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Add-on Policies Under Vertical Differentiation: Why Do Luxury Hotels Charge for Internet While Economy Hotels Do Not?

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Abstract. This paper examines firms' product policies when they sell an add-on (e.g., Internet service) in addition to a base product (e.g., hotel rooms) under vertical differentiation (e.g., four- versus three-star hotels). I show that the role of an add-on differs; higher-quality firms prefer to sell it as optional to discriminate consumers, and lower-quality firms trade off discrimination and differentiation, trying to lure consumers from higher-quality rivals with a lower-price add-on. Equilibrium policies of lower-quality firms are more sensitive to the cost-to-value ratio of an add-on. If the ratio is sufficiently small, then they sell it to all consumers, potentially explaining why lower-end hotels are more likely than higher-end ones to offer free Internet service. Contrary to consensus in the literature, optional add-ons can intensify price competition over consumers who trade off a higher-quality base product versus a lower-quality base including an add-on. Hence, higher-quality firms are incentivized to commit to bundling, while lower-quality firms prefer to commit to not selling it. Add-ons can further reduce lower-quality firms' profits if consumers cannot observe the prices, because holding up consumers ex post encourages them to switch to higher-quality rivals, which then become better off. Therefore, lower-quality firms are incentivized to advertise add-on prices, and higher-quality firms are not.

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Keywords: add-on pricing • competitive price discrimination • multiproduct pricing • vertical differentiation • bundling

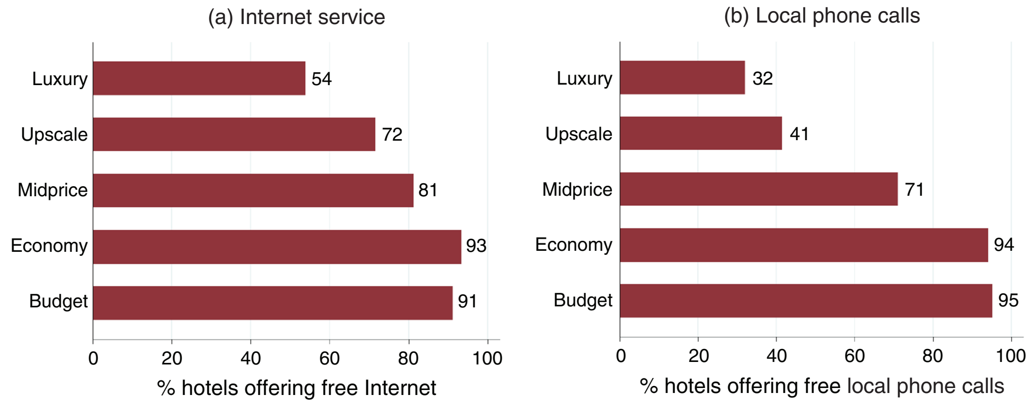
1. Introduction

Although Internet service has become widely available in the hotel industry, only 54% of luxury hotels provide it free. By contrast, the percentage grows to 72%, 81%, 93%, and 91% for upscale, midpriced, economy, and budget hotels, as shown in Figure 1. The pattern also holds for amenities such as local phone calls and breakfast. Anecdotal evidence suggests that the phenomenon arises in other industries as well. For example, more luxurious apartments tend to charge for gym access;[1] higher-end salons typically charge for hair wash separately from haircut, whereas lower-end ones often bundle them.[2]

This puzzling phenomenon appears to be counterintuitive, attracting considerable public attention and media coverage.[3] Two seemingly inconsistent explanations prevail. Many embrace the view that luxury hotels charge for Internet service "because they can," though the arguments vary. One argument is that consumers do not know about the Internet charge before booking a room, and hence hotels can charge a high price ex post just as they do for mini-bars. A related argument is that luxury hotels can price discriminate because of consumer heterogeneity in price sensitivity. Yet, the free-Internet policy of lower-end hotels seems to contradict these arguments. An alternative argument builds on the fact that customers of higher-end hotels are much less price sensitive,[4] and thus are willing to pay extra. However, this fact would only suggest a higher *total* price rather than Internet charges that are *separate* from room rates. Conversely, managers of lower-end hotels appear to view a free-Internet policy as a differentiation strategy. However, differentiation does not work if competing hotels adopt the same policy.

I argue that the *because-they-can* view of higher-end hotels and the *because-they-want-to-differentiate* view of lower-end hotels can be unified by introducing vertical differentiation between hotels to offer a coherent explanation. The argument goes as follows. Consider two hotels that are vertically differentiated: a four-star hotel competes with a three-star hotel, or an established, more reputable hotel competes with a new, less reputable hotel. With the competitive pressure from the lower-quality rival, the higher-quality hotel faces a more elastic demand downward and thus tends to lower its room rate to attract more price-sensitive consumers. Since these consumers are less interested in paying extra for Internet service, the higher-quality

Figure 1. (Color online) Likelihood of Offering Free Internet/Local Calls by Hotel Tiers



Data source. 2012 Lodging Survey by Smith Travel Research and American Hotel and Lodging Association.

hotel can charge a high Internet price to the less price-sensitive customers. However, the consumers who do not pay extra at the higher-quality hotel are more valuable to the lower-quality hotel, and to attract them, a low Internet price is appealing. Given the low marginal cost of the Internet, the price can be set sufficiently low such that even the most price-sensitive consumer pays for it. Then every customer of the lower-quality hotel is getting Internet service, or equivalently, the hotel offers free Internet.

This paper formalizes the above intuition in a game-theoretic framework and provides conditions under which this phenomenon arises. The theory, of course, has more general implications. It elucidates an important managerial problem in which firms sell complementary items or upgrades (hereafter, "*add-ons*") in addition to a base good or service.[5] Examples are everywhere, including airlines selling drinks and snacks on a flight, car manufacturers selling upgrades such as GPS and leather seats on a base model, and mobile applications offering in-app purchases or premium upgrades. The important strategic decision for firms is the following: when should they sell an add-on separately as optional to some consumers, offer it as standard to all consumers (i.e., free), and not sell it at all?

Optimal add-on polices may depend on the nature of the add-on, market structure, and consumer characteristics. Prior studies in the literature of add-on pricing have focused on the observability of add-on prices when firms are symmetric (Lal and Matutes 1994, Verboven 1999, Ellison 2005). Others examine the impacts of boundedly rational consumers when firms are symmetric (Gabaix and Laibson 2006, Dahremöller 2013) or asymmetric (Shulman and Geng 2013). More recently, Shugan et al. (2017) study add-on pricing in a monopolist's product line. The current paper contributes to this growing literature by analyzing the context when firms are vertically differentiated and consumers are rational. The central question is: how does vertical differentiation influence add-on policies and profitability?

I first analyze, in Section 2, a duopoly model by integrating the key features of second-degree price discrimination and vertical differentiation: a higher-quality firm H competes with a lower-quality firm L, both selling a base good and add-on. The main insight from this analysis is that an add-on plays disparate roles when firms are vertically differentiated. With some market power, selling an add-on as an option at a high price serves as a segmentation device so less price-sensitive consumers self-select to buy the expensive add-on. This role is further strengthened for firm H, which benefits from selling the lower-priced base good without the add-on to lure lower-end customers from firm L. The discriminatory role of the add-on, contrarily, is weakened for firm L because of the opposite effect that selling the add-on at a low price can be an effective differentiation device. The trade-off between discrimination and differentiation renders firm L's policy sensitive to the cost-to-value ratio of the add-on. As the ratio decreases, the policy shifts from no add-on (e.g., mini-bars and room service) through optional add-on (e.g., laundry and airport shuttles) to standard add-on (e.g., Internet and phone calls). The mechanism is quite robust under relaxed assumptions allowing the marginal costs of the base good to be nonzero or different across firms, the market to be partially covered, the add-on to be heterogeneous across firms, and the unobservable tastes for the base and the add-on to be separate. In Section 5, I test the prediction when the ratio is sufficiently small using a sample of duopoly markets with vertical differentiation in the hotel industry, and find suggestive evidence for it.

I then derive, in Section 3, the profit implications of these equilibrium policies by comparing them to the results from an extended game that allows the firms to have commitment power. Surprisingly, selling an add-on as optional can intensify competition, because the firms price aggressively to attract consumers who trade off firm H's base good versus firm L's base good and the add-on. Although the optional-add-on policy is unilaterally optimal, a prisoner's dilemma emerges in which both firms lose profit in equilibrium. This result contrasts with extant literature. Verboven (1999) shows that when add-on prices are observed, an optional add-on does not change equilibrium profits under competition because any profit earned from selling a high-priced add-on is competed away on the base price. Ellison (2005) points out that the profit-irrelevant result may not hold if consumers' vertical and horizontal tastes are correlated, and profits can be higher when an add-on is sold optionally than standard. In a model with asymmetric firms, Shulman and Geng (2013) find that an optional add-on benefits a superior firm but hurts an inferior firm when all consumers know the add-on prices, under the assumption that the add-on of the superior firm has a higher quality. Current results suggest a loss-loss situation that does not rely on asymmetric add-ons. It is the interaction between price discrimination and vertical differentiation that leads to the competition-intensifying result. This raises the issue of strategic commitments. With commitment power, firms can avoid losing profit by committing to a standard-add-on policy (firm H) or to a no-add-on policy (firm L).

