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How Add-on Pricing Interacts with Distribution Contracts

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With the rise of the Internet economy, an increasing number of firms are offering their core products through online platforms, but retail add-ons directly to consumers. Meanwhile, many online platforms have also started adopting the agency (model) contract, where the upstream firms decide the retail prices of products while the downstream platforms take a predetermined cut from each sale. This study examines the interaction between an upstream firm's add-on strategy and a downstream online platform's distribution contract choice. We find that such a firm prefers bundling the add-on and the core product together under the wholesale contract, but prefers retailing the add-on separately under the agency contract. Our research thus is the first to suggest that the distribution contract can critically affect a firm's choice between add-on pricing and bundling. On the platform side, we show that a higher commission rate does not always result in a higher profit for the platform under the agency contract. We further identify two conditions under which the platform prefers the agency contract over the wholesale contract: The commission rate for the platform cannot be too low, and the market potential of the add-on cannot be too large. For the overall channel, we show that the interaction between add-on pricing and distribution contracts leads to sub-optimal channel performance. That said, it is possible for both the firm and the platform to obtain higher profits under the agency contract than under the wholesale contract. Finally, we also demonstrate the robustness of our findings under several alternative model specifications.

Key words: add-on pricing; online platform; agency model; supply chain contract
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1. Introduction

In this age of Internet economy, firms often offer their core products through online platforms but retail add-ons directly to consumers. For example, hotels often sell rooms through online travel agencies (OTA) and then sell add-ons such as Internet access and parking directly to customers when they arrive. Similarly, airlines often use intermediaries to sell flight tickets but sell ancillary services such as luggage check-in and snacks directly to passengers. Video game publishers frequently sell their game titles through e-tailers such as Amazon.com, and later sell in-game equipment or downloadable content directly to gamers when they play. Beauty shops and spas often offer their services through online platforms such as LivingSocial and then market add-ons to customers upon arrival.

This study studies how the distribution contract between a firm (which provisions a core product and an add-on) and an online platform (which intermediates sales) interacts with the firm's add-on strategy. A growing body of literature on the economics of add-on attempts to determine when a firm benefits from *add-on pricing*, such as in the aforementioned examples where the add-ons are priced separately, and when it benefits from *bundling*, under which the core products and the add-ons are bundled together for a single price (Cui et al. 2015, Ellison 2005, Geng and Shulman 2015, Shulman and Geng 2013). While previous add-on literature assumes direct sales from a firm to consumers, our research accounts for the fact that the sales of core products are often intermediated by platforms in practice. This study thus contributes uniquely to the add-on literature by demonstrating how distribution contracts between a firm and a platform affect the firm's choice between add-on pricing and bundling, as well as the welfare of all stakeholders involved.

Two popular forms of distribution contracts used by online platforms are the *wholesale contract* and the *agency contract*. Under the wholesale contract, the platform purchases the core product from the firm, and in turn retails it to consumers with a markup. Wholesale contracts have been widely studied in the operations literature (Cachon 2003, Cai 2010). Under the agency contract, the firm decides the retail price of a product while the platform takes a commission from each sale. For example, Priceline has followed this business model; hotels and other service providers pay Priceline a commission for each transaction (Schmidt 2015). In recent years, many online platforms have started adopting the agency contract, and there is growing research interest in this contractual form in academia as well (Hao and Fan 2014, Kwark et al. 2016). We consider both the wholesale contract and the agency contract in this study.

This study also accounts for the firm-side operational cost often incurred in add-on pricing. Compared to bundling, a firm that adopts add-on pricing has to promote the add-ons and process their sales at additional cost. For example, hotel receptionists have to issue parking permits and process parking charges should parking cost a fee. Airline attendants have to process in-air payments—often a nuisance to both attendants and passengers—should airlines charge for in-flight drinks and snacks.

Given the above considerations, we study the following research questions in this article. First, under a wholesale contract, should a firm that sells both a core product and an add-on adopt add-on pricing or bundling? Second, under an agency contract, should the firm adopt add-on pricing or bundling? Third, how does the commission rate (i.e., the revenue proportion that the platform takes) affect firm and platform profits under an agency contract? Fourth, given the firm's optimal choice between add-on pricing and bundling, should a platform adopt the wholesale contract or the agency contract? Fifth, what are the implications of the interaction between distribution contract and add-on strategy on overall channel performance?

To answer these research questions, we develop a game-theoretic model with a firm, a platform and a continuum of consumers. Distinct from the previous add-on literature is our supply chain structure: The firm must sell the core product (either by itself or in a bundle) through the platform. The firm, however, can bypass the platform and directly sell the add-on to consumers if the firm adopts add-on pricing, as illustrated in the earlier examples. Furthermore, whenever the firm bypasses the platform for add-on sales, the firm does not share the add-on revenue with the platform. For example, in practice, hotels or airlines keep to themselves all parking or luggage fees levied directly upon customers, regardless of which platform these customers used to book the lodging or flights. In contrast, under bundling, such bypassing is infeasible as add-ons are already priced into the bundle that is sold through the platform.

One might intuitively expect that, as add-on pricing allows the firm to bypass and thus avoid sharing add-on revenue with the platform, the firm would favor add-on pricing over bundling in the presence of a platform. Our first finding is that, surprisingly, the firm earns more profit with bundling than with add-on pricing under a wholesale contract. This finding is consistent with business practices, where many firms still choose to bundle their add-ons with their core offerings and thus share revenue over the whole bundle with their hosting platforms. For example, a quick search on Expedia shows that many hotels still bundle Wi-Fi and parking into their lodging rates. The underlying intuition of this finding is a *bundling effect*: Bundling enables the firm to better price discriminate consumers as compared to unbundling (Adams and Yellen 1976, Schmalensee 1984). Under the wholesale contract, the bundling effect dominates the revenue benefit from bypassing the platform; therefore, the firm benefits the most from bundling.

Under an agency contract, however, our second finding is that the firm earns more profit with add-on pricing than with bundling as long as the operational cost of add-on pricing is not high. This finding contrasts sharply with the one under the wholesale contract. To our knowledge, this is the first research in the add-on literature demonstrating that distribution contracts can critically affect a firm's add-on strategy.

To put this finding in perspective, first note that under add-on pricing the firm can increase the sales of the add-on by reducing the standalone price of the core product. While the commission charged by the platform under agency pricing is a burden to the firm when the latter considers a price increase, the commission is instead a boon to the firm when it considers a price reduction: To reduce the retail price by one unit, the firm's share of margin loss is less than one unit because the platform absorbs a portion of the margin loss equal to the platform's commission rate. For example, if the platform charges 30% commission, to reduce the retail price by \$1, the firm only shoulders \$0.70 of the margin loss. Therefore, because of the commission, cutting the price of the core product (to subsequently induce more sales of the add-on) is more cost-effective under the agency contract than under the wholesale contract; we refer to this as the *loss-sharing effect*. This loss-sharing effect, coupled with the revenue benefit from bypassing the platform, dominates the bundling effect under the agency contract. Consequently, the firm benefits the most from add-on pricing.

Our third finding focuses on the relationship between the commission rate and channel member profit under the agency contract. We show that a higher commission rate always results in a lower firm profit. Interestingly, a higher commission rate does not always result in a higher platform profit: This is because that, when the commission rate is already high, further increasing the rate triggers a strong loss-sharing effect and the firm cuts the price of the core product aggressively. Consequently, the percentage gain the platform enjoys from a higher commission rate is more than offset by the fast reduction in the total channel revenue from the core product.

Our fourth finding addresses the online platform's optimal choice of distribution contract. We identify two key conditions under which the platform prefers the agency contract over the wholesale contract: The commission rate cannot be too low, and the market potential of the add-on (as measured by the sum of add-on valuation among all consumers) cannot be too large. Barring the first condition, the agency contract is not profitable to start with from the platform's perspective. Barring the second condition, the firm will aggressively cut the price of the core product, thus reducing the revenue share for the platform under the agency contract. We further show that a positive operational cost for add-on pricing, compared to no operational cost, strengthens the platform's preference for the agency contract.

Our research also leads to two findings regarding overall channel performance as measured by total channel profit. First, the interaction between add-on pricing and distribution contracts leads to sub-optimal channel performance: If the platform chooses wholesale, double marginalization hurts channel performance; if the platform chooses agency, while double marginalization can be mitigated, the loss-sharing effect causes the firm to set the price of the core product excessively low, which in turn reduces channel performance. Second, under a large commission rate, it is possible for both the firm and the platform to obtain higher profits under the agency contract than under the wholesale contract.

We also extend our model in the following directions: allowing an alternative timing where the add-on price is observable before core product purchase, allowing correlation between the core-product valuation and add-on valuation, having the platform intermediate the sales of the add-on, and considering competing platforms. We demonstrate that our main findings are robust to these model extensions. These extensions also lead to further findings. The firm tends to favor add-on pricing (bundling) more under a positive (negative) correlation between the core-product valuation and add-on valuation. The firm is more likely to adopt bundling if the platform intermediates the sales of the add-on. Competition causes all platforms to adopt agency contracts and benefits the firm through lower commission rates.

The rest of the study proceeds as follows: Section 2 reviews related literature. Section 3 lays out the model, and Section 4 presents the findings. Section 5 considers several model extensions, and Section 6 concludes the article.

