. At least one room is available 91.5 percent of the time over the 4270 opaque rooms in the sample. Conditional on at least one hotel room being available, an opaque room is available 90 percent of the time. Opaque rooms are available when regular rooms are.

To sum up, there are two main challenges to the inter-temporal price discrimination hypothesis: (a) opaque rooms are widely available 13 days in advance; (b) opaque room availability does not increase (or the opaque price does not decrease) close to the travel night. One may argue that we do not find support for the inter-temporal price discrimination hypothesis because distressed inventory rarely occurs in the sample. But the inter-temporal hypothesis says that opaque rooms should not be available at all in the absence of distressed inventory. This is not the case in the sample.[13]

5 Conclusions

We document several stylized facts on the use of opaque selling in the context of the hotel industry using posted prices from Hotwire. Opaque rooms sell undifferentiated goods at a discount of 40 percent over differentiated offers. The opaque discount is higher in

[13] Others have also reported that hotels are unwilling to offer last minute discounts. Kalnins (2006) asks whether "margins decrease before rooms perish" and finds little support for such discounts.

markets where product differentiation plays a more important role such as non-airport markets, cities that serve additional traveler segments, and when the opaque room covers a larger geographical area. The opaque discount increases by 3.7 percent for each additional hotel covered within an opaque room. The availability of opaque rooms, and the size of the opaque discount, do not increase closer the travel night. Overall, the evidence is broadly consistent with a static model of price discrimination as in Shapiro and Shi (2008). No evidence was found in support of inter-temporal price discrimination as in Jerath et al. (2010).

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Figures and Tables

Figure 1. The 11 opaque areas in New York City.

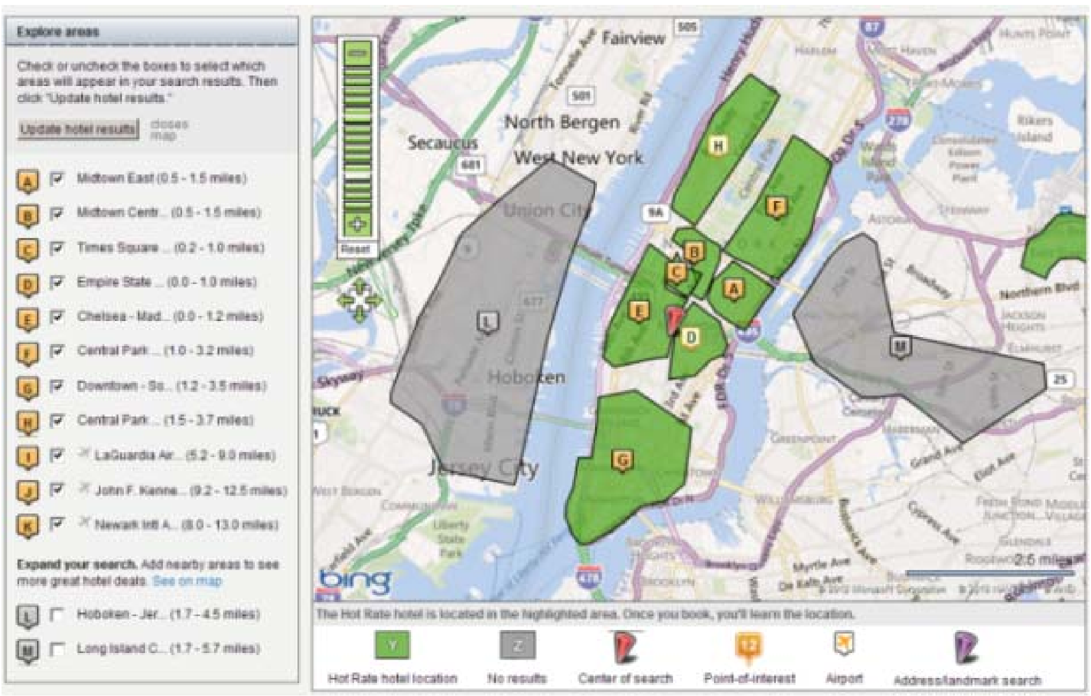

Table 1. Data Collection Design

	Booking days	May 17	May 18	May 19	May 20	May 21	May 22	May 23	May 24	May 25	May 26
Travel nights		Mon	Tue	Wed	Thur	Fri	Sat	Sun	Mon	Tue	Wed
18-May	Fri	Book (1)									
19-May	Sat		Book (1)								
20-May	Sun	Book (3)		Book (1)							
21-May	Mon		Book (3)		Book (1)						
22-May	Tue	Book (5)		Book (3)		Book (1)					
23-May	Wed		Book (5)		Book (3)		Book (1)				
24-May	Thu	Book (7)		Book (5)		Book (3)		Book (1)			
25-May	Fri		Book (7)		Book (5)		Book (3)		Book (1)		
26-May	Sat	Book (9)		Book (7)		Book (5)		Book (3)		Book (1)	
27-May	Sun		Book (9)		Book (7)		Book (5)		Book (3)		Book (1)
28-May	Mon	Book (11)		Book (9)		Book (7)		Book (5)		Book (3)	
29-May	Tue		Book (11)		Book (9)		Book (7)		Book (5)		Book (3)
30-May	Wed	Book (13)		Book (11)		Book (9)		Book (7)		Book (5)	
31-May	Thu		Book (13)		Book (11)		Book (9)		Book (7)		Book (5)
01-Jun	Fri			Book (13)		Book (11)		Book (9)		Book (7)	
2-Jun	Sat				Book (13)		Book (11)		Book (9)		Book (7)
3-Jun	Sun					Book (13)		Book (11)		Book (9)	
4-Jun	Mon						Book (13)		Book (11)		Book (9)
5-Jun	Tue							Book (13)		Book (11)	
6-Jun	Wed								Book (13)		Book (11)
7-Jun	Thu									Book (13)	
8-Jun	Fri										Book (13)

