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Consumer Mental Accounts and Implications to Selling Base Products and Add-ons

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Firms in a variety of industries offer add-on products to consumers who have previously purchased a base product. We posit that consumers, in making their decisions as to whether to purchase add-ons that complement the base products, find a greater need for the value offered by the add-ons when the "unrecovered" value (i.e., price paid minus the benefits obtained so far) associated with the base products is higher. We conduct experiments that test the proposed hypothesis and examine the strategic implications of such consumer decision making to a firm that sells base product add-on pairs.

Consistent with our hypothesis, the experiments show that a consumer's unrecovered value associated with the base product is positively correlated to his likelihood of purchasing the add-on. Formal modeling of this bias shows that firms may find penetration pricing strategies (such as loss leader pricing) suboptimal. Furthermore, the identified bias leads the firm to spend more resources toward enhancing both the base product and the add-on quality, especially so when the add-on will be offered before the consumer has a chance to extensively use the base product. Finally, the effect of competition in the base product market is also considered.

Key words: consumer behavior; pricing; behavioral decision theory; lab experiments; mental accounting
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1. Introduction

Firms in a variety of different industries sell add-on products or features that enhance the value of a base product. For instance, electronic equipment retailers frequently offer a wide range of accessories, such as carrying cases and memory cards, to consumers who purchase digital cameras or laptop computers. In the travel industry, hotel rates or airline ticket prices almost never include add-on services such as meals, alcoholic beverages, or different forms of entertainment, all of which are typically priced and sold separately.

In each of these examples, selling the add-on allows the firm to segment the market, as these "optional" features (from the add-on) may be valued only by a fraction of the overall market. The contingent nature of the demand for the add-on—namely, the fact that *only* those consumers who purchased the base product are potential consumers for the associated add-ons (see Mahajan and Peterson 1978)—implies that the price charged by a firm for a base product will influence the size of the potential pool of customers for the add-on. This aspect, needless to say, makes the pricing of and sales decision for the base product very important for a firm that wants to *jointly maximize* the profits from the base product and the add-on.

A common pricing practice in some industries that sell such product pairs is to set the price of the base product at a sufficiently low level so that it induces consumers to purchase it and to subsequently charge a high enough price for the add-ons. Although the firm makes little or no profits from the base product, the pricing strategy aims to compensate for these initial low rents by charging high add-on prices. Such a pricing strategy is commonly referred to as *loss leader pricing* (Hess and Gerstner 1987, Lal and Matutes 1994) or low-balling (Cohen and Whang 1997).[1]

This research was motivated by the view that demand for add-ons does not always seem to follow

[1] Existing research argues that the loss leader pricing scheme may be optimal when customers have a switching cost, as such a cost will prevent customers from leaving when faced with a higher-priced add-on (Hess and Gerstner 1987, Lal and Matutes 1994, Cohen and Whang 1997). This key argument has been shown to be robust in a number of different settings, some of the more recent ones being contexts where (i) a fraction of customers may be myopic (Ellison 2005), and (ii) firms may advertise/educate consumers about their rivals' prices (Gabaix and Laibson 2006).

certain notions of economic rationality. For instance, consider the following example (modified from Thaler 1985): Imagine a person who has purchased a specific brand of somewhat uncomfortable shoes, either at regular price or at a steep discount. When deciding whether to purchase gel insoles (which can ease the discomfort of wearing the shoes), this person should "rationally" not place any weight on how much he paid for the shoes. Still, it seems plausible that someone would be more likely to purchase the insoles if he or she paid more for the shoes compared with the case where he or she got the shoes at a steep discount. Similarly, consider a person who buys the *same* printer either at a low price of $10 or at a high price of $100. When the consumer decides on how much (and what quality) toner to purchase, rationality should demand that he place no weight on the price paid to acquire the printer. But, as an executive at Hewlett-Packard put it: "No one buys toners for those [$10] printers. [People] just throw the [printer] away" (Delouri 2008).[2]

The above examples hint at theoretically interesting consumer behavior that links the price paid for a base product with the purchase decision of an add-on. This behavior, if it exists, has important practical implications for pricing and sales of base products and add-ons, and it directly leads us to the two main questions addressed in the current study:

1. How is the demand for the add-on influenced by the base product price? Specifically, can *lowering* the price of a base product result in *fewer* consumers actually purchasing the add-on?