2. Literature Review

This article's contribution lies at the intersection of two research streams: add-on pricing and agency pricing. A central theme in the add-on pricing literature is the comparison between add-on pricing and bundling in terms of their impacts on firm profit. Several early papers show that add-on pricing and bundling result in equivalent profit for a firm (Gabaix and Laibson 2006, Lal and Matutes 1994, Verboven 1999). Ellison (2005) is the first to show that add-on pricing can lead to a higher firm profit than bundling if less price-sensitive consumers are more likely to value add-ons. Shulman and Geng (2013) show that a firm can benefit from add-on pricing if there exists quality asymmetry in both the core product and the add-on, or if consumers are boundedly rational. Cui et al. (2015) consider both uniform pricing and discriminatory pricing of the core product, and show that these two pricing strategies over the core product have contrasting implications on the profitability of add-on pricing. Geng and Shulman (2015) show that competing firms can both lose from add-on pricing when consumer price sensitivity is correlated with their demand of add-ons. Lin (2016) shows that a higher quality firm under competition optimally chooses unbundling of the add-on. Ødegaard and Wilson (2016) consider a multiperiod pricing problem with capacity constraint and stochastic consumer arrival, and derive the optimal pricing policy over the add-on. Unlike the above papers, we consider a distribution-channel context where an online platform intermediates the sales of the core product (or the bundle) and uniquely show that the distribution contract can critically affect the firm's choice between add-on pricing and bundling.

There is an emerging body of literature on agency pricing due to the rapid growth of online platforms in recent years. An earlier stream of papers addresses this issue specifically as it pertains to the e-book industry. Hao and Fan (2014) find that e-book retail prices in the agency contract can be higher than that in the wholesale contract due to the existence of the complementary market. Tan and Carrillo (2014) explain how the agency model can benefit both the upstream publisher and the retailer in the digital publishing industry. The authors further extend this

result in a setting with downstream competition (Tan et al. 2016). Recent studies have focused on agency pricing in a broader setting. Abhishek et al. (2016) find that the cross-channel effect (i.e., brick-and-mortar retailing and online retailing) will influence the retailer's choice over the agency pricing and wholesale pricing. Kwark et al. (2016) show that the retailer can leverage the pricing model, wholesale or agency, as a strategic tool to benefit from online product reviews. Tian et al. (2017) find that the wholesale pricing will outperform the agency pricing in terms of profitability when the upstream competition between suppliers becomes intense. Hao et al. (2016) find that the advertising revenue-sharing contract under agency pricing for app sales leads to a higher app price than would be offered by the integrated platform found in traditional advertising. Unlike the aforementioned studies, the study investigates add-on pricing with the agency contract, which is prevalent in many industries. The interplay between these two components leads to new and important practical implications for managers.

Add-on pricing is a special case of unbundling where the add-on is valuable to a consumer only upon core-product purchase. Adams and Yellen (1976) and Schmalensee (1984) show that a firm can benefit from pure bundling when consumer valuations of products are either negatively correlated or independent. McAfee et al. (1989) show that mixed bundling almost always benefits a monopoly more than unbundling. Fang and Norman (2005) and Geng et al. (2005) consider the optimality of bundling a large number of products. Banciu et al. (2010) consider bundling of vertically differentiated products. Prasad et al. (2010) study bundling under network effects. Three recent papers consider bundling in a distribution channel and show that channel conflict may weaken a firm's incentive to bundle (Bhargava 2012), and bundling can serve as a channel-coordination mechanism (Cao et al. 2015a) and may improve firm profit under supply constraint (Cao et al. 2015b). Unlike the above papers, we consider agency pricing and are the first to show when and how channel contracts including agency pricing interact with add-on pricing.

3. The Model

We consider a distribution channel consisting of an upstream firm that provides products, a downstream online platform that intermediates sales, and a continuum of consumers.

3.1. The Firm and the Platform

The firm provisions both a core product (e.g., hotel room, video game, or basic spa treatment) and an add-on (e.g., hotel Wi-Fi, in-game purchasable content, or optional spa treatment). The firm can choose between two pricing strategies: selling the core product and the add-on together for a single price (bundling), or selling them separately (add-on pricing). Note that, in practice, businesses sometimes offer the add-on for free to consumers who purchase their core products; this is mathematically equivalent to bundling and thus treated as bundling in our article.

We limit the scope of this research to the case where the firm sells its core product through the platform. This fits industries where platforms play an essential role in enabling firms to reach consumers. For example, regarding the travel industry, a recent European Union report cites that "there is consensus that online platforms ... have been instrumental in enabling the industry to reach customers globally" (European Union 2016).

Under bundling, the firm sells the bundle through this platform. Under add-on pricing, while the firm must sell the core product through the platform, our main model flexibly allows for the possibility that the firm can directly sell the add-on to consumers (thus bypassing the platform). This setup is consistent with many business practices: For example, regardless of the platform a traveler uses to book a hotel, the hotel can directly market add-ons such as Wi-Fi to the traveler upon arrival. We also study an alternative scenario, where the firm sells the add-on through the platform in a model extension.

In this study, we consider two prevalent distribution contracts between the firm and the platform: wholesale and agency contracts. Under the wholesale contract, the firm charges a wholesale price w for the bundle under bundle pricing, or w_c for the core product only under add-on pricing. After adding its own markup, the platform in turn charges a retail price p for the bundle under bundle pricing, or p_c for the core product under add-on pricing. Moreover, under add-on pricing, the firm charges a retail price of p_a for the add-on directly to consumers.

Under the agency contract, the platform yields the retail pricing power regarding p or p_c to the firm. Therefore, a key distinction between the wholesale contract and the agency contract is whether the firm or the online platform has the control to set the retail price (Tan and Carrillo 2017). Similar to Hao and Fan (2014), for each bundle (under bundling) or core product (under add-on pricing) sold under the agency contract, the platform takes β proportion of the revenue while the upstream firm gets the remaining $1-\beta$ proportion. β is referred to as the commission rate in this study.[1] Anecdotal data suggest that common β values range from 15% to 40%. According to media reports, OTA often charge 15% to 25% (Kelleher 2016), and digital publishing industries

charge a 30% commission fee for e-books (WSJ 2012). To reflect the fact that, in business practice, the firm can keep the majority of the revenue, we assume that $\beta < 1/2$.

Without loss of generality, we normalize the marginal cost of the core product and the add-on to zero. We further assume that, for each add-on sold, the firm will incur an additional cost c_a, which captures the labor and operational cost when the add-on is sold separately from the core product. There is a proliferation of examples in practice where the firms need to bear this operational cost when selling add-ons. For example, upon hotel check-in, front desk staff need to go through additional questions and procedures if the guests need to purchase parking, Internet service, or breakfast separately. Airline attendants have to process in-air payments—often a nuisance to both attendants and passengers—should airlines charge for in-flight drinks and snacks.

3.2. Consumers

Similar to the extant literature (Ellison 2005, Geng and Shulman 2015), under bundling consumers can either purchase the bundle or abstain from the market; under add-on pricing consumers can either purchase the core product only, purchase both the core product and the add-on, or abstain from the market. Consumers are heterogeneous in their willingness to pay for the core product: Their valuation of the core product, θ, is uniformly distributed between 0 and 1. As is standard in the price discrimination literature, the firm knows only the distribution of consumer valuation, but cannot observe each consumer's exact valuation; in other words, θ is private knowledge to each consumer.

Following Geng and Shulman (2015), we assume that α proportion of consumers can derive a positive utility $\theta_a = v_a$ from the consumption of the add-on.[2] The remaining $1-\alpha$ proportion of consumers do not derive utility (i.e., $\theta_a = 0$) from the consumption of the add-on. Our assumption that only a proportion of consumers can derive positive utility from the consumption of an add-on fits many practical examples: Hotel parking does not bring value to travelers who do not drive a car; checked baggage services only matter for passengers who carry more luggage. Our choice of using a discrete distribution to model the heterogeneity of add-on valuation is also consistent with conventions established in the add-on pricing literature (Ellison 2005, Geng and Shulman 2015). Furthermore, this modeling choice not only permits us the closed-form solution but also allows us to concentrate on the interaction between selling strategy and channel contract forms in a parsimonious way.

Note that the above setup implies that consumer valuations of the core product and the add-on are independent. We relax this assumption to allow correlation of valuations between the core product and the add-on later in a model extension.

In practice, an add-on usually accounts for a small portion of consumer valuation of a bundle: Check-in luggage fees are usually a small part of the total airfare and Wi-Fi charges are much lower than lodging rates. Accordingly, we assume that the valuation of the add-on is relatively small as opposed to the maximum possible valuation of the core product, that is, $v_a \le 1/3$. We normalize the market size to be unit.

Obviously, if the operational cost c_a of selling the add-on separately is too high relative to v_a, add-on pricing will never be attractive to the firm regardless of the distribution contract. We therefore assume $c_a < \beta v_a$ to rule out the uninteresting case where add-on pricing never emerges in equilibrium.[3]

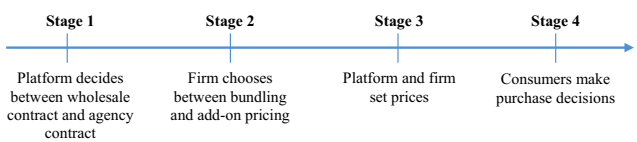
Given the above assumptions, if the firm adopts bundling, a consumer derives a utility of $\theta + \theta_a - p$ when she purchases the bundle, and 0 utility if she chooses not to purchase. If the firm adopts add-on pricing, a consumer derives a utility of $\theta - p_c + [\theta_a - p_a]^+$ when she purchases at least the core product, and 0 utility if she chooses not to purchase at all. The term $[\theta_a - p_a]^+ \equiv \max(0, \theta_a - p_a)$ reflects the fact that a consumer will purchase the add-on only if doing so nets her a non-negative utility.

3.3. Timing of the Model

Online platforms such as Booking.com and LivingSocial often possess significantly more market power than their member firms in determining the form of distribution contracts. For example, Booking.com mandates the agency contract upon all its members.[4] Accordingly, we model the interaction between the online platform and the firm using a stylized Stackelberg game, where the platform leads in choosing the form of the distribution contract. The firm follows by deciding whether to offer the add-on separately or to bundle it together with the core product. For example, some hotels listed on booking.com offer free Wi-Fi (which is effectively bundling of Wi-Fi into the room rate), while others do not. Figure 1 below illustrates the timing of the model.