Note. Advance booking days are in parenthesis.

Table 2. Summary Statistics

	Obs	Mean	Std. Dev.	Relative S.D.	Median	P25	P75	Min	Max
Price of Opaque rooms ($)	3921	96.94	60.85	0.627	82	56	120	8	505
Price of Regular Rooms ($)	6496	169.71	104.17	0.613	149	91	219	30	787
Availability of Opaque rooms	4550	0.863	0.344	0.399	1	1	1	0	1
Availability of Regular Rooms	7601	0.844	0.363	0.430	1	1	1	0	1
Opacity of Opaque rooms	4550	3.245	2.287	0.705	3	1	5	0	9
Area Size	32	3.94	3.25	0.83	2.84	1.79	5.02	0.71	15.75

Notes: (a) The total number of availability observations is 12,151 instead of 12,250 because the hotel website could not be accessed in 99 instances.
(b) Opacity is measured as the number of regular offers for a given opaque room.
(c) Area size is measured in miles as the longest distance between any two points within an opaque area.

Table 3: Effects of product characteristics on Log price

VARIABLES	(1)	(2)	(3)
Business+T/L	0.492***	0.552***	0.553***
	(0.0410)	(0.0391)	(0.0391)
Convention+T/L	-0.484***	-0.378***	-0.383***
	(0.0399)	(0.0473)	(0.0495)
ALL	0.00403	0.127***	0.128***
	(0.0410)	(0.0472)	(0.0472)
Opaque	-0.504***	-0.273***	-0.194***
	(0.0135)	(0.0284)	(0.0284)
High-Quality	0.656***	0.693***	0.690***
	(0.0233)	(0.0265)	(0.0263)
Medium-Quality	0.278***	0.334***	0.329***
	(0.0134)	(0.0155)	(0.0197)
Airport Area	-0.0558*	-0.0876***	-0.0845***
	(0.0287)	(0.0162)	(0.0183)
Weekend	0.0852*	0.0458	0.0458
	(0.0451)	(0.0489)	(0.0490)
Advance Booking Days 3,5	-0.0344**	-0.0320*	-0.0319*
	(0.0169)	(0.0177)	(0.0177)
Advance Booking Days7,9	-0.0650**	-0.0586**	-0.0586**
	(0.0263)	(0.0289)	(0.0290)
Advance Booking Days11,13	-0.0317	-0.0140	-0.0141
	(0.0308)	(0.0323)	(0.0323)
Area Size	No	-0.0118***	-0.0115**
		(0.00444)	(0.00461)
Opacity	No	No	0.00361
			(0.00377)
(Business+T/L)*Opaque	No	-0.129***	-0.106***
		(0.0337)	(0.0340)
(Convention+T/L)*Opaque	No	-0.0806***	-0.0340
		(0.0214)	(0.0250)
ALL*Opaque	No	-0.185***	-0.179***
		(0.0274)	(0.0277)
High-Quality*Opaque	No	-0.107***	-0.0875***
		(0.0238)	(0.0248)
Medium-Quality*Opaque	No	-0.125***	-0.0828***
		(0.0191)	(0.0216)
Airport Area*Opaque	No	0.130***	0.0925***
		(0.0227)	(0.0201)
Weekend *Opaque	No	0.104***	0.105***
		(0.0242)	(0.0244)
Advance Booking Days 3,5*Opaque	No	-0.00926	-0.0102
		(0.0130)	(0.0130)
Advance Booking Days 7,9*Opaque	No	-0.0173	-0.0179
		(0.0176)	(0.0179)
Advance Booking Days11,13*Opaque	No	-0.0459**	-0.0466**
		(0.0188)	(0.0188)
Area Size*Opaque	No	-0.0131***	-0.0155***
		(0.00263)	(0.00279)
Opacity*Opaque	No	No	-0.0367***
			(0.00621)
Constant	4.698***	4.629***	4.621***
	(0.0334)	(0.0288)	(0.0313)
Observations	10,417	10,417	10,417
R-squared	0.642	0.656	0.659

Notes: The table reports results with robust standard errors clustered by City*Booking Night.
Statistically significance:*** p<0.01, ** p<0.05, * p<0.1