In Section 4, I extend the analysis to the case in which consumers do not observe add-on prices, and ask what difference it makes to policies and profits in comparison to the observed-price case. The well-known hold-up problem arises, interacting with the vertical differentiation effect. Firm H's policy is unaffected because its consumers expect the add-on to be charged at a price exactly the same as the one in the observed-price case. Anticipating being held up by firm L, the marginal consumers prefer to buy from firm H, without paying for the add-on. Consequently, firm H demands a higher base price, but firm L is forced to lower its base price while keeping the add-on price high. In equilibrium, firm H continues to offer the add-on as optional to a subset of its consumers, but with a higher profit. Firm L's policy remains sensitive to the cost-to-value ratio of the add-on in the same way as when add-on prices are observed, but its profit can be lower. This asymmetric effect on profits contrasts with extant results that unobserved add-on prices either have no impact on firm profits because profits earned by holding up consumers ex post are competed away by lowering advertised base prices (Lal and Matutes 1994), or raise profits by creating an adverse selection problem that makes price cutting unappealing (Ellison 2005). This profitability result implies that firm L has a strong incentive to advertise the add-on price, while firm H does not.

Related Literature

This work relates to the broader literature on price discrimination and multiproduct pricing. Studies on *competitive* second-degree price discrimination have been quite limited because of model complexity. Most work (Stole 1995, Armstrong and Vickers 2001, Rochet and Stole 2002, Ellison 2005, Schmidt-Mohr and Villas-Boas 2008) has focused on symmetric firms, finding that firms practice price discrimination if sufficient consumer heterogeneity exists. They do not consider the possibility of vertical pressure competing firms face, a scenario that arises often in the real world because of asymmetry in, for example, product quality, brand reputation, and first-mover advantage. One notable exception is Champsaur and Rochet (1989), who study differentiated firms competing by offering intervals of qualities (or "product lines") to heterogeneous consumers. They show that price competition between firms dominates the benefits from price discrimination, motivating the firms to offer quality ranges that do not overlap. Unlike these authors, I study the context of add-on pricing in which qualities are discrete instead of continuous, and derive implications of competitive price discrimination and observability of add-on prices on profitability. Balachander et al. (2017) study a closely related game in which firms are vertically differentiated and are able to commit to bundling an additional feature with a base product. Their results are similar to the modified game with strategic commitments that I analyze in Section 3. We both show that, despite the temptation to price discriminate, the higher-quality firm has an incentive to commit to offering an add-on (or a feature) as standard, whereas the lower-quality firm has an incentive to commit to not offering it.

The result that selling an add-on can intensify competition also relates to several findings in the literature. One mechanism by which price discrimination can intensify competition is competitive *third-degree* price discrimination (Thisse and Vives 1988, Shaffer and Zhang 1995, Corts 1998). Corts (1998) points out that when firms have a divergent view on the ranking of consumer segments (i.e., a strong market for one firm is weak for the other), it is possible that price discrimination leads to lower prices in all market segments, reducing profits.[6] Another mechanism is competitive *mixed bundling* in the two-stop shopping framework (Matutes and Regibeau 1992, Anderson and Leruth 1993, Armstrong and Vickers 2010).[7] Practicing mixed bundling might trigger fierce price competition, lowering prices for component products. This paper identifies an alternative mechanism in a different modeling framework and business context. The add-on pricing problem studied here differs from third-degree price discrimination because firms do not know consumers' preferences and thus rely on incentive compatibilities to practice discrimination. The problem is also different from multiproduct bundling because an add-on is only available and valuable conditional on the purchase of a base good.[8]

Finally, this paper relates to growing academic interest in *drip pricing*.[9] When consumers are myopic, firms often find it profitable to exploit them by shrouding the price of an add-on. Gabaix and Laibson (2006) show that firms may choose to shroud even under perfect competition. Shulman and Geng (2013) extend the mechanism to the situation in which firms are differentiated both horizontally and vertically. Dahremöller (2013) introduces a commitment decision of shrouding or unshrouding, which can alter underlying incentives to unshroud. Seim et al. (2017) provide empirical evidence of drip pricing that driving schools surprise many students by extra fees. Unlike these authors, I examine long-run market outcomes in which consumers know or correctly anticipate add-on prices in equilibrium. This assumption is not unreasonable, given that consumers might learn about prices through repeat purchases and/or word of mouth,[10] and in many cases, firms advertise add-on prices because of a regulation requirement or reputation concerns.

2. A Theory of Add-on Policy Under Vertical Differentiation

In this section, I present a theory that builds on the standard models of second-price discrimination (discrete qualities) and of vertical differentiation, and discuss its implications. I first write down the simplest model to illustrate the key mechanism, and then relax some of the simplifying assumptions to demonstrate its robustness.

2.1. Model Setup and Results

Consider two competing firms $j \in \{l, h\}$ offering different quality of the base good V with $V_h > V_l > 0$. Hereafter, the higher- and lower-quality firms will be called H and L, respectively. The quality difference, $\Delta V = V_h - V_l$, may stem from differences in product design and/or brand reputation/image that are relatively harder to change in the short run compared to supplying an add-on. The marginal cost of the base good is normalized to zero for both firms. In an extension discussed in Section 2.5, I allow the marginal cost to be positive and different across the firms. In addition to the base good, both firms can sell an add-on with positive value w and nonnegative cost c. The efficiency of supplying the add-on is captured by the cost-to-value ratio, $\alpha = c/w$. I assume that $\Delta V > w$ so that firm L remains inferior even with the add-on. Each firm can set a base price P_j and an add-on price p_j. The total price is denoted as P_j^+.

A continuum of consumers differ in their marginal valuation, or taste, for quality captured by θ, which is distributed uniformly within $[\underline{\theta}, \bar{\theta}]$.[11] To simplify the analysis, I assume that $\underline{\theta} > 0$ and V_j is sufficiently large so that the market is fully covered by the two firms. This assumption will be revisited in Section 2.5. Two additional assumptions are made throughout the analysis: (1) $\bar{\theta} > 2\underline{\theta}$, implying a sufficient amount of consumer heterogeneity in the market to accommodate both firms, and (2) $\bar{\theta} > \alpha$, implying a positive sale of add-on by firm H in equilibrium. The utility of buying from firm j for type-θ consumer is

$$U_{\theta j} = \begin{cases} \theta V_j - P_j & \text{if only the base good is purchased;} \\ \theta(V_j + w) - P_j - p_j & \text{if both the base good and the add-on are purchased.} \end{cases} \quad (1)$$

The base and add-on values V and w are both common knowledge to all parties, a reasonable assumption for industries in which consumers possess sufficient knowledge or information because of, say, repeat purchases.[12] However, consumers know their own tastes θ, but the firms do not. The firms only know the distribution of tastes, and hence rely on incentive compatibilities to screen consumers.

It is worth noting that the assumption that the unobserved consumer preferences are summarized entirely in one dimension, θ, may appear strong, but it keeps the model tractable. One can interpret the tastes as the inverse of price sensitivities.[13] This assumption implies that willingness to pay for the base good and for the add-on (θV_j and θw) correlate perfectly, a restriction that can be relaxed. What is necessary is the unobserved heterogeneity in both the base good and add-on, enabling consumers to trade off between the add-on and the base quality and self select given their tastes.[14]

The timing of the game is as follows. Both firms announce prices simultaneously, (P_h, p_h) and (P_l, p_l). Consumers observe all prices and decide which firm to visit and whether to pay for the add-on from the chosen firm. The formulation naturally builds on two stylized models. With no add-on, the model reduces to a duopoly model of vertical differentiation (Shaked and Sutton 1982). With no competition, the model reduces to a monopoly model of nonlinear pricing (Mussa and Rosen 1978) with continuous-type consumers and discrete qualities. Each reduced model is straightforward to solve. However, combining the two features complicates equilibrium analysis substantially because of the many possibilities of market outcomes. Specifically, taking into account consumers' incentive compatible decisions, each firm can price its base and add-on to implement any of the three outcomes: (1) no add-on (*no* consumer buys the add-on); (2) standard add-on