In Figure 1, depending on the platform's choice between wholesale contract and agency contract in stage 1, and the firm's choice between add-on pricing

Figure 1 Timeline of the Model [Color figure can be viewed at wileyonlinelibrary.com]



and bundling in stage 2, there are four possible subgames from stage 3 onward that differ in how prices are set:

- In the wholesale add-on (*WA*) model, that is, the stage 3 subgame given that the platform chooses wholesale contract and the firm chooses add-on pricing, the firm first sets the wholesale price of the core product w_c^{WA}, then the platform responds by setting the retail price of the core product p_c^{WA}, and then the firm sets the retail price of the add-on p_a^{WA}.
- In the wholesale bundle (*WB*) model, the firm first sets the wholesale price for the bundle w^{WB}, then the platform responds by setting the retail price of the bundle p^{WB}.
- In the agency add-on (*AA*) model, the firm first sets the retail price of the core product p_c^{AA}. The firm then sets the retail price of the add-on p_a^{AA}.
- In the agency bundle (*AB*) model, the firm sets the retail price of the bundle p^{AB}.

Note that, under agency pricing, the platform yields the pricing power to the firm. The platform receives a commission in proportion to the firm's revenue (from the core product only under add-on pricing, and from the bundle under bundling) at a predetermined rate β.

Consumer purchase behavior in stage 4 depends on the firm's add-on strategy. If the firm chooses bundling, consumers simply decide whether or not to purchase the bundle. If the firm chooses add-on pricing, consumers first need to decide whether to purchase the core product. We consider the scenario where consumers do not observe the price of the add-on at the time of core product purchase. This may be due to sequential pricing by the firm: For example, at the time of releasing a new video game title, the publisher may not have decided on the pricing of add-on content. This may also be due to the lack of information transparency: Even if a spa has already posted its prices of add-on treatments in-store, consumers who purchased its basic offerings through a deal site cannot observe these in-store add-on prices until they arrive. Consumers who purchased the core product and have positive utilities of the add-on then observe the add-on price and make add-on purchase decisions.

In one extension, we consider an alternative scenario where, at the time of core product purchase, consumers also observe the price of the add-ons. Our findings show that the main qualitative insights from the base model are robust to this model variation.

We summarize the notations used in this study in Table 1.

Table 1 Parameters and Decision Variables

Symbol	Definition
p_c	Price for core product
p_a	Price for add-on product
p	Price for the bundle product
w_c	Wholesale price for the core product
w	Wholesale price for the bundle product
θ	Consumer's utility from the consumption of core product
θ_a	Consumer's utility from the consumption of add-on product
c_a	Operational cost for providing the add-on service
α	Proportion of consumers who value the add-on (i.e., $\theta_a = v_a \geq 0$)
β	Commission rate that the platform can keep from selling the product

4. Results

Using backward induction, we first analyze the four possible subgames in stage 3, and characterize the firm's choice between add-on pricing and bundling in stage 2. We then study the platform's distribution contract decision in stage 1. We subsequently describe how the interaction between the firm's add-on decision and the platform's distribution decision affects the overall channel profit.

4.1. Firm's Add-on Strategy under the Wholesale Contract

In this subsection, we analyze the firm's stage-2 add-on strategy (i.e., the choice between add-on pricing and bundling) under the wholesale contract. To do so, we will first derive the equilibrium prices and profits for two possible stage-3 subgames: the wholesale add-on model and the wholesale bundle model. Note that, under the wholesale add-on model, the firm can bypass the platform and directly sell the add-on to consumers who have already purchased the core product. The following lemma summarizes equilibrium prices, demands, and profits under the wholesale add-on model.

Lemma 1. *In the wholesale add-on model, the firm and the platform charge wholesale price* $w_c^{WA} = \frac{1}{2}[1 - \alpha(v_a - c_a)]$ *and retail price* $p_c^{WA} = \frac{1}{4}[3 - \alpha(v_a - c_a)]$ *for the core product, respectively. The firm charges* $p_a^{WA} = v_a$ *for the add-on directly to consumers. The corresponding market demand for the core product and the add-on are* $D_c^{WA} = \frac{1}{4}[1 + \alpha(v_a - c_a)]$ *and* $D_a^{WA} = \frac{\alpha}{4}[1 + \alpha(v_a - c_a)]$, *respectively. The firm, platform and system's profits are* $\pi_F^{WA} = \frac{1}{8}[1 + \alpha(v_a - c_a)]^2$, $\pi_p^{WA} = \frac{1}{16}[1 + \alpha(v_a - c_a)]^2$, *and* $\pi_S^{WA} = \frac{3}{16}[1 + \alpha(v_a - c_a)]^2$, *respectively.*

All proofs are in the Online Appendix. For consumers who value the add-on and have already purchased the core product, Lemma 1 shows that the

firm charges a high add-on price $p_a^{WA} = v_a$ to extract the maximum possible amount of surplus from these consumers. A high add-on price is a signature dynamic in the add-on pricing literature: For example, the seminal papers Lal and Matutes (1994) and Gabaix and Laibson (2006) also find that the optimal add-on price equals the maximum add-on valuation. Intuitively, once a consumer purchases the core product, the consumer is locked in to the firm, and thus, the firm has no incentive to leave any add-on surplus to the consumer.[5] We next summarize equilibrium prices, demands, and profits under the wholesale bundle model.

LEMMA 2. *In the wholesale bundle model, the firm and the platform charge wholesale price* $w^{WB} = \frac{1}{2}(1 + \alpha v_a)$ *and retail price* $p^{WB} = \frac{3}{4}(1 + \alpha v_a)$ *for the bundle, respectively. The corresponding market demand is* $D^{WB} = \frac{1}{4}(1 + \alpha v_a)$. *The firm, platform and system's profits are* $\pi_F^{WB} = \frac{1}{8}(1 + \alpha v_a)^2$, $\pi_P^{WB} = \frac{1}{16}(1 + \alpha v_a)^2$, *and* $\pi_S^{WB} = \frac{3}{16}[1 + \alpha v_a]^2$, *respectively.*

For consumers who purchase both the core product and the add-on, it is straightforward from Lemmas 1 and 2 that they pay a lower total price under the wholesale bundle model (i.e., $\frac{3}{4} + \frac{3}{4}\alpha v_a$) than under the wholesale add-on model (i.e., $\frac{3}{4} + v_a - \frac{1}{4}\alpha(v_a - c_a)$). This is because the high-add-on-price strategy under add-on pricing is not applicable under bundling. In other words, bundling limits the firm's ability to pursue a high margin on the add-on. Furthermore, under bundling, the firm has to share revenue over the whole bundle with the platform (as the platform is able to charge a markup over the whole bundle), whereas under add-on pricing the firm keeps all add-on revenue to herself by bypassing the platform. Therefore, from the perspective of firm profitability, both dynamics described above seemed to suggest that add-on pricing would be preferable over bundling. Our next result, surprisingly, shows that the above dynamics are actually dominated and thus do not critically drive the firm's comparison between add-on pricing and bundling under a wholesale distribution contract.

PROPOSITION 1. *Given a wholesale contract, the firm earns a higher profit with bundling than with add-on pricing.*

This result follows a comparison of the firm's profits under the wholesale add-on model (as in Lemma 1) and under the wholesale bundling model (as in Lemma 2). In other words, if the platform chooses the wholesale contract in stage 1, this proposition says that the firm will then optimally choose bundling over add-on pricing in stage 2, despite the fact that add-on pricing enables the firm to bypass the platform.

To understand this result, first note that the firm is able to sell more units of the add-on (i.e., $\frac{1}{4}(1 + \alpha v_a)$) under the wholesale bundle model than under the wholesale add-on model (i.e., $\frac{\alpha}{4}[1 + \alpha(v_a - c_a)]$). A primary reason for this difference in add-on demands is that under bundling, there are $(1 - \alpha)(1 - p^{WB})$ consumers who do not value the add-on yet have a high valuation of the core product; thus, they are still willing to acquire the add-on as a part of the bundle they purchase. In contrast, under add-on pricing, consumers not valuing the add-on never buy the add-on. Also note from Lemmas 1 and 2 that the bundle price p^{WB} under bundling is higher than the core product price p_c^{WA} under add-on pricing. In summary, bundling (as compared to add-on pricing) enables the firm to better price discriminate consumers who both have a high valuation of the core product and do not value the add-on, which we refer to as the *bundling effect* in this research.[6] Proposition 1 proves that, under the wholesale contract, this bundling effect dominates the revenue benefit the firm can obtain from bypassing the platform. Consequently, the firm earns a higher profit with bundling than with add-on pricing.

It is worth noting that Proposition 1 holds under any positive operational cost c_a.[7] With the advancement in automated technologies, such as the adoption of self-check-in terminals in airports, this firm-side operational cost of add-on pricing may decrease in some industries. Nevertheless, as long as it is operationally more cost-effective for a firm to adopt bundling than add-on pricing—even if this cost-effectiveness is small in magnitude—Proposition 1 shows that bundling always strictly dominates add-on pricing in terms of firm profitability under the wholesale distribution contract. We next study the firm's add-on strategy under a different distribution contract: the agency contract.

4.2. Firm's Add-on Strategy under the Agency Contract

We now analyze the firm's stage-2 add-on strategy under the agency contract. Agency contracts have gained popularity along with the rise of the platform economy. To date, the agency contract is widely adopted in the digital publishing industry (Hao and Fan 2014) as well as in the online travel industry (Kelleher 2016). Under the agency contract, the online platform simply serves as a passive agent and retains β proportion of the revenue while the firm keeps the remaining $1 - \beta$ proportion of the revenue. The key characteristic of this distribution contract is that the upstream firm, rather than the downstream platform, sets the retail prices. We will first derive the equilibrium prices and profits for two possible stage-3

subgames: the agency add-on model and the agency bundle model. We then compare these two subgames to determine the firm's optimal choice between add-on pricing and bundling.