Table 4. Effects of Product Characteristics on Room Availability

VARIABLES	(1)	(2)
BUS+T/L	0.0154	0.152***
	(0.0460)	(0.0569)
CONV+T/L	0.0807**	0.206***
	(0.0402)	(0.0546)
ALL	0.0132	0.136***
	(0.0403)	(0.0485)
Airport	0.0880***	0.101***
	(0.0161)	(0.0192)
High-Quality	-0.0301*	-0.0179
	(0.0165)	(0.0227)
Medium-Quality	-0.0265**	-0.0110
	(0.0118)	(0.0167)
Weekend	-0.124***	-0.148***
	(0.0381)	(0.0424)
Opaque	0.00744	0.168***
	(0.0101)	(0.0394)
Advance Booking Days 3,5	0.00222	0.0152***
	(0.00244)	(0.00389)
Advance Booking Days 7,9	0.0200*	0.0260
	(0.0110)	(0.0192)
Advance Booking Days 11,13	0.0151	0.0289*
	(0.00948)	(0.0154)
(BUS+T/L)*opaque	No	-0.219***
		(0.0460)
(CONV+T/L)*opaque	No	-0.175***
		(0.0402)
ALL*opaque	No	-0.171***
		(0.0352)
Airport*Opaque	No	-0.0311
		(0.0222)
Weekend*Opaque	No	0.0648***
		(0.0228)
High-Quality*Opaque	No	-0.0216
		(0.0310)
Medium-Quality*Opaque	No	-0.0314
		(0.0302)
Advance Booking Days 3,5*Opaque	No	0.0205
		(0.0179)
Advance Booking Days 7,9*Opaque	No	0.0168
		(0.0322)
Advance Booking Days 11,13*Opaque	No	-0.0106
		(0.0347)
Constant	0.855***	0.722***
	(0.0352)	(0.0519)
Observations	12,151	12,151
R-squared	0.044	0.053

Note: The table reports results from a linear probability model with robust standard errors clustered by City*Travel night.
Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

Appendices

Appendix 1. Opaque rooms (area and quality) sorted by cities and traveler segments.

City	Area	Quality
Business+T/L:		
New York	Midtown East	4, 3.5
	JFK intl airport	3.5, 3
	Central park	4
	Time Squares	4.5
	Downtown SOHO	4, 3
Convention+T/L:		
Las Vegas	Near Strip East	4, 3, 2
	Las Vegas Strip-south	4, 3
	Las Vegas strip-North	5, 4, 3
	Henderson-SE	4, 3, 2
	Las Vegas Airport South	3
	Disney Main Gate	3.5, 3
Orlando	SeaWorld-I-drive south	4, 3
	Downtown Orlando	2
	Int airport MCO	3, 2
	Universal-I-drive North	4, 3

City	Area	Quality
ALL=Business+Convention+T/L:		
Chicago	Magnificent Mile	4, 3.5
	O' Hare intl airport North	4, 3.5, 3
		3
	Lombard-Oak brook-downers grove	4, 3
		3
	Lake View- Lincoln-Wrigleyville	4
	Arlington Heights-Elk Grove Village	3, 2
Washington, DC	DuPont Circle- National Zoo	4.5, 4, 3.5
	White House-Downtown	4, 3.5
	Alexandria and Old Town	4, 2.5
	Georgetown-Foggy Bottom	3.5, 3
	Chantilly-dulls Intl Airport south	4, 3, 3.5
		3
Tourism/Leisure (T/L):		
Palm Springs	Palm Springs	4, 3.5, 2
	Rancho Mirage-Palm Desert	4
		3
	Cathedral City	3, 2
Honolulu	Central Waikiki area	3, 2.5
	Waikiki Beach	4, 3
	Downtown Honolulu	3, 2
	Honolulu Intl Airport HNL	2

Appendix 2. Effects of product characteristics on the number of offers.

The dependent variable is the number of offers (opaque or regular) posted on Hotwire for a given city and for the booking days and travel nights in the sample (see Table 1). There are 980 observations (7 cities, 7 travel nights, 10 booking days, opaque/regular).

VARIABLES	
BUS+T/L	1.155***
	(0.0735)
CONV+T/L	0.994***
	(0.0232)
ALL	1.205***
	(0.0634)
Opaque	-1.197***
	(0.0745)
Weekend	-0.212**
	(0.0987)
Advance Booking Days 3,5	0.105***
	(0.0388)
Advance Booking Days 7,9	0.139**
	(0.0526)
Advance Booking Days 11,13	0.155**
	(0.0608)
(BUS+T/L)*opaque	-0.483***
	(0.0948)
(CONV+T/L)*opaque	-0.0877
	(0.0620)
ALL*Opaque	-0.113
	(0.0812)
Weekend*Opaque	-0.0201
	(0.112)
Advance Booking Days 3,5*Opaque	-0.0395
	(0.0490)
Advance Booking Days 7,9*Opaque	-0.0540
	(0.0629)
Advance Booking Days 11,13*Opaque	-0.0971
	(0.0707)
Constant	4.017***
	(0.0613)
Observations	980
R-squared	0.919

Note: The table reports results with robust standard errors clustered by City*Travel night.
Statistical significance: *** p<0.01, ** p<0.05, * p<0.1.