Table 1. Summary of Equilibrium Prices and Profits in Proposition 1

Case 1. $\alpha \geq \frac{1}{3}(2\bar{\theta}-\underline{\theta})$	
$P_h^* = \frac{1}{3}(2\bar{\theta}-\underline{\theta})\Delta V, \quad p_h^* = \frac{1}{2}(\bar{\theta}+\alpha)w$	$\Pi_h = \frac{1}{9}(2\bar{\theta}-\underline{\theta})^2\Delta V + \frac{1}{4w}(\bar{\theta}w-c)^2$
$P_l^* = \frac{1}{3}(\bar{\theta}-2\underline{\theta})\Delta V, \quad p_l^* > \frac{1}{3}(\bar{\theta}+\underline{\theta})w$	$\Pi_l = \frac{1}{9}(\bar{\theta}-2\underline{\theta})^2\Delta V$
Case 2. $\underline{\theta} < \alpha < \frac{1}{3}(2\bar{\theta}-\underline{\theta})$	
$P_h^* = \frac{1}{3}(\Delta V - w)(2\bar{\theta}-\underline{\theta}) + \frac{1}{3}c, \quad p_h^* = \frac{1}{2}(\bar{\theta}+\alpha)w$	$\Pi_h = \frac{1}{9(\Delta V - w)}[(2\bar{\theta}-\underline{\theta})(\Delta V - w)+c]^2 + \frac{1}{4w}(\bar{\theta}w-c)^2$
$P_l^{+*} = \frac{1}{3}(\Delta V - w)(\bar{\theta}-2\underline{\theta}) + \frac{2}{3}c, \quad p_l^* = \frac{1}{2}(\underline{\theta}+\alpha)w$	$\Pi_l = \frac{1}{9(\Delta V - w)}[(\bar{\theta}-2\underline{\theta})(\Delta V - w)-c]^2 + \frac{1}{4w}(\underline{\theta}w-c)^2$
Case 3. $\alpha \leq \underline{\theta}$	
$P_h^* = \frac{1}{3}(\Delta V - w)(2\bar{\theta}-\underline{\theta}) + \frac{1}{3}c, \quad p_h^* = \frac{1}{2}(\bar{\theta}+\alpha)w$	$\Pi_h = \frac{1}{9(\Delta V - w)}[(2\bar{\theta}-\underline{\theta})(\Delta V - w)+c]^2 + \frac{1}{4w}(\bar{\theta}w-c)^2$
$P_l^{+*} = \frac{1}{3}(\Delta V - w)(\bar{\theta}-2\underline{\theta}) + \frac{2}{3}c, \quad p_l^* \leq \underline{\theta}w$	$\Pi_l = \frac{1}{9(\Delta V - w)}[(\bar{\theta}-2\underline{\theta})(\Delta V - w)-c]^2$

(*all* consumers buy the add-on); (3) optional add-on (*some but not all* consumers buy the add-on).

Under the "no-add-on" policy, the firms choose not to serve the add-on by setting a sufficiently high add-on price. Under the "standard-add-on" policy, the add-on is essentially "free" or *as if* "bundled" with the base good because every consumer is served with both goods. Even though both policies require the presence of the add-on prices to ensure incentive compatibility, they are equivalent to the decisions that the firms choose to sell only the base good and announce just the base price (no-add-on policy) or choose to sell both products together and announce just the bundle price (standard-add-on policy).[15]

The asymmetric setup leads to nine possible market configurations, each constituting a possible equilibrium profile. To prove the existence of an equilibrium for each profile, one has to examine, for each firm, all nonlocal deviations that lead to any form of the remaining eight possible market configurations. The following proposition summarizes all possible pure-strategy equilibria. Let $\Delta_1 \equiv w(2\bar{\theta}-\underline{\theta}-\alpha)/(2\bar{\theta}-\underline{\theta}-3\alpha)$ and $\Delta_2 \equiv w(\bar{\theta}-2\underline{\theta}+\alpha)/(\bar{\theta}-2\underline{\theta})$.

Proposition 1. (1) *If $\alpha \geq \frac{1}{3}(2\bar{\theta}-\underline{\theta})$, there exists a unique equilibrium in which H sells the add-on as optional, whereas L does not sell it.* (2) *If $\underline{\theta} < \alpha < \frac{1}{3}(2\bar{\theta}-\underline{\theta})$, there exists a unique equilibrium when $\Delta V > \Delta_1$, in which both firms sell the add-on as optional.* (3) *If $\alpha \leq \underline{\theta}$, there exists a unique equilibrium when $\Delta V > \Delta_2$, in which H sells the add-on as optional, whereas L sells it as standard.* (4) *No pure-strategy equilibrium exists in other parameter regions.*

Next I derive the solution with the intuition behind it, and subsequently discuss its implications and robustness. The online appendix documents the remaining proof, which verifies the existence and uniqueness of the equilibrium results.[16] Table 1 summarizes the equilibrium prices and profits. In Appendix A, I present a numerical example illustrating the equilibrium prices and demand.

2.2. The Higher-Quality Firm Focuses on Price Discrimination

If firm H implements the optional-add-on policy, then its customers are divided into two segments: the less price-sensitive consumers, $\theta \in [\theta_h, \bar{\theta}]$, and the more price-sensitive ones, $\theta \in [\theta_{hl}, \theta_h]$. Figure 2 illustrates the segmentation assuming L sells the add-on optionally. Firm H's profit is composed of two additive components

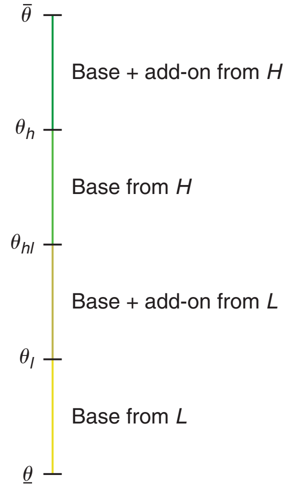
$$\Pi_h = \underbrace{\left(\bar{\theta} - \frac{P_h - P_l^+}{\Delta V - w}\right)P_h}_{\text{profit from selling the base}} + \underbrace{\left(\bar{\theta} - \frac{p_h}{w}\right)(p_h - c)}_{\pi_h(p_h):\,\text{profit from selling the add-on}}. \quad (2)$$

To maximize profit, firm H simply chooses the base and add-on prices to maximize the two components separately subject to the incentive constraints, $\bar{\theta} \geq \theta_h^* \geq \theta_{hl}^*$. If the first constraint is binding, then the no-add-on policy is optimal. This cannot occur in equilibrium because any add-on price slightly above the marginal cost will attract some high-type consumers and thus enhance profit (because $\alpha < \bar{\theta}$). If the second constraint is binding, then it is optimal to serve the add-on to all consumers. However, this constraint becomes harder to bind in the presence of a lower-quality rival, as shown in the following lemma.

Lemma 1. *For firm H, selling the add-on as standard is strictly dominated by selling it as optional if (a) $P_l > -\alpha\Delta V$ in the case when firm L does not sell the add-on, or (b) $P_l^+ > -\alpha(\Delta V - w)$ in the case when firm L sells the add-on.*

The proof is provided in Appendix B. To see the intuition, suppose that firm H sells the add-on as standard with the add-on price set sufficiently low. Consider a

Figure 2. (Color online) Market Segmentation When Both Firms Sell Optional Add-on



local deviation whereby the firm increases the add-on price by a small amount ϵ and decreases the base price by the same amount. Although increasing the add-on price loses some consumers who have originally bought the add-on, it can be offset by the gain from expanding the market of the base good. The net profit increases with firm L's price because more consumers will be attracted by the cut of firm H's base price if buying from firm L is more costly.[17] The following prediction then holds (see Appendix C for the proof):

Observation 1. In any pure-strategy equilibrium, firm H sells the add-on as optional.

While this result may seam strong, it substantially simplifies the analysis because only three possible equilibrium profiles are left to evaluate, depending on firm L's implementation. The sharp result for firm H should be interpreted in comparison to the result for firm L, whose policy turns out to be more sensitive to the cost-to-value ratio.

2.3. The Lower-Quality Firm Trades off Discrimination and Differentiation

Assume temporarily that firm L sells the add-on also as optional as depicted in Figure 2. Like its rival, firm L is incentivized to set a high add-on price to allow the consumers to self-select. Unlike its rival, however, the firm uses the add-on to attract consumers who consider the rival's base product without the add-on. A low add-on price can induce these consumers to switch. To see the optimal pricing strategy that resolves this trade-off, it is instructive to write the firm's profit in the following form:

$$\Pi_l = \underbrace{\left(\frac{P_h - P_l^+}{\Delta V - w} - \underline{\theta}\right)(P_l^+ - c)}_{\text{profit from selling the bundle}} \underbrace{-\left(\frac{p_l}{w} - \underline{\theta}\right)(p_l - c)}_{\pi_l(p_l)\text{: cost saving from excluding add-on consumption}} . \quad (3)$$

The first component depends only on total price P_l^+, whereas the second depends only on add-on price p_l. The unconstrained problem is solved by maximizing each component separately.[18] The strategic interaction between the two firms then reduces to the competition between L's bundle (priced at P_l^+) and H's base good (priced at P_h), yielding the equilibrium prices

$$P_h^* = \tfrac{1}{3}(\Delta V - w)(2\bar{\theta} - \underline{\theta}) + \tfrac{1}{3}c \quad \text{and}$$
$$P_l^{+*} = \tfrac{1}{3}(\Delta V - w)(\bar{\theta} - 2\underline{\theta}) + \tfrac{2}{3}c. \quad (4)$$

The marginal consumer becomes $\theta_{hl}^* = \frac{1}{3}[(\bar{\theta} + \underline{\theta}) - c/(\Delta V - w)]$, which determines the equilibrium market share of each firm. Within their own market segments, the firms set the optimal add-on prices to maximize $\pi_h(p_h)$ and $\pi_l(p_l)$ in Equations (2) and (3), yielding

$$p_h^* = \tfrac{1}{2}(\bar{\theta} + \alpha)w \quad \text{and} \quad p_l^* = \tfrac{1}{2}(\underline{\theta} + \alpha)w,$$

with resulting intramarginal consumers, $\theta_h^* = \frac{1}{2}(\bar{\theta} + \alpha)$ and $\theta_l^* = \frac{1}{2}(\underline{\theta} + \alpha)$. Although both firms sell exactly the same add-on, they set very different prices that reflect the underlying motives and customer tastes. The price of firm H is higher and generates positive profit because it is used to extract surplus from the highest types. However, the price is considerably lower for firm L because, unlike firm H (and standard price discrimination as in Mussa and Rosen 1978), it is used to minimize the cost of overselling the add-on to the lowest types.[19]

To complete the derivation, it remains to evaluate whether the incentive constraints for firm L, $\theta_{hl}^* \geq \theta_l^* \geq \underline{\theta}$, are binding, which depend crucially on the magnitude of α. On one hand, the marginal consumer θ_{hl}^* decreases as α increases because some switchers would rather buy only the base from H when L's bundle becomes more expensive. On the other hand, the intramarginal consumer for firm L, θ_l^*, increases with α because, as the add-on becomes more costly to provide, it is optimal for the firm to exclude more consumers who do not value it much. Hence, as α becomes sufficiently large, the firm excludes all consumers from buying the add-on.[20] Constraint $\theta_{hl}^* > \theta_l^*$ ensures that the firm sells the add-on in equilibrium, leading to $\alpha < \frac{1}{3}(2\bar{\theta} - \underline{\theta})$ and $\Delta V > \Delta_1$.