LEMMA 3. *In the agency add-on model, the firm charges* $p_c^{AA} = \frac{1}{2}\left[1 - \frac{\alpha(v_a - c_a)}{(1-\beta)}\right]$ *for the core product and* $p_a^{AA} = v_a$ *for the add-on. The corresponding market demand for the core product and the add-on are* $D_c^{AA} = \frac{1}{2}\left[1 + \frac{\alpha(v_a - c_a)}{(1-\beta)}\right]$ *and* $D_a^{AA} = \frac{\alpha}{2}\left[1 + \frac{\alpha(v_a - c_a)}{(1-\beta)}\right]$, *respectively. The firm, platform and system's profits are* $\pi_F^{AA} = \frac{1-\beta}{4}\left[1 + \frac{\alpha(v_a - c_a)}{(1-\beta)}\right]^2$, $\pi_P^{AA} = \frac{\beta}{4} - \frac{\beta}{4}\left[\frac{\alpha(v_a - c_a)}{1-\beta}\right]^2$, *and* $\pi_S^{AA} = \frac{1}{4} + \frac{\alpha(v_a - c_a)}{2} + \frac{1-2\beta}{4} \times \left[\frac{\alpha(v_a - c_a)}{1-\beta}\right]^2$, *respectively.*

Similar to the wholesale add-on model, in the agency add-on model the firm also optimally sets a high add-on price because consumers who purchased the core product are effectively locked in to the firm. A new result in Lemma 3 is that the higher the commission rate that the platform demands (i.e., the higher β is), the lower the price the firm will charge for the core product. Intuitively, a higher β hurts the firm's revenue from the core product. In response, the firm strategically chooses a lower core product price in order to induce more sales of the add-on, bypassing the commission.

Note that our model assumptions $\beta < 1/2$ and $v_a \le 1/3$ together imply that $p_c^{AA} > 0$. Barring these assumptions, our Lemma 3 still qualitatively holds except that p_c^{AA} can potentially hit 0 if $\beta > 1 - \alpha(v_a - c_a)$. That is, it is possible for the firm to offer the core product for free and profit solely from the add-on, a phenomenon prevalent in information products and software. This result of free core product holds when the platform can keep a very high proportion of the revenue (i.e., high value of β) or when the market potential of the add-on is large enough (i.e., high value of $\alpha(v_a - c_a)$).

LEMMA 4. *In the agency bundle model, the firm charges* $p^{AB} = \frac{1}{2}(1 + \alpha v_a)$ *for the bundle. The corresponding market demand is* $D^{AB} = \frac{1}{2}(1 + \alpha v_a)$. *The firm, platform and system's profits are* $\pi_F^{AB} = \frac{1-\beta}{4}(1 + \alpha v_a)^2$, $\pi_P^{AB} = \frac{\beta}{4}(1 + \alpha v_a)^2$, *and* $\pi_S^{AB} = \frac{1}{4}[1 + \alpha v_a]^2$, *respectively.*

Note that the revenue-sharing arrangement under the agency contract—namely, the magnitude of β—does not affect the firm's optimal bundle price p^{AB} in this lemma. Essentially, when the firm has full pricing power and the platform merely takes a fixed proportional cut of the revenue of the bundle, the firm's incentive is aligned with the total profit of the channel. As a result, the firm picks a bundle price that maximizes the channel profit, which is independent of β. We next compare the firm's profits under the agency add-on model and the agency wholesale model.

PROPOSITION 2. *Given an agency contract, the firm earns a higher profit with add-on pricing than with bundling.*

Our finding in Proposition 2 contrasts sharply with the one in Proposition 1: Under a wholesale contract (as in Proposition 1), the firm earns a higher profit with bundling than with add-on pricing; under an agency contract, however, the reverse is true. In other words, the firm's optimal choice between add-on pricing and bundling depends on whether the distribution contract takes the wholesale format or the agency format. To the best of our knowledge, this is the first research in the add-on literature demonstrating that distribution contracts can critically affect a firm's add-on strategy.

To see the intuition of this finding, first note that under add-on pricing the firm faces a trade-off between the revenue from the core product and the revenue from the add-on. A reduction in the price of the core product can reduce the revenue from the core product, yet at the same time, it leads to more sales and thus revenue from the add-on. The intuition hinges on the fact that the firm's cost for price reduction over the core product differs between the wholesale contract and the agency contract. Under the wholesale contract, to reduce the retail price of the core product by one unit, the firm has to reduce its wholesale price by at least the same amount. However, to reduce the retail price by one unit under the agency contract, the firm's share of margin loss is less than one unit, because the platform absorbs a portion of the margin loss equal to the platform's commission rate.[8] For example, if the platform charges 30% commission, to reduce the retail price by \$1, the firm only shoulders \$0.70 of the margin loss. We refer to this dynamic as the *loss-sharing effect*, where the platform shoulders part of the margin loss under the agency contract. Thus, cutting the price of the core product (to subsequently induce more sales of the add-on) is more cost-effective under the agency contract than under the wholesale contract.

A comparison between Lemmas 1 and 3 helps to reveal how the loss-sharing effect impacts the firm's trade-off between core-product revenue and add-on revenue. First, the firm is willing to charge a lower price for the core product and subsequently capture a higher revenue from the add-on, under the agency contract than under the wholesale contract (i.e.,

$p_c^{AA} = \frac{1}{2}\left[1 - \frac{\alpha(v_a - c_a)}{(1-\beta)}\right]$ vs. $w_c^{WA} = \frac{1}{2}[1 - \alpha(v_a - c_a)]$). Second, the higher the commission rate under the agency contract is, the stronger the loss-sharing effect becomes. Consequently, the firm cuts its price of the core product even deeper (as p_c^{AA} decreases in β) in order to capture an even larger revenue from the add-on (as D_a^{AA} increases in β). Overall, the loss-sharing effect positively affects the firm's profit as it keeps all revenue generated from the add-on, yet shares the loss caused by the price cut on the core product with the platform. Under the agency contract, this loss-sharing effect dominates the bundling effect; thus, the firm benefits more from add-on pricing than from bundling.

Note that Proposition 2 holds when the operational cost is not too high (i.e., $c_a \le \beta v_a$ as assumed in the model setup). That is, it is not too expensive for the firm to sell the core product and the add-on separately. Otherwise, the firm would prefer bundling to add-on pricing to avoid the high operational cost of the latter.

The loss-sharing effect is unique to the agency contract, as the gain and loss between the firm and platform are tied together. The commission rate β governs the allocation of the revenue and has important implications on the profitability of both the firm and the platform, which we investigate next.

PROPOSITION 3. *In the agency bundle model, the firm's profit decreases while the platform's profit increases in β. In the agency add-on model, the firm's profit decreases in β. However, there exists a β_P^{AA} such that the platform's profit increases in β for $\beta \in \left(0, \beta_P^{AA}\right)$ and decreases in β for $\beta \in \left(\beta_P^{AA}, 1 - \alpha(v_a - c_a)\right)$.*

β is the proportion that the platform can keep from sales. An increase in this value suggests an additional gain by the platform but an additional loss for the firm. Consistent with this intuition, we find that as β's value increases, the platform's profit improves, while the firm's profit shrinks under the agency bundle model. Similarly, under the agency add-on model, we find that the firm's profit also decreases with the value of β.

Nevertheless and interestingly, the platform's profit is not monotonic in the value of β under the agency add-on model: Profit first increases and then decreases in β. To understand the intuition behind this result, note that there are two opposite dynamics, one direct and one indirect, that drive the platform's profit. First, a higher β directly results in a higher proportional cut of the core-product revenue, which benefits the platform profit. Second, a higher β also results in a stronger loss-sharing effect, which in turn causes the firm to further cut the price of the core product, thus indirectly hurting the platform's profit. Furthermore, this indirect dynamic strengthens when β increases: The firm's rate of price cutting accelerates as β gets larger, that is, $\frac{\partial p_c^{AA}}{\partial \beta} < 0$. Therefore, when β is relatively small (i.e., $\beta \le \beta_P^{AA}$), an increment in β only triggers a mild price cut by the firm, the impact of which on the platform is dominated by the higher proportion of commission collected. When β becomes relatively large (i.e., $\beta > \beta_P^{AA}$); however, the firm gets aggressive in price cutting on the core product (due to the loss-sharing effect), which becomes the dominating dynamic that hurts the platform. As a result, we observe that the platform's profit first increases and then decreases in the commission rate.

4.3. Platform's Choice of the Distribution Contract

We are now ready to analyze the platform's stage-1 strategy over the distribution contract, namely, whether to adopt the wholesale contract or the agency contract. As we have shown in propositions 1 and 2, on one hand, if the platform adopts the wholesale contract, then the firm will respond by choosing bundling. On the other hand, if the platform adopts the agency contract, then the firm will respond by choosing add-on pricing. As a result, the platform's strategy (i.e., wholesale or agency) boils down to the comparison of its profits under two subgames: the wholesale bundle model and the agency add-on model.

To proceed, we will first analyze a special case in which we set $c_a = 0$. This is followed by a discussion on how a positive operational cost c_a influences the findings. Examining this special case offers two benefits. First, it allows us to isolate and highlight how the commission rate β and market potential of add-ons αv_a shape the choice facing the platform. Second, we can leverage the insights derived from the special case to better illustrate the results obtained from the general case. In the following proposition, we summarize the platform's contract choice when the operational cost c_a is negligible. For convenience, define $u_P(\beta) \equiv \left[2\beta(1-\beta)\sqrt{2+\beta} - (1-\beta)^2\right]/(1+\beta)^2$ and $\frac{du_P(\beta)}{d\beta} > 0$.

PROPOSITION 4. *When $c_a = 0$, by comparing the platform's profits under the wholesale bundle model (π_P^{WB}) and the agency add-on model (π_P^{AA}), we have:*

(*i*) *If $\beta \le 1/4$, then $\pi_P^{WB} > \pi_P^{AA}$.*
(*ii*) *If $\beta > 1/4$, then $\pi_P^{WB} > \pi_P^{AA}$ for $\alpha v_a > u_P(\beta)$, and $\pi_P^{WB} \le \pi_P^{AA}$ for $\alpha v_a \le u_P(\beta)$.*

Proposition 4 shows that the platform's choice between wholesale and agency contracts depends critically on two model parameters: the commission rate β and market potential of add-ons αv_a. When the commission rate is relatively small (i.e., $\beta \le \frac{1}{4}$), the platform always prefers the wholesale contract to the

agency contract. This result is intuitive: A low value of β suggests that the platform can only keep a small proportion of the revenue, which discourages the platform from adopting the agency contract.