2. What are the implications to firms that sell base products and add-ons when the consumers' demand for the add-on is influenced by the price paid for the base product?

We may posit at least two distinct reasons why a consumer's purchase decision about the add-on may be correlated with the price she paid for the base product. The first reason is related to the consumer's belief, rational or otherwise (see, for instance, Almenberg and Dreber 2011), that price indicates the quality of a product. If a higher price for the base product indicates higher base product (or add-on) quality, it is possible that the marginal value from the contingent add-on is also higher, thus resulting in higher purchase intention for the add-on.

The second reason—a consumer's mental account of the base product and its role in her add-on purchase decisions—is the focus of this article. Consumers keep a mental account of their expenses and consumption for the purpose of making decisions (Thaler 1985). This "mental book value" is canceled out as the base product gets used and benefits are accrued (Thaler 1985, Prelec and Loewenstein 1998), and it depreciates over time (Gourville and Soman 1998); it may be defined as

$$BV \overset{\text{def}}{=} p - V,$$

where p is the price that the consumer paid for the product, and V is the cumulative benefit (value) she has obtained so far from using it.[3] Thus, the mental book value as defined above is consistent with prior literature (for instance, see Okada 2001) and represents the cost incurred to obtain the product from which the benefits accrued so far (dollar-scaled) are netted out. See Soman and Ahn (2010) for a recent review of the boundaries and some interesting implications of mental accounting.

Because our goal is not only to document an empirical regularity in consumer behavior but also to use it in a formal model to evaluate its implications to firm's optimal strategies, we shall next attempt to formalize a (paramorphic) description of the consumer's decision calculus for base product add-on pairs. Consider the following model of a consumer who has already purchased a base product: Let the consumer have a book value BV assigned to his base product mental account. We make the assumption that consumers are averse to holding mental accounts in deficit (i.e., the costs incurred so far outweigh the benefits obtained so far), especially so when the consumer's attention is focused on them. Specifically, we model this by assuming that a consumer who holds a mental account in deficit incurs a (psychic) cost that is convex in the level of mental account deficit. For ease of exposition, we make the specific parametric assumption that the convex cost is represented by a quadratic cost function; i.e., when a consumer has the book value deficit of BV for the base product, she incurs a cost given by $(\gamma'/2)BV^2$. Note that the nonnegative parameter γ' scales the psychic book value deficit "costs" into dollar terms.

The above specification explicitly helps us to capture the consumer's benefit from a reduction in the book value deficit: specifically, a reduction in book value deficit is beneficial, as it leads to a

[2] We do not, of course, mean to suggest that it is impossible to come up with a "rational" story for why consumers may be influenced by the price previously paid for the base product. Indeed, some rational explanations—for instance, the base product price may indicate its expected ownership duration, or the base product price signals either the base product or the add-on quality—are eminently plausible in some contexts. Hence, in testing our explanation for the hypothesized phenomenon, we will be careful to isolate these (and some other) alternative explanations.