Conversely, if α becomes smaller, then θ_{hl}^* increases whereas θ_l^* decreases. The segment of consumers who buy L's bundle expands, with some switching from firm H and some upgrading to buy the add-on. As α becomes sufficiently small, all of L's customers are paying for the add-on, which is then essentially standard, or free. In this case, constraint $\theta_l^* \geq \underline{\theta}$ is binding. To ensure that firm L remains in the market, the constraints now reduce to $\theta_{hl}^* > \underline{\theta}$, yielding the condition of $\Delta V > \Delta_2$.

2.4. Discussions and Implications

Internet service has arguably a very low marginal cost and/or a large value, implying a very small α. The equilibrium under a small α accords with the stylized fact that lower-end hotels are more likely than higher-end ones to offer free Internet. The equilibrium when α is moderate can possibly explain why lower-end hotels are equally likely as higher-end hotels to offer add-ons such as laundry or airport shuttle services as optional. It is also consistent with the fact that most airlines or cruise lines charge for Internet service regardless of whether they are high- or low-end, because the costs of providing Internet access are still prohibitive.[21] The equilibrium under a large α is consistent with the observation that lower-end hotels are less likely to offer amenities such as a mini-bar or room services, compared to higher-end hotels, which often sell them as optional at high prices.

In my model, firm L's incentive to serve all consumers the add-on (as if it is bundled) is driven by the need to differentiate. This mechanism is different from Shugan et al. (2017). In their model, the incentive to bundle stems from the profits from getting an early purchase commitment from consumers who are uncertain about their preference for add-ons. They show that, without competition and product lines, bundling is optimal for a monopolist as long as the base quality is sufficiently small.

The theory does not rely on horizontal differentiation. If the firms are differentiated horizontally, then standard theory would suggest that an add-on would be sold at the marginal cost (Verboven 1999). One should then expect that hotels would unbundle Internet but charge it at a very low price that is almost negligible. Hence, horizontal differentiation alone is insufficient to explain the stylized fact, and the present theory suggests that, with some degree of vertical differentiation, the prediction can be consistent with the phenomenon. One could argue, however, that if some firms compete horizontally in the high-end market and, independently, others compete horizontally as well in the low-end market, then different market outcomes may emerge if the two markets differ in some way. However, marginal costs of Internet services are unlikely to vary substantially across the higher- and lower-end markets, and thus horizontal competitions in the two markets should not lead to different Internet policies. A more plausible explanation along this line might be following the Ellison (2005) key assumption that consumers' horizontal and vertical tastes are correlated. We could then predict that the firms in the higher-end market discriminate among consumers whereas the firms in the lower-end market do not, if consumers are homogeneous in the low end but heterogeneous in the high end.

The insights from the model can extend to more general cases in which firms offer multiple add-ons or multiple qualities of an add-on. For example, "all-inclusive" hotels are typically not the most luxurious; less-than-luxurious hotels are more likely to offer all-inclusive services. It is increasingly common that higher-end hotels adopt tiered pricing for Internet service. They offer complimentary Internet access for basic use such as sending emails and browsing websites, but charge for higher-speed Internet or heavy use such as video conferencing and streaming movies. Lower-end hotels are less likely to adopt this practice.

Similarly, the theory can shed light on the scenario in which firms offer a product line with different quality levels. For example, many high-end hotels and full-service airlines offer free Internet service, snacks, or drinks only to their favored customers who select their premium services (e.g., executive suites, business class, loyal members). It is likely that the more price-sensitive consumers who do not choose the premium services are potential switchers to a lower-end competitor, and thus are less attracted by the perks available for the premium products. The less price-sensitive consumers, however, do not respond to the lower price of the base level, and consider paying for the add-ons if they are affordable. It is then optimal for the firms to offer the add-ons to all these consumers as long as they are not too costly to provide. The following corollary formalizes this insight.

Corollary 1. *If firm H offers an additional premium product with value $V_h + v$ and marginal cost c_v, then in any pure-strategy equilibrium firm H sells the add-on as standard to all consumers who choose the premium if and only if $\alpha \le c_v/v$.*

The theory assumes that the quality difference in the base good is exogenously given. One may wonder whether vertical differentiation exists in the first place when the firms are able to sell the add-on. This can be analyzed in an extended game in which the firms first invest in the base quality and then determine add-on policies. Corollary 2 shows that maximal differentiation on the base quality prevails and hence Proposition 1 follows. Interestingly, despite the incentive to maximally differentiate on the base quality, neither firm would use the add-on to increase the overall quality gap. This is driven by the fact that the add-on is not committed: the add-on policy decision can be flexibly made *after* the base quality is determined. If it is committed, a situation to be examined in Section 3, then using the add-on to make the product more attractive is essentially equivalent to enhancing the base quality directly.

Corollary 2. *If both firms can endogenously change the base quality before setting the add-on policy, then they prefer to be maximally differentiated on the base quality.*

An add-on may evolve because of, for example, technology improvement or changing consumer preferences. The cost and/or value of the add-on may then change. For example, the cost of Internet service has decreased, and the value has increased over time. Proposition 1 leads to a straightforward prediction about the dynamics of add-on policies.

Corollary 3. *As the cost of an add-on decreases, or its value increases, over time, firm L's policy changes from no add-on, to optional, and eventually to standard add-on.*

2.5. Robustness

Recall that the market is assumed fully covered and the marginal cost of the base good, C, is normalized to zero. These assumptions may not be realistic in many markets.[22] The main insight, however, continues to hold when these assumptions are relaxed: firm H still sells the add-on optionally; firm L's policy remains sensitive to cost-to-value ratio α in the same way as in Proposition 1 except that the thresholds now depend on the value and marginal cost of the base good. Intuitively, whether or not the lowest type, θ_0 who is indifferent between firm L and leaving the market, should get the add-on (in addition to the base good) depends on the cost of serving θ_0 with the add-on (α) relative to the cost of serving θ_0 with the base good (C/V). If α is smaller than C/V, then it is efficient for firm L to serve θ_0 with the add-on as well (i.e., the standard-add-on policy). If α is greater than C/V but not too large, then the optional-add-on policy is optimal. The online appendix provides the details and the proofs of this extension and the extensions below.

Relaxing other simplifying assumptions does not alter the main insight either. One assumption is that the marginal cost of the base good is equal for both firms even though the base quality differs. This assumption may be reasonable if the quality premium originates from the fixed investment costs of the base good.[23] Yet it is undoubtedly more realistic to allow asymmetric marginal costs. Another convenient assumption is that the add-on is homogeneous even though the firms are differentiated vertically with respect to the base good. Unlike Internet service, many other add-ons may be asymmetric across firms in cost and/or value.[24] Last, consumers are assumed to have the same marginal utility or taste for the base good and for the add-on, making the preferences for the two perfectly correlated. More realistically, consumers may have separate tastes, one for the base good and the other for the add-on, and the two tastes are positively correlated.[25] The insight from the main theory still applies if we relax these convenient assumptions.

3. Strategic Commitments and Profitability of Add-on Policies

In this section I explore the profit implication of the equilibrium policies derived in the main theory. Note that the main theory allows both firms to have the flexibility of offering the add-on optionally to a subset of its consumers in response to its rival's strategy. One natural question to ask is then what difference it makes to the profits if they have the abilities to commit (costlessly) to not selling an add-on and to bundling. To address the question, I add a commitment stage to the original model: both firms first simultaneously decide their commitment choices during the first stage,[26] and then compete in prices during the second stage. Once the firms have made a commitment, they forgo the flexibility of using both the base and add-on prices to segment consumers in the second-stage pricing game. This is the key difference from the setup in Section 2. The following proposition summarizes the equilibrium behaviors under commitment with the proof provided in the online appendix:

Proposition 2. *Suppose that firms can commit to either the no-add-on or standard-add-on policy. There exists a threshold* $\hat{\alpha} > \frac{1}{3}(2\bar{\theta} - \underline{\theta})$ *such that* (1) *firm H commits to bundling if* $\alpha < \hat{\alpha}$, *but does not commit* (*and sells the add-on as optional*) *if otherwise*; (2) *firm L commits to the no-add-on policy if* $\alpha < \frac{1}{3}(2\bar{\theta} - \underline{\theta})$, *and is indifferent between committing and not if otherwise.*

On one hand, firm H has no incentive to commit to not selling the add-on because it can always gain by selling it to some higher-type consumers without affecting the price competition with firm L in the second stage. However, firm H has a strong incentive to commit to bundling because an add-on can enhance product quality, softening price competition in the second stage. This incentive is weakened by the cost of the add-on. As α becomes sufficiently large ($\alpha > \hat{\alpha}$), serving all consumers with the same add-on becomes less efficient and thus not committing to bundling is optimal. On the other hand, committing to the no-add-on policy is always optimal for firm L because it softens price competition with H in the second stage. Note that when the add-on is costly ($\alpha \geq \frac{1}{3}(2\bar{\theta} - \underline{\theta})$), even if firm L did not commit in the first stage, the optimal add-on price would be so high that no consumer will pay for it. Hence, the firm implements the no-add-on policy anyway and commitment becomes irrelevant.