More interestingly, we find that the platform will not necessarily benefit from the agency contract when the commission rate becomes relatively large (i.e., $\beta > 1/4$). In fact, the platform still favors the wholesale contract when the market potential of add-on products αv_a is large enough (i.e., $\alpha v_a > u_P(\beta)$). To understand this result, note that when the market of the add-on product is lucrative (i.e., when αv_a is large), under add-on pricing the firm will aggressively cut the price of the core product in order to induce higher sales of the add-on product. Also recall that the firm bypasses the platform in add-on sales under add-on pricing. This aggressive price reduction in the core product by the firm dominates the large commission rate in terms of its impacts on the platform's profit under add-on pricing. Consequently, the platform still prefers the wholesale contract in this scenario.

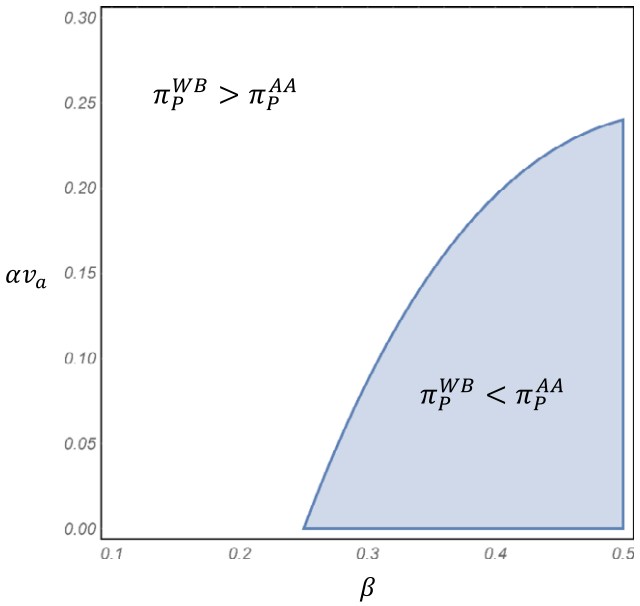
Alternatively, the platform chooses the agency contract over the wholesale contract when the market potential of add-on products αv_a is relatively small to medium (i.e., $\alpha v_a \le u_P(\beta)$). From a practical perspective, we observe that more and more online platforms are switching from wholesale contracts to agency contracts. This is accompanied by the emerging trend of firms implementing the add-on pricing by separating the previously bundled product. For example, leading online travel agency Expedia switched its distribution contract from wholesale to agency in 2012 (Freed 2012, Nielson 2014). Over the same period, an increasing number of hotels have introduced fees for services such as parking and Wi-Fi that were previously provided to the customers free of charge (Trejos 2012). Our results demonstrate that distribution contracts can interact with the firm's add-on strategy, which provides an explanation for the wide acceptance of the agency add-on strategy in today's market. We illustrate the results of Proposition 4 in the following Figure 2, where the highlighted area depicts the region in which the platform prefers the agency contract over the wholesale contract.

Next, we discuss the impact of a positive operational cost c_a on platform's choice of distribution contract. We summarize the results in the following proposition.

PROPOSITION 5. *A positive value of operational cost, as compared to no operational cost, makes the platform more inclined to choose the agency contract.*

The firm's margin on each unit of the add-on sold is $v_a - c_a$, which decreases in c_a. Therefore, when c_a increases under add-on pricing, the firm's trade-off between the revenue from the core product and the revenue from the add-on tilts more toward the former. Consequently, a higher c_a implies that the firm will be less aggressive in cutting the price of the core product, which in turn benefits the platform more.

Figure 2 Illustration of Platform's Decision on the Distribution Contract [Color figure can be viewed at wileyonlinelibrary.com]



4.4. Channel Performance

We now turn our attention to the influence of the interaction between the add-on strategy and the distribution contract on channel performance. We address two questions. First, is it possible for this interaction to coordinate the channel in terms of total channel profit? Here, we use the first-best solution (i.e., the profit under a vertically integrated channel) as a benchmark. Second, how does the commission rate affect the channel performance? In particular, what values of the commission rate are most beneficial to the channel members? We highlight our findings regarding the first question in the following proposition.

PROPOSITION 6. *The agency bundle model will coordinate the supply chain and lead to the first-best channel profit. The wholesale bundle and agency add-on strategies, however, are sub-optimal for the channel performance.*

Proposition 6 shows that the agency bundle model matches the channel performance of a vertically integrated supply chain. It is well known that if both the firm and the platform are risk neutral and maximize their individual profits, double marginalization will prevail under a wholesale contract, which leads to

channel inefficiency. In the agency bundle model, however, the firm and platform are "virtually" vertically integrated, where the friction between the parties is resolved through the alignment of interest.

More importantly, Proposition 6 illustrates that the interaction between add-on pricing and distribution contracts will actually lead to a profit loss for the channel, as only the wholesale bundle and agency add-on strategies are possible in equilibrium. This result is new to the literature and has important practical implications as it demonstrates the influence of channel structure on add-on pricing. In the wholesale bundle model, it is clear that the double marginalization effect causes the channel performance to be suboptimal. In the agency add-on model, although the agency contract tends to mitigate the double marginalization effect and add-on pricing improves the firm's price discrimination, the combination of these two phenomena does not resolve the channel inefficiency. The root cause is again the loss-sharing effect: The firm tends to set the core product price low to lure more customers to purchase the add-on, which in turn results in the inefficiency of channel performance.

Collectively, the above results demonstrate that the interaction between add-on pricing and distribution contracts plays a critical role in channel performance. More specifically, it will lead to the inefficiency of the supply chain performance. Thus, one natural and intriguing question arises. What should be an appropriate commission rate to improve channel performance? The answer to this question will not only be theoretically interesting but also provide practical guidance to the managers in the relevant industries. We summarize our finding in the following proposition.

PROPOSITION 7. *When the operational cost c_a is relatively small, there exists a Pareto-improvement region of β such that both firm and platform profits are higher under the agency add-on model than under the wholesale bundle model.*

We reach this result by comparing both firm and platform profits under the wholesale bundle model and the agency add-on model. Although the agency contract can potentially improve channel performance by reducing double marginalization, it also needs to balance the allocation such that the channel improvement can pass to both platform and firm. Interestingly, we find that as long as the operational cost c_a is relatively small, a carefully chosen β value under the agency add-on model will lead to higher profits for both the firm and the platform (as compared to the wholesale bundle model). Consequently, the overall channel performance also improves. We illustrate this result in the following Figure 3 with different values of αc_a.

From the above figure, we observe that this Pareto-improvement region exists if (1) the commission rate β is not too small, (2) the market potential αv_a for the add-on is not too large, and (3) αv_a is not too small. The first two conditions together ensure that the platform is better off with agency add-on than with wholesale bundle: Condition 1 means the platform receives a sizeable share of the channel revenue from the sales of the core product, and condition 2 ensures that the firm does not aggressively cut the price of the core product. Condition 3 is necessary for the firm to be better off with agency add-on than with wholesale bundle, as otherwise the market potential of the add-on is too small to generate enough revenue for the firm.

A comparison between the three plots in Figure 3 also reveals that, as the operational cost of add-on pricing c_a increases, the size of this Pareto-improvement region shrinks. This is intuitive as a higher c_a directly reduces the margin the firm can collect from each sale of the add-on, which in turn reduces the total channel profit under the agency add-on model.

This result has interesting implications for channel performance and also reveals important managerial implications to guide firms and platforms to choose an appropriate commission rate under the agency add-on model. From a practical point of view, the valuation of the add-on product is determined mainly by the characteristic of the product itself, while the commission rate is often set through negotiation between firms and platforms. Our results suggest that a wide range of parameters exist which benefit both firms and platforms.

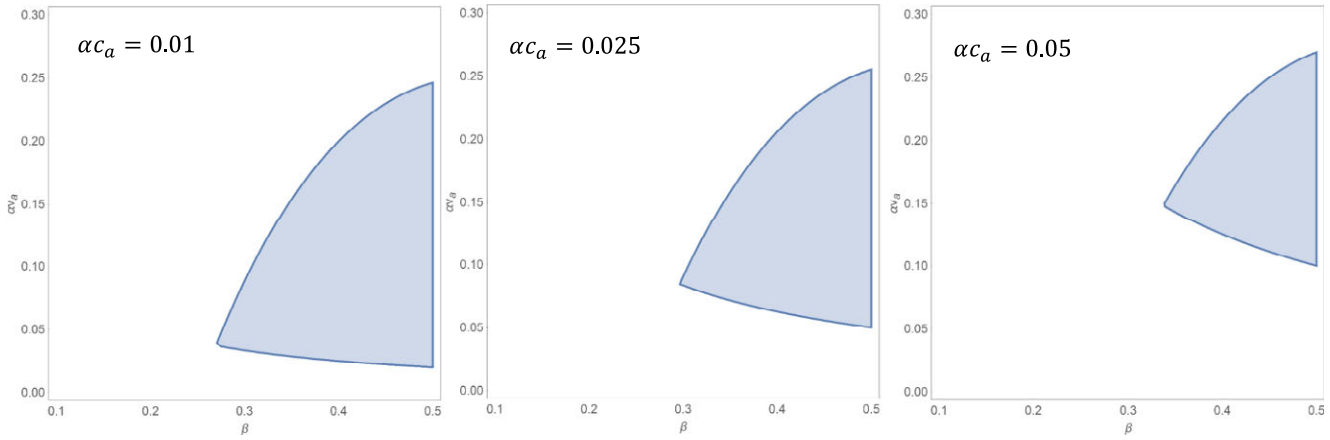
5. Extensions

In this section, we extend our base model in four directions. To begin with, we consider an alternative timing scenario, where consumers are aware of the add-on price during their core product purchase. In the second extension, we consider the possibility of a correlation (either positive or negative) between core product valuation and add-on valuation. In the third extension, we consider the scenario that the online platform takes a proportion of the revenue from the add-on sales. In the fourth extension, we consider two platforms competing for the business of the upstream firm. We illustrate that our main results from the base model are robust to these alternative model specifications.