The model with commitment ability is very similar to the one in Balachander et al. (2017), which assumes partial market coverage. Their results are very similar to mine in that both firms have the incentive to be maximally differentiated and that firm H commits to bundling only when the cost is not too large. However, firm L never offers the add-on in my model, a result in line with Shaked and Sutton (1982). Balachander et al. (2017) show that this may not arise if the market is not fully covered.

The profit implication immediately follows from Proposition 2. Of particular interest is the case when

α is moderate ($\underline{\theta} < \alpha < \frac{1}{3}(2\bar{\theta} - \underline{\theta})$). With no commitment power, as shown in Section 2, selling the add-on as optional is unilaterally optimal for both firms. However, taking into account rivals' reactions, the firms find themselves trapped in a prisoner's dilemma: they can both be better off by committing not to do so. To understand the intuition, one can imagine what might have happened if, under the equilibrium of Proposition 2, the firms fail to commit. Lemma 1 implies that firm H prefers to price discriminate, by setting the base price to $P_h^{(1)} = (P_l^* + \Delta V \bar{\theta})/2$. In response, firm L sells the add-on to those who buy only the base from H, inducing them to switch. The best-response bundle price $P_l^{+(1)}$ and add-on price $p_l^{(1)}$ are

$$P_l^{+(1)} = \tfrac{1}{2}(P_h^{(1)} + c - (\Delta V - w)\underline{\theta}) \quad \text{and} \quad p_l^{(1)} = \tfrac{1}{2}(w\underline{\theta} + c).$$

Then, in response to L's bundle price, firm H lowers its base price further to $P_h^{(2)} = (P_l^{+(1)} + (\Delta V - w)\bar{\theta})/2$.[27] This lower base price triggers an even lower bundle price by firm L. This interaction iterates and converges to an equilibrium in which both firms end up being worse off by selling the add-on as optional. Essentially, under commitment failure, firm H finds segmentation more profitable, whereas firm L can benefit from selling the add-on as long as it is not too costly. Since the quality gap between the low-end version of H and the high-end version of L becomes smaller, price competition is intensified, enough to erode their profits.

The loss-loss result presents a challenge for firms selling an add-on. In the short run, firms may be better off selling an add-on as optional. In the long run, however, profits may be damaged if firms are vertically differentiated. Clearly, it is beneficial for firms to have commitment powers. Even in the hotel industry, one could argue that hotels can commit through advertising, reputation, or costly upfront investment, providing them incentive to bundle. Indeed, some hotels do offer free Internet or other amenities, and commit to this policy. Commitment may be more feasible in the manufacturing industries. For example, many features in the automobile industry (side airbags, GPS navigation, leather seats, etc.) cannot be flexibly added to, or removed from, a base model. These features tend to be first offered and become standard in luxury cars, a phenomenon consistent with Proposition 2. The insight can similarly shed light on how firms' policy should change as the base quality improves. Hyundai and Toyota, for example, have substantially improved their quality image in the past decade and started offering some advanced features such as Android Auto, backup cameras, and power-adjustable seats as standard.

4. Unobserved Add-on Prices

Thus far, I have assumed that add-on prices are observable by consumers. This is not unreasonable if consumers learn about prices through repeat purchases or word of mouth, or if firms advertise add-on policies because of regulation or reputation concerns. However, many situations exist in which consumers do not really observe add-on prices. One canonical example is that prices of mini-bar items are often unknown when consumers book a hotel. In this section, I explore how the assumption of unobserved add-on prices influences the equilibrium policies and profits in the main theory. To that end, I modify the game as follows. At $t = 0$, both firms set prices for the base and add-on. At $t = 1$, consumers observe only base prices P_h and P_l, and decide which firm to buy from, and pay the base price. At $t = 2$, consumers visit the firms they have chosen; the add-on price is revealed and they decide whether to pay for the add-on. Consumers have rational expectations about add-on prices p_h^e and p_l^e.[28]

4.1. The Unobserved-Price Equilibria

Firm H's problem is essentially the same as the one under observable prices, because it possesses market power over the high-type consumers in $[\theta_{hl}, \bar{\theta}]$. In equilibrium, these consumers expect the price to be $p_h^{e*} = \frac{1}{2}(\bar{\theta}w + c)$. Whether or not the price is observed becomes irrelevant. Thus, maximizing the total profit is equivalent to maximizing base profit, $(\bar{\theta} - \theta_{hl})P_h$.

Targeting the remaining consumers $\theta \in [\underline{\theta}, \theta_{hl}]$, firm L maximizes ex post profit, $\pi_l = (\theta_{hl} - \theta_l)(p_l^e - c)$ with $\theta_l = p_l^e/w$. It is useful to change the control variable from add-on price p_l^e to intramarginal consumer θ_l. The optimal θ_l is chosen as a function of the marginal consumer such that $\theta_l^*(\theta_{hl}) = (\theta_{hl} + \alpha)/2$. Then firm L sets marginal consumer θ_{hl} to maximize its total profit

$$\max_{\theta_{hl}} (\theta_{hl} - \underline{\theta})[\underbrace{P_h - \theta_{hl} \cdot (\Delta V - w)}_{= P_l + p_l^e} - c] - (\theta_l^*(\theta_{hl}) - \underline{\theta})(\underbrace{w \cdot \theta_l^*(\theta_{hl})}_{= p_l^e} - c).$$

The best responses of both firms lead to the following equilibrium profiles:

$$\theta_{hl}^* = \frac{2(\bar{\theta} + \underline{\theta})\Delta V - (2\bar{\theta} + \underline{\theta} + 2\alpha)w}{6\Delta V - 5w};$$

$$P_h^* = \frac{2(2\bar{\theta} - \underline{\theta})\Delta V - (3\bar{\theta} - \underline{\theta} - 2\alpha)w}{6\Delta V - 5w} \cdot (\Delta V - w).$$

Proposition 3 then follows by examining whether the incentive constraints are binding. The details are provided in the online appendix.

Proposition 3. *There exist equilibria in which firm H always sells the add-on as optional, whereas firm L's policy depends on cost-to-value ratio α such that (1) if $\alpha \geq \frac{1}{3}(2\bar{\theta} - \underline{\theta})$, then the firm does not sell the add-on; (2) if $\alpha \in (\underline{\theta}, \frac{1}{3}(\bar{\theta} + \underline{\theta}))$, then the firm sells the add-on as optional when $\Delta V > \Delta_1^{(u)}$; (3) if $\alpha \leq \underline{\theta}$, then the firm sells the add-on as standard when $\Delta V \in [\Delta_0^{(u)}, \Delta_2^{(u)}]$, and sells it as optional when $\Delta V > \Delta_2^{(u)}$.*

The result reveals that the interplay between screening and vertical differentiation continues to hold even when add-on prices are unobserved. Firm H's incentive to price discriminate is strengthened, whereas firm L has to trade off between discrimination and differentiation with its add-on policy sensitive to the cost ratio. However, firm L's add-on price is unobservable, resulting in a hold-up problem that keeps the add-on price high. Consequently, the lowest types refrain from buying the expensive add-on, and hence firm L becomes less likely to sell it as standard even when it is not costly to provide.

4.2. Unobserved-Price vs. Observed-Price Equilibria

How does the equilibrium under unobservable prices differ from the one under observable prices? To facilitate the comparison, I restrict the analysis to an add-on with moderate cost so both firms sell it as optional under either scenario. The following proposition summarizes the comparison of the two cases (see the online appendix for the proof).

Proposition 4. *Suppose that* $\alpha \in (\underline{\theta}, \frac{1}{3}(\bar{\theta} + \underline{\theta}))$ *and that* $\Delta V > \Delta_1^{(u)}$. *Compared to the observed-price equilibrium, under the unobserved-price equilibrium,* (1) *firm L has a smaller market share and less add-on sales;* (2) *firm H charges a higher base price but the same add-on price, whereas firm L charges a lower base price but a higher add-on price; the total prices for both firms are higher;* (3) *firm H's profit improves, whereas firm L's profit is reduced.*

The main reason for the differences in equilibrium outcomes and profits lies in the different effects of the hold-up problem on the vertically differentiated firms. For firm H, the hold-up problem has no effect because consumers anticipate an ex post high add-on price charged to exploit the highest-type consumers. The hold-up problem at firm L is more subtle. Its higher-type consumers anticipate being held up with a high add-on price, thereby considering switching to firm H to buy the base only. Consequently, firm L loses market share. This further relaxes firm H's competitive pressure, which then can raise its base price. In response, firm L also increases its total price. Clearly, firm H benefits from the add-on price being unobserved at L. Although firm L's total price becomes higher, its segment of consumers who pay for the expensive add-on shrinks, resulting in a lower total profit.

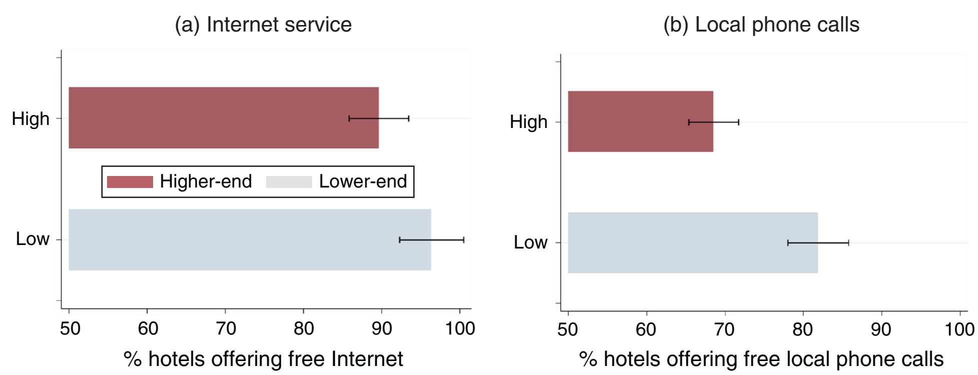
This result implies that vertically differentiated firms may experience disparate incentives regarding whether to advertise add-on prices. Firm H has no incentive to do so because its higher-type consumers expect the add-on to be expensive. Its lower-type consumers are uninterested in the add-on anyway, so whether the price is advertised or not is irrelevant to them. Contrarily, firm L has an incentive to advertise to its rival's consumers that it offers a better deal by lowering the bundle price. Although the total price drops, the gains from acquiring new consumers who originally bought only the higher-quality base good and from persuading more existing consumers to buy the add-on, make advertising profitable. Given the incentive to advertise, one may expect that firms' behaviors will converge to the ones in the observed-price equilibrium.

5. Empirical Evidence

In this section, I provide some suggestive evidence that is consistent with the impact of vertical differentiation on add-on policies. The objective is to identify whether firms become more likely to offer a free add-on when they face competition from a higher-end firm, when the add-on is almost costless. The hotel industry is a good candidate for such a test because many markets are possibly differentiated vertically and Internet and local phone call services arguably have small cost-to-value ratios.

The main data came from a survey study conducted biennially by Smith Travel Research and the American Hotel and Lodging Association. The surveys were distributed to all hotels in the United States with 15 or more rooms (more than 52,000 hotels),[29] and collected information about amenity policies. For Internet and local phone call services, hotel managers reported

Figure 3. (Color online) Likelihood of Offering Free Internet/Local Calls



Note. Error bars represent ±1 standard errors.

whether they are provided for free. Hotels are grouped into five tiers of approximately equal size based on average room rates: luxury, upscale, midpriced, economy, and budget. I obtained the individual-level data for the most recent four surveys (from 2006 to 2012) with 25,179 respondents.[30] To identify duopoly markets that are most likely to be vertically differentiated, I used zip codes to approximate markets with an additional data set documenting the number of active properties in each zip code.[31]

5.1. The Main Findings

Figure 3 visualizes the likelihoods of offering free Internet and local calls in the higher- and lower-end conditions. A clear pattern emerges that hotels become more likely to offer the services free when they are at the lower-end than at the higher-end. Logistic regressions were performed to test the differences with the dependent variable being whether or not a hotel offered free Internet/local calls. The higher-end condition was treated as the benchmark. As shown in Table 2 ("No Controls" columns), hotels in the lower-end condition are significantly more likely to offer free Internet and local calls.

Note that the absolute percentages are quite high on average for both conditions. The primary reason is that these hotels are mainly located in suburban or small towns rather than in large cities. They are less likely to be luxury or upscale, and hence are more likely to face upward competition from other markets. Furthermore, some higher-end hotels offer basic Internet access for free but charge for heavy use. They might report a free Internet policy even though they were practicing price discrimination. Therefore, the observed difference in the Internet policy between lower-end and higher-end hotels might be smaller than the actual difference, suggesting that the reported results are conservative.

Other factors might have influenced hotels' add-on policies, including hotel size, age, structure (with a VIP floor or not), location (airport, interstate, resort, small town, suburban, or urban), and type of operation (chain operated, franchise, or independent). I control for these factors in the analysis reported in Table 2 ("With Controls" columns) and find the same pattern. Note that hotels with a VIP floor were less likely to offer free Internet or phone calls. Since higher-end hotels typically have VIP rooms, this result is consistent with Corollary 1. Note also that larger hotels were less likely to offer these services free. This is likely because lower-end hotels typically have fewer rooms, resulting in the correlation between hotel size and policies on Internet and phone calls. Another possible explanation is that the cost of implementing price discrimination is more of a barrier for small-size hotels because of labor or technology related transaction costs. Hence, smaller hotels tend to offer a bundle with no discrimination. Even after controlling for these potentially confounding explanations, the main effect of vertical structure on Internet/phone call policies remains strong.

5.2. Robustness

One limitation of the preceding analysis is that market-specific factors are not controlled, resulting in a noisy comparison between hotels (e.g., a three-star hotel in Boston is compared to a four-star hotel in New York). A more direct test is to compare the two hotels in the

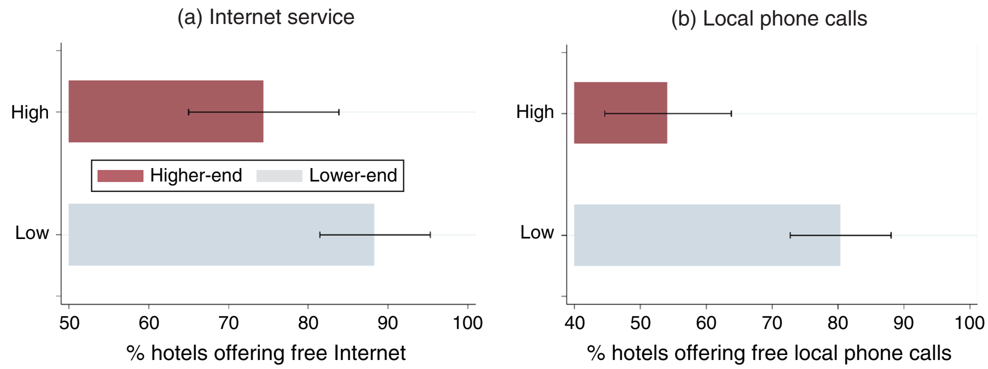
Table 2. Regression Analysis: Do Hotels Become More Likely to Offer Free Internet/Local Calls if They are Lower-End?

	Internet		Local calls	
	No controls	With controls	No controls	With controls
Low-end in duopoly	0.056** (0.028)	0.044* (0.024)	0.142*** (0.029)	0.132*** (0.027)
VIP floor		−0.138*** (0.026)		−0.102*** (0.035)
No info on VIP floor		−0.164*** (0.033)		−0.048 (0.033)
Year 2008		−0.008 (0.036)		−0.017 (0.037)
Year 2010		−0.008 (0.036)		0.010 (0.040)
Year 2012		−0.030 (0.042)		−0.093** (0.037)
Location—Interstate		−0.017 (0.057)		0.054 (0.088)
Location—Resort		0.100 (0.080)		0.038 (0.105)
Location—Small town		−0.018 (0.052)		0.036 (0.081)
Location—Suburban		−0.031 (0.043)		−0.041 (0.076)
Location—Urban		−0.030 (0.048)		−0.121 (0.080)
Operation—Franchised		0.184*** (0.029)		0.141*** (0.037)
Operation—Independent		0.198*** (0.039)		0.022 (0.047)
Size—75 to 149 rooms		−0.045 (0.036)		−0.147*** (0.031)
Size—150 to 299 rooms		−0.166*** (0.039)		−0.278*** (0.036)
Size—300 to 500 rooms		−0.258*** (0.049)		−0.385*** (0.058)
Size—> 500 rooms		−0.266*** (0.095)		−0.266** (0.132)
Age		−0.000 (0.001)		0.000 (0.001)
No info on age		−0.184** (0.088)		0.285 (0.258)
Observations	984	984	1,211	1,211

Notes. This table reports the average marginal effects from logistic regressions. The dependent variable is whether or not a hotel offers the service (Internet or local calls) free (1—yes, 0—no). Robust standard errors are in parentheses.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Figure 4. (Color online) Likelihood of Offering Free Internet/Local Calls: Higher- vs. Lower-end in the Same Markets



Note. Error bars represent ±1 standard errors.

same market. Thus, I restricted attention to duopoly markets in which *both* hotels reported their policies. There were 86 such duopoly markets in the Internet sample and 107 in the local calls sample. Figure 4 illustrates the same patterns observed in the previous analysis. Paired t-tests verify that the differences are statistically significant ($p = 0.022$, $t = 2.325$ for Internet, and $p = 0.000$, $t = 4.481$ for local phone calls).

In the sample, a luxury hotel might locate in the same zip code with a hotel from a much lower tier. It is likely that there is not much competition between the two if they serve very different consumer segments.[32] The results in Table 3 suggest that the patterns persist even if markets with large tier gaps are eliminated. Note that the difference between higher- and lower-end conditions becomes smaller as the gap becomes smaller, consistent with the monotone pattern that hotels become more likely to offer free Internet or local calls as they move from the luxury to the budget tiers. This pattern may be explained by extending the theoretical insight from the duopoly model to the oligopoly model: as firms move from the highest to the lowest end, the incentive to discriminate decreases monotonically because of the increasing need to differentiate.