5.1. Alternative Timing Structure

In our base model, consumers decide on core product purchase before observing the add-on price. Here, we consider an alternative timing scenario, where

Figure 3 Illustration of Pareto-Improvement Region [Color figure can be viewed at wileyonlinelibrary.com]



consumers are aware of the add-on price during their core product purchase. That is, consumers know and explicitly account for the add-on price in their core product purchase decision (Geng and Shulman 2015). There are several practical scenarios where this timing structure applies. For example, online platforms may publicize the add-on price explicitly, such as specifying a hotel's Internet fee when consumers book rooms, or consumers may be aware of the add-on price due to prior shopping experience.

To proceed, we will first analyze the equilibrium prices and profits for both wholesale add-on model and agency add-on model. Note that this model extension does not affect any result under bundling.

LEMMA 5. *Under this alternative timing, and in the wholesale add-on model, the firm charges wholesale price* $w_c^{WA} = \frac{1}{2}$ *for the core product, and retail price* $p_a^{WA} = \frac{1}{2}(v_a + c_a)$ *for the add-on. The platform charges retail price* $p_c^{WA} = \frac{1}{4}[3 + \alpha(v_a - c_a)]$ *for the core product. The corresponding market demand for core product and the add-on are* $D_c^{WA} = \frac{1}{4}[1 + \alpha(v_a - c_a)]$ *and* $D_a^{WA} = \frac{\alpha}{4}[1 + (2 - \alpha)(v_a - c_a)]$, *respectively. The firm and platform's profits are* $\pi_F^{WA} = \frac{1}{8}[1 + 2\alpha(v_a - c_a) + \alpha(2 - \alpha)(v_a - c_a)^2]$ *and* $\pi_I^{WA} = \frac{1}{16}[1 + \alpha(v_a - c_a)]^2$, *respectively.*

Lemma 5 shows that the firm will charge add-on price $p_a^{WA} = \frac{1}{2}(v_a + c_a)$ when consumers are aware of the add-on price during their core product purchase. In contrast, in our base model the firm charges a higher add-on price $p_a^{WA} = v_a$ (recall Lemma 1). Essentially, in the base model, once a consumer purchases the core product, the consumer is locked in to the firm, and thus, the firm has no incentive to leave any add-on surplus to the consumer. Under the alternative timing in this extension, however, consumers will factor in the observed add-on price in their decision regarding the core product purchase; a higher observed add-on price implies a lower demand for the core product. Consequently, the firm chooses to charge a relatively low add-on price to achieve a balance between profit margin and demand. Further, we note that the firm charges a higher wholesale price for the core product to compensate for the loss from the lower add-on price. This in turn triggers the platform to charge a higher retail price for the core product. Overall, we find that, under this alternative timing, the firm is better off from a higher margin of the core product while the platform keeps the same amount of profit, as compared to our base model. We next summarize equilibrium prices, demands, and profits under the agency add-on model.

LEMMA 6. *Under this alternative timing, and in the agency add-on model, there are two cases:*

Case 1: If $\alpha < \frac{(1-\beta)(2v_a - 2c_a - \beta)}{(2-\beta)(v_a - c_a)}$, *then the core product price* $p_c^* = \frac{2(1-\alpha-\beta)+\alpha\beta(1-v_a+c_a)}{4(1-\beta)-\alpha(2-\beta)^2}$ *and the add-on price* $p_a^* = \frac{2(1-\beta)(1+v_a+c_a)-(2-\beta)(1-\beta)(1+\alpha v_a)-(2-\beta)\alpha c_a}{4(1-\beta)-\alpha(2-\beta)^2} < v_a$. *The demand for the add-on is* $D_a = \alpha\left(1 - p_c^* + v_a - p_a^*\right)$, *and the demand for the core product is* $D_c = 1 - p_c^* + \alpha\left(v_a - p_a^*\right)$. *The firm's profit* $\pi_F^{AA} = (1-\beta)p_c^* D_c + \left(p_a^* - c_a\right)D_a$, *the platform's profit* $\pi_P^{AA} = \beta p_c^* D_c$, *and the system's profit* $\pi_S^{AA} = p_c^* D_c + \left(p_a^* - c_a\right)D_a$.

Case 2: If $\alpha \geq \frac{(1-\beta)(2v_a - 2c_a - \beta)}{(2-\beta)(v_a - c_a)}$, *then* $p_a^* = v_a$, *and the result is the same as that in Lemma 3.*

Unlike under Lemma 5 where the retail price of the add-on is always lower than v_a, Case 2 in Lemma 6 shows that under the agency contract, the firm may still charge the maximum add-on price v_a even though doing so hurts its sales of the core product. The loss-sharing effect drives this result: Intuitively, each sale of the core product is less valuable to the firm under an agency contract than under a wholesale

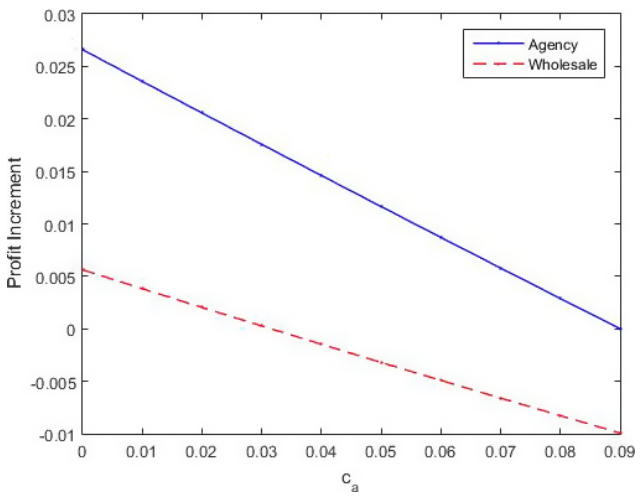
contract because the platform takes away a share of the core-product revenue under the agency contract. Consequently, the firm is more aggressive in cutting the core product price and raising the add-on price under the agency contract.

Case 1 in Lemma 6 represents the interior solution where the add-on price is not set to its upper bound v_a. This is the case when only a small proportion of consumers value the add-on (i.e., $\alpha < \frac{(1-\beta)(2v_a-2c_a-\beta)}{(2-\beta)(v_a-c_a)}$); thus, the strategy of aggressively cutting core price and raising add-on price will not lead to a significant increase in add-on revenue.

Next, we analyze the impact of this alternative timing structure on firm and platform strategies. Due to the complexity of the equilibrium results, we resort to a numerical study, which allows the main insights to take center stage rather than the technical complexities inherent to this alternative timing structure. Our objective here is to examine whether this alternative timing structure affects the key insight in our base model that add-on pricing synergizes better with the agency contract than the wholesale contract. To do so, for each of the contracts we numerically calculate the difference between the firm's profits under add-on pricing and bundling. We refer to this difference as the *profit increment*. For a given distribution contract, if the profit increment is positive, the firm then prefers add-on pricing. Figure 4 below provides a representative illustration of the profit increment under agency and wholesale contracts, respectively. We used parameter values $\alpha = 0.5$, $\beta = 0.3$, and $v_a = 0.3$ in this plot. We also tried a wide variety of parameter values for this plot, and the results are robust to the different parameter values.

In Figure 4, we observe that the profit increment under the agency contract (the blue line) is above the profit increment under the wholesale contract (the red dotted line). This numerical study thus confirms that our key insight in the base model, that is, that add-on pricing is more attractive to the firm (as compared to bundling) under the agency contract than under the wholesale contract, continues to hold in this model extension. Furthermore, Figure 4 clearly illustrates that there exists a range of values for c_a under which the profit increment is positive under the agency contract and negative under the wholesale contract. In other words, within this range of values for c_a, the firm will choose bundling under the wholesale contract but will choose add-on pricing under the agency contract, a result qualitatively in line with our propositions 1 and 2 under the base model.

Figure 4 Profit Increment under Agency and Wholesale Contracts [Color figure can be viewed at wileyonlinelibrary.com]



5.2. Correlation between Core Product Valuation and Add-on Valuation

In our base model, we treated core product valuation and add-on valuation as two independent variables. One may argue that a customer who values the core product more tends to also value the add-on more, or alternatively, less, which corresponds to the positive and negative correlation cases, respectively.[9] We analyze both cases of correlated valuations in this extension. To capture the heterogeneity among consumers, we still assume that α proportion of the consumers value the add-on while the remaining consumers do not. For consumers who value the add-on, we allow their valuation of the add-on to take the form of $v_a + k\theta$, where the correlation strength k can take both positive and negative values. Recall that θ is a uniformly distributed random variable representing a consumer's valuation of the core product. Therefore, the above new form of add-on valuation immediately implies that the valuations of the add-on and the core products are correlated. In particular, if $k > 0$ $(k < 0)$, they are positively (negatively) correlated. All other model parameters remain the same as in the base model.

We next present the results of positive correlation and negative correlation separately. This is because the derivations for positive correlation and negative correlation are quite different. Specifically, the negative correlation case will significantly alter consumer behavior so that high valuation consumers may no longer purchase the add-on as in the positive correlation case.

5.2.1. Positive Correlation. We first consider the case where core product valuation and add-on valuation are positively correlated (a consumer who values the core product more also values the add-on more). For example, it is reasonable to argue that a business traveler who is willing to pay more for a flight ticket (i.e., core product) is also likely to be willing to pay more for expedited check-in (i.e., add-on). We

characterize the equilibrium results first under the wholesale contract then under the agency contract.