Finally, using zip codes to define markets may lead to biases if hotels in neighboring zip codes locate close to each other introducing a strong competition across zip codes. To test the robustness, I collected another data set from Expedia.com, which defines markets based on geographic proximity, and focused on Internet service. The details of the data are summarized in Appendix D. The defined markets are broader than zip codes such that one market can encompass several zip codes. Table 4 reports the regression results using both market definitions, zip codes, and regions defined by Expedia. The pattern that hotels in the lower-end condition are more likely to offer free Internet is not affected by different market definitions.

Table 4. Regression Results Using Expedia Data

	Markets defined by zip codes	Markets defined by regions
Low-end	0.077***	0.079***
	(0.016)	(0.021)
Observations	1,442	851

Notes. This table reports the average marginal effects from logistic regressions. The dependent variable is whether a hotel offers free Internet service (1—yes, 0—no). Robust standard errors are in parentheses.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

6. Concluding Remarks

This paper examines the role of vertical differentiation in add-on policies. The theory uncovers the disparate roles of add-ons for vertically differentiated firms. Higher-quality firms' incentive to price discriminate using an add-on is further strengthened in the

Table 3. Regression Results by Tier Gaps

	Internet			Local calls		
	Tier gap ≤ 3	Tier gap ≤ 2	Tier gap ≤ 1	Tier gap ≤ 3	Tier gap ≤ 2	Tier gap ≤ 1
Low-end	0.051*	0.056*	0.047	0.131***	0.109***	0.093***
	(0.028)	(0.030)	(0.035)	(0.029)	(0.030)	(0.035)
Observations	954	842	540	1,178	1,056	692

Notes. This table reports the average marginal effects from logistic regressions. The dependent variable is whether a hotel offers free Internet or local phone call services (1—yes, 0—no). Robust standard errors are in parentheses.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

presence of lower-quality rivals. Lower-quality firms, however, have to trade off discrimination and differentiation and thus become sensitive to the cost-to-value ratio of an add-on. Selling an optional add-on can intensify competition, because firms price aggressively to attract marginal consumers who trade off a higher-quality base good versus a lower-quality base together with an add-on. These insights are particularly relevant to add-on policy decisions in many industries. Marketing managers should evaluate add-on policies based on the positioning of the base good in the market and the cost and value nature of the add-on. They should be cautious regarding the negative impact of an optional-add-on policy on long-term profitability under competition.

A number of questions remain unaddressed in this paper, and may be worth future investigation. First, the comparative statics implied by Proposition 1 with respect to the cost-to-value ratio of an add-on provide a direction for future empirical work. Detailed data with exogenous variations in the cost or value of an add-on will be useful for such a study. Second, the proposition that selling an optional add-on can hurt profits of vertically differentiated firms is an interesting hypothesis to test. Unfortunately, the data used in this paper were unsuitable to test it. Future empirical research into this topic is worth exploring. Third, the theory focuses on pure vertical differentiation, assuming away horizontal differentiation. In reality, firms are often differentiated both vertically and horizontally. Further theoretical or empirical research allowing for both aspects may shed light on their relative influences on add-on policies.

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Appendix A. A Numerical Example of Proposition 1

To illustrate the main model with an example, I set $\bar{\theta} = 2.2$, $\underline{\theta} = 0.2$, $\Delta V = 100$, and $w = 10$. The cost-to-value ratio is varied based on Proposition 1 from small to large: 0.2, 1.0, and 1.6. Table A.1 summarizes the corresponding equilibrium policy, prices, and market share of each firm. In the last two columns of the table, the percentage of consumers buying the add-on for each firm is indicated in parentheses. Note that the theoretical lower bound of firm H's market share is $\frac{2}{3}$ under the modeling assumption.

Appendix B. Proof of Lemma 1

There are two cases to consider depending on whether firm L sells the add-on. The proof of each case follows the same logic and thus I will present only the proof of the case in which firm L does not sell the add-on. Suppose that firm H sells the add-on as standard and sets the bundle price at P_h^+. Then the marginal consumer indifferent between the two firms is $\theta_{hl} = (P_h^+ - P_l)/(\Delta V + w)$. Firm H's profit is $\Pi_h = (\bar{\theta} - \theta_{hl})(P_h^+ - c)$. This strategy is exactly equivalent to setting the base price P_h and the add-on price p_h such that $P_h^+ = P_h + p_h$, and that

$$\frac{p_h}{w} = \frac{P_h^+ - P_l}{\Delta V + w} = \frac{P_h - P_l}{\Delta V}. \tag{B.1}$$

Consider a small increase of the add-on price to $p_h' = p_h + \epsilon$ with $\epsilon > 0$, and a small decrease of the base price to $P_h' = P_h - \epsilon$. The total price P_h^+ remains unchanged. This results in a segmentation of consumers because the binding constraints are relaxed

$$\frac{p_h'}{w} > \frac{P_h^+ - P_l}{\Delta V + w} > \frac{P_h' - P_l}{\Delta V}.$$

The profit function now becomes

$$\Pi_h(P_h', p_h') = \left(\bar{\theta} - \frac{P_h' - P_l}{\Delta V}\right)P_h' + \left(\bar{\theta} - \frac{p_h'}{w}\right)(p_h' - c).$$

Evaluating this function around the original prices (P_h, p_h) by Taylor series yields the following:

$$\begin{aligned}
\Pi_h(P_h', p_h') &= \Pi_h(P_h, p_h) - \epsilon \cdot \Pi_{P_h}(P_h, p_h) + \epsilon \cdot \Pi_{p_h}(P_h, p_h) \\
&\quad + \tfrac{1}{2}[\epsilon^2 \cdot \Pi_{P_h P_h}(P_h, p_h) + 2\epsilon^2 \cdot \Pi_{P_h p_h}(P_h, p_h) \\
&\quad + \epsilon^2 \cdot \Pi_{p_h p_h}(P_h, p_h)] + R_2 \\
&= \Pi_h(P_h, p_h) - \epsilon \cdot \left[\bar{\theta} - \frac{P_h - P_l}{\Delta V} - \frac{P_h}{\Delta V}\right] \\
&\quad + \epsilon \cdot \left[\bar{\theta} - \frac{p_h}{w} - \frac{p_h - c}{w}\right] + \frac{\epsilon^2}{2}\left[-\frac{2}{\Delta V} - \frac{2}{w}\right] \\
&= \Pi_h(P_h, p_h) + \underbrace{\frac{\epsilon}{\Delta V}(P_l + \alpha \Delta V) - \frac{\epsilon^2}{w \Delta V}(\Delta V + w)}_{M},
\end{aligned}$$

Table A.1. Summary of the Numerical Example

α	Add-on policy (H, L)	P_h	p_h	P_l^+	P_l	p_l	Demand of H (% Add-on)	Demand of L (% Add-on)
1.6	(Optional, No)	140.00	19.00	—	60.00	—	70% (21%)	30% (0%)
1.0	(Optional, Optional)	129.33	16.00	60.67	54.67	6.00	72% (42%)	28% (29%)
0.2	(Optional, Standard)	126.67	12.00	55.33	—	—	70% (71%)	30% (100%)

which follows from Equation (B.1) and the fact that the remainder term R_2 is zero because the higher-order derivatives are all zero. Therefore, $M > 0$ for small ϵ when $P_l + \alpha\Delta V > 0$.

Appendix C. Proof of Observation 1

Suppose that the statement is not true. Then in equilibrium, firm H would either (1) sell the add-on as standard, or (2) do not sell it at all. Each case further entails two possibilities, depending on whether firm L sells the add-on. Next, I show that in each case firm H finds it profitable to deviate to the optional-add-on policy.

C.1. Firm H Sells the Add-on as Standard

Case (a). *Firm L sells the add-on.* The marginal consumer indifferent between the two firms becomes $\theta_{hl} = (P_h^+ - P_l^+)/\Delta V$. Equilibrium prices are given by

$$P_h^{+*} = \tfrac{1}{3}\Delta V(2\bar{\theta} - \underline{\theta}) + c, \quad p_h^* < w\theta_{hl}^*;$$
$$P_l^{+*} = \tfrac{1}{3}\Delta V(\bar{\theta} - 2\underline{\theta}) + c, \quad p_l^* < w\theta_{hl}^*,$$

with $\theta_{hl}^* = (\bar{\theta} + \underline{\theta})/3 > \underline{\theta}$. Note that whether or not firm L sells only the base or the bundle to the lowest type (i.e., whether $p_l^* > \underline{\theta}$) does not affect the argument. Because $P_l^{+*} > 0$, by Lemma 1(b), firm H can profitably deviate to the optional-add-on policy by raising the add-on price while lowering the base price.

Case (b). *Firm L does not sell the add-on*. The marginal consumer indifferent between the two firms becomes $\theta_{hl} = (P_h^+ - P_l)/(\Delta V + w)$. Equilibrium prices are

$$P_h^{+*} = \tfrac{1}{3}(\Delta V + w)(2\bar{\theta} - \underline{\theta}) + \tfrac{2}{3}c, \quad p_h^* < w\theta_{hl}^*;$$
$$P_l^{*} = \tfrac{1}{3}(\Delta V + w)(\bar{\theta} - 2\underline{\theta}) + \tfrac{1}{3}c, \quad p_l^* > w\theta_{hl}^*,$$

with $\theta_{hl}^* = (\bar{\theta} + \underline{\theta})/3 + c/(3\Delta V + 3w) > \underline{\theta}$. Because $P_l^* > 0$, by Lemma 1(a), firm H can profitably deviate to the optional-add-on policy by raising the add-on price while lowering the base price.

C.2. Firm H Does Not Sell the Add-on

In this case, firm H's profit becomes $\Pi_h = (\bar{\theta} - \theta_{hl})P_h$. The marginal consumer θ_{hl} is either $(P_h - P_l^+)/(\Delta V - w)$ or $(P_h - P_l)/\Delta V$, depending on whether firm L sells the add-on to its highest-type consumers. The best-response prices lead to a threshold $\theta_{hl}^* < \bar{\theta}$. Firm H would need to set a high add-on price $p_h^* > \bar{\theta}w$ so that no one buys the add-on. However, it is always profitable for firm H to lower its add-on price such that $p_h' < \bar{\theta}w$, without affecting the profit from selling the base as long as $p_h' > w\theta_{hl}^*$. Therefore, no equilibrium exists where firm H sells only the base good.

Appendix D. Details of the Expedia Data

I obtained public data sets from Expedia in December 2013, including full text descriptions, amenity lists, hotel IDs, star ratings, etc., for every property listed on Expedia.com. Internet information was embedded in the texts in multiple data sets on hotel description, amenity, policy, and room type. There are several types of Internet information including Wi-Fi, wired Internet, and high-speed Internet. I restricted attention to Wi-Fi as its information is most complete. I conducted text mining to create a variable indicating whether a hotel provides free Internet service and whether it charges it for a fee.

Vertical differentiation is defined using the variable *High Rate* provided in the data. If hotels A and B were in the same market, then vertical differentiation exists if and only if |A's *High Rate* − B's *High Rate*| > D, where D = \$0. I used *High Rate*, instead of star ratings and *Low Rate*, to define the vertical structure because this information is more complete. Robustness checks suggested that using alternative measures such as star ratings or *Low Rate* or the average of *High Rate* and *Low Rate*, and using different thresholds D = \$20, \$40 do not alter the qualitative conclusions. There were 1,442 duopoly markets with vertical differentiation if I used zip codes to define the markets, and 851 if I used regions defined by Expedia based on geographic proximity.

Endnotes

[1] Many luxury apartments in New York City charge extra for gym access despite the already high rent (Grout 2004).

[2] For example, many cheap haircuts in New York City cost as low as \$20 and include a wash and blow dry, whereas high-end salons can charge as much as \$250 for the blowout alone (Lipton 2014).

[3] See, for example, the *New York Times* (Higgins 2009), *USA Today* (DeLollis 2012), and the *Wall Street Journal* (McCartney 2015).

[4] For example, higher-end hotels have more business travelers than leisure travelers.

[5] Some add-ons are better described as surcharges that are mandatory or necessary such as shipping fees (online retailers), fuel surcharges (airlines), and concession recovery fees (car rental at airports). Research on partitioned pricing explores how consumers react under this situation (Morwitz et al. 1998, Cheema 2008). This paper focuses on add-ons that are not mandatory or not necessary on the purchase of a base good.

[6] Many cases exist in which this condition does not hold, and thus competing firms are better off in equilibrium (e.g., Chen et al. 2001, Shaffer and Zhang 2002).

[7] Balachander et al. (2010) show that mixed bundling can also soften price competition.

[8] Consumers cannot buy the add-on without buying the base good, but they can buy the base good alone without buying the add-on. For example, a consumer cannot access Internet service in a hotel if she does not stay at the hotel, but she can stay in the hotel room without using the Internet service.

[9] The Federal Trade Commission defines drip pricing as "a pricing technique in which firms advertise only part of a product's price and reveal other charges later as the customer goes through the buying process." https://www.ftc.gov/news-events/events-calendar/2012/05/economics-drip-pricing.

[10] For example, having stayed at a Marriott and learning that the Internet service costs \$13, a consumer may keep this in mind the next time she books a room at the same hotel or at another location of the same chain.

[11] The standard assumption of uniform distribution greatly simplifies the analysis of vertical differentiation. However, one unattractive consequence is that the theoretical lower bound of firm H's market share is $\frac{2}{3}$, leaving a very small market share for firm L.

[12] There are, of course, situations in which consumers are uncertain about V and/or w. If firms have private information on V, then the add-on may signal the base quality (Bertini et al. 2009). How firms design product policies under this situation is an interesting direction to explore, but it is beyond the scope of this paper. If firms are also uncertain about these values, then insights from this simple model still apply.

[13] Equivalently, one can specify a utility model, $U_{\theta j} = V_j + w - (P_j + p_j)/\theta$, similar to Ellison (2005).

[14] This feature distinguishes this paper from Shulman and Geng (2013), which assumes some consumers value the add-on but others do not, and from Dogan et al. (2010), which models rebates in the framework of competitive second-degree price discrimination incorporating vertical differentiation. Both studies assume no consumer heterogeneity in the taste for the base quality.

[15] In the bundling literature, however, the decision to offer no add-on or to offer a bundle is often committed. Although whether firms can commit is irrelevant in a static monopoly setting, it becomes strategically important in competitive markets. With commitment powers, the firms' deviation strategies become more restricted, weakening strategic interactions between firms. For example, in a two-stage model with commitment choices in the first stage, if firm H commits to bundling, it cannot separate the charges in any deviation of the pricing subgame. However, such deviation is feasible in a simultaneous-move game without the commitment stage. The role and implication of strategic commitments are examined in depth in Section 3.

[16] An equilibrium is called unique under a parameter region in the sense that no other equilibrium with a different policy implementation exists in that region.

[17] Note that the argument requires that there is a sufficient number of different types (more than two) so that a local deviation by separating the prices is profitable. With just two types of consumers, it can easily lead to the conclusion that selling an add-on as standard is optimal, as in Ellison (2005) and Shugan et al. (2017).

[18] Intuitively, the firm can advertise an attractive package (e.g., a three-star hotel offers "Internet included" packages) to its potential consumers, $\theta \in [\underline{\theta}, \theta_{hl}]$, and convinces all to visit. Once they accept the offer, the firm can exclude the lowest types, $\theta \in [\underline{\theta}, \theta_l]$, from consuming the add-on by offering a subsidy to avoid the costs of supplying the add-on.

[19] In fact, firm L prices the add-on significantly lower than what it would have charged if there were no competition. To see that, imagine that the lower-quality firm is the monopolist for a market of consumers with types $\theta \in [\underline{\theta}, \bar{\theta}_l]$. The maximization problem would lead to an add-on price of $\tilde{p}_l^* = \frac{1}{2}(\bar{\theta}_l + \alpha)w$, which is greater than p_l^* in the equilibrium under vertical differentiation because $\bar{\theta}_l > \underline{\theta}$.

[20] More generally, not selling the add-on is strictly dominated by selling it if α is sufficiently small. This result is summarized in Lemma A-1 in the proof of Proposition 1 in the online appendix.

[21] Unlike hotels, airlines use ground stations or satellites to provide Internet access on a flight and most cruise lines use satellite technology to provide Internet access.

[22] For example, some very price-sensitive consumers may choose not to stay at any hotel and switch to other alternatives instead (e.g., sleeping in a car or in a friend's place, staying at a campground, or even shortening the trip to avoid overnight accommodation).

[23] A five-star hotel, for example, can invest in better locations and views, swimming pools, fitness centers, the costs of which may be substantially higher than those at a four-star hotel, but less so for the marginal costs.

[24] For example, breakfast may be of higher quality but cost more at a five-star hotel than at a four-star hotel.

[25] For example, a less price-sensitive consumer may be willing to pay more for a more comfortable room and for Internet service.

[26] In the online appendix, I provide additional results under two other possible scenarios: (a) both firms can only commit to the no-add-on policy; (b) both can only commit to the standard-add-on policy (bundling). However, much of the important insight can be delivered by allowing the firms to commit to either policy.

[27] This is lower than its price $P_h^{(1)}$ in the previous round given that $\alpha < \frac{1}{3}(2\bar{\theta} - \underline{\theta})$.

[28] The assumption that consumers cannot learn about add-on prices by searching may be strict, but it is sufficient to illustrate the hold-up problem. Alternatively, one can assume that consumers can incur search costs to discover add-on prices. The well-known argument by Diamond (1971) suggests that even with a very small search cost, firms can enjoy ex post monopoly power after consumers have paid the search cost. The equilibrium outcomes are the same as the ones here.

[29] The overall response rate is 23% with more than 12,000 participants, believed to be representative of the U.S. lodging industry.

[30] Among them, 65% completed one survey, 24% two, 9% three, and 2% all four.

[31] If smaller geographic regions than zip codes were used to define markets, competition between neighboring markets would be strong but ignored. If larger regions were used to define markets, there would be fewer markets with only two hotels. To evaluate the robustness of market definition, I later used larger geographic regions to define markets based on another data set from Expedia.com.

[32] For example, consumers who consider a Holiday Inn may not consider the Ritz-Carlton because of budget limits, or the reverse may occur because consumers only consider hotels above a certain quality threshold. Neither of these decision rules is incorporated in the theory.

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