PROPOSITION 8. *Given a wholesale contract and positive correlation between add-on valuation and core product valuation, we have:*

(*i*) *If* $k<\hat{k}(c_a)$*, the firm earns a higher profit with bundling than with add-on pricing.*
(*ii*) *If* $k > \hat{k}(c_a)$*, the firm earns a higher profit with add-on pricing than with bundling.*

As shown in the proof of this proposition, $\hat{k}(c_a)$ is defined as the threshold value that equals the firm profit under bundling with that under add-on pricing. $\hat{k}(c_a)$ is positive and increases in c_a. Part (i) of this proposition demonstrates the robustness of our base finding: As long as the correlation strength k is small, the firm prefers bundling over add-on pricing under the wholesale contract, similar to Proposition 1.

Part (ii) of this proposition contributes a new insight: When the correlation is positive and k is large, the firm can actually earn a higher profit with add-on pricing under the wholesale contract. Intuitively, under the positive correlation scenario, consumers who purchase the core product on average have a higher valuation of the add-on than consumers who do not. This allows the firm to charge a higher add-on price than that under no correlation. The higher the correlation strength, the higher the add-on price the firm can impose, and the more consumer surplus it extracts. Consequently, when the correlation strength is large enough, that is, $k > \hat{k}(c_a)$, this benefit of add-on pricing due to correlation dominates the bundling benefit for the firm. We next consider positive correlation under the agency contract.

PROPOSITION 9. *Given an agency contract and positive correlation between add-on valuation and core product valuation, when the operational cost is not too large* ($c_a<\beta v_a$)*, the firm earns a higher profit with add-on pricing than with bundling. The profit difference between add-on and bundling increases in the correlation strength* k *but decreases in the operational cost* c_a*.*

Similar to Proposition 2, we find that the firm prefers add-on to bundling under the agency contract when there is positive correlation. This result is in line with the expectation that the firm can further leverage the positive correlation to charge a higher price for the add-on to generate higher profits under add-on pricing. Further, our results also reveal that the benefit of the add-on pricing is strengthened with the increase in the correlation strength but weakened with the surge of the operational cost of the add-on.

5.2.2. Negative Correlation. Next, we consider the case where core product valuation and add-on valuation are negatively correlated. For instance, a consumer who has already paid for basic software may be reluctant to purchase optional content. To avoid a trivial case where the firm offers the add-on at zero price under add-on pricing (which essentially becomes bundling), in the following analysis, we impose condition $|k| \le v_a - c_a$.

PROPOSITION 10. *Given a wholesale contract and negative correlation between add-on valuation and core product valuation, the firm earns a higher profit with bundling than with add-on pricing.*

Proposition 10 is consistent with Proposition 1, where the firm can earn a higher profit with bundling than add-on under the wholesale contract. To understand this result, note that when the correlation between core product and add-on is negative, compared with add-on pricing, bundling is more effective in reducing valuation heterogeneity among consumers. As a result, under the wholesale contract, the firm prefers bundling to add-on even more when the correlation strength is negative.

PROPOSITION 11. *Given an agency contract and negative correlation between add-on valuation and core product valuation, we have:*

(*i*) *If* $|k|<v_a-\frac{c_a}{\beta}$*, the firm earns a higher profit with add-on pricing than with bundling.*
(*ii*) *If* $|k| > v_a-\frac{c_a}{\beta}$*, the firm earns a higher profit with bundling than with add-on pricing.*

This finding is consistent with Proposition 2 in that, when the magnitude of the correlation strength is not too large, the firm earns a higher profit under add-on pricing than under bundling in the agency contract. Interestingly, our result also reveals that, with negative correlation and when $|k|$ is large enough, bundling can dominate add-on pricing under the agency contract (even if the operational cost of add-on pricing is low). Essentially, the intuition hinges on the role of negative correlation, which can synergize with bundle pricing. Specifically, negative correlation implies that, under add-on pricing, consumers who have high valuations of the core product will be less likely to purchase the add-on. Bundling, however, can "force" such consumers to purchase the add-on as long as their valuation of the whole bundle is higher than the bundle price.

In summary, we find that when the correlation strength between the core product and add-on is not too large, the upstream firm is better off with bundling under a wholesale contract and is better off with add-on pricing under the agency contract. This

demonstrates the robustness of our base model. Further, our analysis reveals that positive correlation can synergize with add-on pricing, which allows the firm to extract the revenue from the add-on; on the other hand, negative correlation is better allied with bundling, which can benefit the firm due to the reduction of valuation heterogeneity.

5.3. Add-on through the Online Platform

In this extension, we consider the scenario where the platform, in addition to receiving a commission from the sales of the core product as discussed earlier, can take a proportion of the add-on revenue as well. This is a reasonable assumption in some practical situations. For example, in online app markets such as Apple App Store and Google Play Store, app developers have to distribute both their core product (i.e., game app) and add-on (i.e., in-app product) through the online markets and are required to share both core product revenue and add-on revenue with the markets.[10] To accommodate this possibility, in this extension, we assume that the platform can keep μ proportion of the add-on revenue. Furthermore, to reflect the reality that the platform typically charges a lower rate for add-on (e.g., Apple charges 30% of app purchase revenue and 15% of in-app purchase revenue after a year), we assume $\mu \le \beta$ without loss of generality. The following lemma summarizes equilibrium prices, demands, and profits under the agency add-on model where the firm must sell add-on products through the online platform.

LEMMA 7. *In the agency add-on model, the firm charges* $p_c^{AA} = \frac{1}{2} - \frac{\alpha[(1-\mu)v_a - c_a]}{2(1-\beta)}$ *for the core product and* $p_a^{AA} = v_a$ *for the add-on. The corresponding market demand for the core product and the add-on are* $D_c^{AA} = \frac{1}{2} + \frac{\alpha[(1-\mu)v_a - c_a]}{2(1-\beta)}$ *and* $D_a^{AA} = \frac{\alpha}{2}\left\{1 + \frac{\alpha[(1-\mu)v_a - c_a]}{(1-\beta)}\right\}$, *respectively. The firm, platform and system's profits are* $\pi_F^{AA} = \frac{1-\beta}{4} \times \left\{1 + \frac{\alpha[(1-\mu)v_a - c_a]}{(1-\beta)}\right\}^2$, $\pi_P^{AA} = \frac{\beta}{4} - \frac{\beta}{4}\frac{\alpha^2[(1-\mu)v_a - c_a]^2}{(1-\beta)^2} + \alpha\mu v_a \frac{1}{2}(1 + \frac{\alpha[(1-\mu)v_a - c_a]}{1-\beta})$, *and* $\pi_S^{AA} = \frac{1}{4} + \frac{1}{2}\alpha[(1-\mu)v_a - c_a] + \frac{1-2\beta}{4}\frac{\alpha^2[(1-\mu)v_a - c_a]^2}{(1-\beta)^2} + \frac{\alpha\mu v_a}{2}(1 + \frac{\alpha[(1-\mu)v_a - c_a]}{1-\beta})$, *respectively.*

It is interesting to explore how the firm responds to the platform's cut of add-on revenue. In Proposition 12, we compare the agency bundle model with the agency add-on model when the platform can charge a proportion of the add-on revenue.

PROPOSITION 12. *Given an agency contract and the platform can keep* μ *proportion of add-on revenue, the firm earns a higher profit with add-on pricing than with bundling if* $(\beta - \mu)v_a > c_a$, *otherwise the firm earns a higher profit with bundling than with add-on pricing.*

Proposition 12 shows that when the operational cost for providing the add-on is relatively low (i.e., $(\beta - \mu)v_a > c_a$), the result from our base model still applies. That is, the firm earns a higher profit under the agency add-on model than that under the agency bundle model even as the platform takes a proportion of the add-on revenue. Moreover, when the operational cost for providing add-ons is relatively high (i.e., $(\beta - \mu)v_a \le c_a$), instead of selling the add-on separately, the firm prefers to sell the add-on as a part of a bundle to avoid this operational cost.

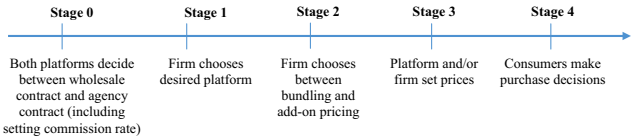
Compared with the case when the firm can sell the add-on directly to consumers, we find that the firm is more likely to adopt bundling than add-on pricing when the firm must sell the add-on through the online platform. Specifically, the threshold for the firm to choose add-on pricing is $c_a < \beta v_a$ in the base model, while the threshold becomes $c_a < (\beta - \mu)v_a$ in this alternative setting. To see the intuition of this finding, first recall that in the base model, the firm can keep all revenue from the add-on sales. Consequently, the firm has strong incentive to cut down the core product price in order to capture a larger revenue of the add-on product (i.e., loss-sharing effect). However, when the platform can take a proportion of the add-on revenue, it weakens the incentive for the firm to cut the core-product price to attract add-on sales (i.e., weakened loss-sharing effect). As a result, we find that the firm is more likely to adopt bundling instead of add-on pricing when the online platform takes a cut of the add-on revenue.

5.4. Platform Competition

In our base model, we consider a setting of a single platform. With the rise of the platform economy, there are examples where several online platforms compete for the exclusive business of a single firm. For example, China's leading e-commerce websites, JD.com and Alibaba.com, recently pressed many merchants to sign exclusive deals with them (Pan 2017). Thus, it is interesting to explore the impact of platform competition on firm strategy.[11] Specifically, we consider a setting with two competing platforms, P1 and P2, and a single firm. The timing of this alternative setting is illustrated in Figure 5.

To capture platform competition, in this extension we allow any platform that chooses the agency contract to first endogenously set its own commission rate.[12] We assume that the reservation profits for platforms P1 and P2 are $\underline{\pi}_{P1}$ and $\underline{\pi}_{P2}$, respectively. Without loss of generality, let $0 \le \underline{\pi}_{P1} \le \underline{\pi}_{P2}$. To avoid trivial

Figure 5 Timeline of the Model with Platform Competition [Color figure can be viewed at wileyonlinelibrary.com]



cases where the platforms choose not to enter the market, we assume that these reservation profits are smaller than any of the platform profits listed in Lemmas 1 to 4.

Given the contractual choices by both platforms in stage 0, there are four possible subgames: both platforms adopt wholesale, P1 adopts wholesale and P2 adopts agency, P1 adopts agency and P2 adopts wholesale, and both platforms adopt agency. Our next finding shows that, in equilibrium, the only surviving subgame is for both platforms to adopt agency contracts. For ease of exposition, we define $\beta_1(\pi)$ as the β value such that $\pi_P^{AA}(\beta) = \pi$ with π_P^{AA} defined in Lemma 3 (we discuss the details regarding $\beta_1(\pi)$ in the proof of Proposition 13).

PROPOSITION 13. *Consider the case with two competing platforms, P1 and P2. In stage 0, both platforms choose agency contracts, and platform P1 offers a commission rate of* $\beta = \beta_1(\underline{\pi}_{P2})$. *In stage 1, the firm chooses platform P1 and earns a higher profit with add-on pricing than with bundling.*

To understand why both platforms will adopt agency contracts under competition, it helps for us to first see what happens if a platform adopts the wholesale contract. Suppose, for a moment, that platform i ($i \in \{1,2\}$) adopts the wholesale contract in stage 0 and that the firm chooses to contract with platform i in stage 1. It immediately follows that the subsequent interaction between the firm and platform i is identical to the one analyzed in subsection 4.1—note that, from stage 2 on, the game sequences (and thus the subgame-perfect equilibrium analysis) are identical between Figures 5 and 1. From Proposition 1, we know that the firm will optimally choose bundling, and from Lemma 2, we know that the profits for the firm and platform i are $\pi_F^{WB} = \frac{1}{8}(1+\alpha v_a)^2$ and $\pi_P^{WB} = \frac{1}{16}(1+\alpha v_a)^2$, respectively.

Now consider the strategy of platform i's competitor, which we denote as platform j ($j \in \{1,2\}$ and $j \neq i$). If j also adopts the wholesale contract, the firm then receives the same profit regardless of which platform to choose. The firm thus randomly picks a platform; therefore, each platform's expected payoff is $\pi_P^{WB}/2$. If j instead adopts the agency contract, and if the firm chooses j, from Proposition 2, we know the firm will adopt add-on pricing, and from Lemma 3, we know the firm receives a profit of $\pi_F^{AA} = \frac{1-\beta}{4}\left[1+\frac{\alpha(v_a-c_a)}{(1-\beta)}\right]^2$ and the platform receives a profit of $\pi_P^{AA} = \frac{\beta}{4} - \frac{\beta}{4}\left[\frac{\alpha(v_a-c_a)}{1-\beta}\right]^2$. Note that

$$\pi_F^{AA} > \frac{1-\beta}{4}\left[1+\frac{\alpha(v_a-\beta v_a)}{(1-\beta)}\right]^2 = \frac{1-\beta}{4}(1+\alpha v_a)^2 > \frac{1}{8}(1+\alpha v_a)^2 = \pi_F^{WB}.$$

Therefore, given that platform i chooses the wholesale contract, platform j can for sure win the firm over by offering an agency contract (regardless of the value of β as long as $\beta < 1/2$). Moreover, platform j itself also benefits more from adopting the agency contract than from adopting the wholesale contract because $\pi_P^{AA}(\beta_P^{AA}) > \pi_P^{WB}/2$, as shown in the proof of this proposition. In summary, in equilibrium no platform will adopt the wholesale contract because the other platform will then adopt the agency contract, and the firm will always contract with the latter platform.

As both platforms adopt agency contracts in equilibrium, they essentially engage in a Bertrand competition that drives both commission rates down until one platform drops out: because $\underline{\pi}_{P1} \leq \underline{\pi}_{P2}$, P1 can drive P2 out by setting its commission rate at $\beta_1(\underline{\pi}_{P2})$.[13] In general, this Bertrand competition lowers the winning platform's commission rate and thus benefits the upstream firm.

Once the firm chooses P1, the rest dynamics are the same as that analyzed in subsection 4.2, and thus, the firm benefits more from add-on pricing than from bundling, a result consistent with Proposition 2.

To summarize, considering competing platforms does not change the core insight of our base model that add-on pricing dominates bundling in terms of firm profit given an agency contract. This again confirms the robustness of our base model. In addition, this extension of competing platforms also leads to a new finding: Using the commission rate as a competition tool, a platform can undercut its competitor, thus resulting in an equilibrium where both platforms adopt agency contracts. This competition results in a lower commission rate, thus benefiting the firm.

6. Managerial Implications and Concluding Remarks

This paper is the first study on the interaction between add-on strategy and distribution contract. A key issue considered is whether and how an online platform's choice of distribution contract (agency or wholesale) affects an upstream firm's preference between add-on pricing and bundling. We show that

under the wholesale contract, the firm prefers bundling because bundling enables the firm to better price discriminate consumers. Under the agency contract, however, the firm prefers add-on pricing. Our research shows that this result is driven by a loss-sharing effect that is unique to add-on pricing under the agency contract: The firm has incentive to cut the price of the core product to boost the sales of the add-on, and this incentive is strengthened by the agency contract, under which the platform shoulders part of the cost of the firm's price reduction.

The finding that an upstream firm's adoption of add-on pricing goes along with a downstream platform's adoption of the agency contract is consistent with recent developments in business. In recent years, many prominent online platforms in various industries have started to embrace the agency contract. Examples include Expedia and Priceline in the travel industry, Groupon and LivingSocial in online sales promotion, and Amazon in online retailing. At the same time, many firms that often depend on these platforms to reach consumers are increasingly resorting to add-on pricing. As Nancy Trejos from USA Today puts it, "At many properties across the country, fees are being charged for parking, early departures, faxes, in-room safes, mini-bar restocking, housekeeping and bellman services, Wi-Fi and even luggage storage" (Trejos 2012). Our research provides the first theoretical evidence that the simultaneous rise of both add-on pricing and agency contracts may not be coincidental. Rather, upstream firms and downstream platforms may have taken their strategic interactions with each other into consideration when making their respective adoption decisions.

Our research also cautions online platforms against charging too high of a commission rate. We find that if the commission rate is too high, the loss-sharing effect becomes so strong that the firm will aggressively cut its price of the core product, eventually leading to dwindling revenue for the platform.

We also consider whether the online platform should adopt the agency contract or the wholesale contract, given the firm's strategy over add-on pricing and bundling. Our research provides two scenarios in when the agency contract is preferable. First, the commission rate cannot be too low. Second, the market potential of the add-on, as measured by the sum of add-on valuation among all consumers, cannot be too large. This second guideline is unique to the agency contract literature and is managerially relevant to platforms that host firms that practice add-on pricing.

Our research also has implications for industrial trade associations and policymakers with interest in overall channel performance. One prominent finding is that the interaction between add-on pricing and distribution contracts leads to sub-optimal channel performance: The channel suffers from double marginalization under the wholesale contract and suffers from the loss-sharing effect under the agency contract. Furthermore, the agency contract may Pareto-dominate the wholesale contract in terms of both firm and platform profits when the commission rate is not too low.

We briefly note a few limitations of this study and provide some ideas for future research. To begin with, we have treated the firm's decision of revealing the add-on price as exogenous. Future research can explore the impact of endogenizing the decision of whether or not to reveal the add-on price before consumers decide on core product purchase. Second, we have adopted the assumption that the upstream firm must sell the core product through the online platform. It may be interesting to investigate the possibility of the firm selling directly to consumers and compare it with selling through a platform. Third, this research considers only two contractual forms (wholesale and agency). How other forms of supply chain contracts interact with add-on pricing is an interesting direction for exploration. Notwithstanding these limitations, the current study presents a first step in understanding how add-on pricing interacts with the distribution contract, and contributes to the burgeoning research directions on online platforms and on the pricing of add-on products.

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Notes

[1]There are several interchangeable terms for the commission rate depending on different contexts, such as revenue-sharing proportion, referral fee, and transaction fee.
[2]Strictly speaking, this is the consumer utility of the add-on *conditional on core-product purchase*, as without the core product the add-on is usually useless for consumers. In other words, this utility is inclusive of any complementarity that the core product spills over onto the add-on.
[3]That said, for the completeness of analysis, we provide a concise discussion of the case $c_a \geq \beta v_a$ in Appendix N.
[4]Information from http://join.booking.com/faq.html (accessed date November 3, 2016).
[5]This result holds if the consumer cannot observe the add-on price *prior* to her purchase of the core product, as we assumed in the model. In Section 5, we relax this assumption.

[6]Our intuition that bundling can serve as a better tool for price discrimination (as compared to unbundling) is consistent with prior work in the bundling literature, such as the seminal papers Adams and Yellen (1976) and Schmalensee (1984).
[7]If the firm does not incur any operational cost when implementing add-on pricing, that is, if $c_a = 0$, the firm will earn the same profit under bundling and add-on pricing.
[8]Interestingly, while prior research often focuses on how a platform gains from agency pricing, little attention has been paid to the fact that a platform also loses when its member firms cut prices.
[9]We thank the SE and the three anonymous referees for suggesting this interesting research direction that both strengthens the applicability of the model and enriches our findings.
[10]We thank an anonymous referee who suggested this extension and provided relevant examples.
[11]We thank the anonymous review team who encouraged us to explore this interesting direction.
[12]While we do not explicitly model endogenous commission rate in the base model, it is straightforward from propositions 2 and 3 that, if the commission rate is endogenous, the firm will choose add-on pricing should the platform choose the agency contract, and accordingly the monopolistic platform should set its commission rate optimally at β_P^{AA} (as specified in Proposition 3).
[13]Strictly speaking, P1's commission rate is infinitesimally smaller than $\beta_1(\underline{\pi}_{P2})$, so the firm strictly prefers P1.

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Supporting Information

Additional supporting information may be found online in the supporting information tab for this article:

Appendix S1. Proofs.