[3] Note that book value BV changes over time as benefits are accrued; i.e., it should strictly be defined as $BV_t = p - V_t$, where p is the price paid for product, and V_t is the cumulative benefit received from it so far. For notational convenience, however, we chose to suppress this dependency.

corresponding reduction in the cost associated with holding that account in deficit. Mathematically, a Δ reduction in the book value deficit results in a reduction of this cost by $(\gamma'/2)BV^2 - (\gamma'/2)(BV - \Delta)^2 = 2(\gamma'/2)BV\Delta - (\gamma'/2)\Delta^2 \approx \gamma' BV\Delta$.[4]

Suppose that the consumer is now offered an add-on that gives an incremental benefit, u_A, and is priced at p_A. Given the contingent nature of the add-on, i.e., the add-on can be used only along with the base product, we suppose that if the consumer purchases the add-on, she will assign a fraction χ of this add-on benefit u_A to the base product's mental account and depreciate its book value deficit from BV to $BV - \chi u_A$. So $\Delta = \chi u_A$. Recall from above that, as our assumption of the quadratic cost of holding a book value in deficit implies, a Δ reduction in book value yields a corresponding benefit $\gamma' BV\Delta$. Hence, if the add-on is purchased, the benefit that corresponds to lowering the base product's book value deficit is given by $\gamma' BV\Delta = \gamma' BV\chi u_A = \gamma BVu_A$, where $\gamma \equiv \gamma'\chi$. Furthermore, in addition to this benefit arising from reducing the cost of holding the book value, the use of the add-on also confers the direct benefit given by u_A. Thus, the total benefit from the add-on is given by $u_A + \gamma u_A BV = u_A(1 + \gamma BV)$. Stated differently, the consumer would choose to purchase the add-on if and only if

$$p_A \leq u_A(1 + \gamma BV). \qquad (1)$$

The parameter γ, termed the *consumer bias parameter*, incorporates both γ' (the parameter that scales the cost of holding a mental account in deficit) and χ (the parameter that determines the fraction of add-on benefit that is assigned to the base product mental account). Before discussing some of the contextual factors that determine these parameters, it is useful to examine the single most important behavioral assumption underlying our model of consumer's decision calculus: the assumption that *consumers incur a convex cost from holding a mental account in deficit*. Although this assumption is not directly testable, we note that it certainly appears plausible. For instance, consider Thaler's (1999) example of people being willing to wear ill-fitting shoes a greater number of times if they paid more for those shoes. Because wearing ill-fitting shoes imposes a (real and physical!) cost on the consumer, it seems reasonable that the consumer is choosing to wear them because of the psychic cost imposed by the mental account deficit. Similarly, Arkes and Blumer (1985) find that people who paid a higher price for season tickets for a set of plays are likely to attend more of them and are likely to attend plays earlier than later in the season. Once again, given the costs associated with attending a play (perhaps the cost of getting a taxi or, more broadly, the "shadow price" of time/resources), the book value deficit must be imposing costs on the consumer (and hence prompting costly usage).[5]

The parameter γ (defined as $\gamma'\chi$) in Equation (1) represents the strength of the bias introduced by the consumer's mental accounting-based decision calculus. It is important to point out that the parameters γ' and χ (and thus γ) are likely to depend on the context. For instance, analogous to Soman and Gourville's (2001) theoretical arguments about transaction decoupling, the mental account associated with the base product will more readily come to mind in some situations and not as much in others. In cases where the mental account comes readily to mind and where the add-on benefits can be unambiguously assigned to this mental account, the fraction χ should be larger.

As BV is defined as $p - V$, note that Equation (1) implies that (i) a *given* consumer is more likely to buy an add-on if the price she paid for the base product is higher, and (ii) a *given* consumer is more likely to buy an add-on if the value she derived from the base product (so far) is smaller. Observe that the proposed bias predicts a relationship between the price of base products and demand for add-ons that is the opposite, at least for some parameters, of traditional models of demand for complementary products (Hess and Gerstner 1987). Specifically, traditional models of demand predict that an increase in price of the base product, because of a decrease of the size of the potential market for the add-on, will only decrease the demand for the add-on.[6]

[4] Note that we have eliminated the second-order term Δ^2 in approximating the benefit from reducing the book value deficit. This approximation, although crude, is sufficient to parsimoniously capture a key implication from our assumption of convex cost of mental account deficits—namely, the implication that the benefit arising from a reduction in book value is higher when the magnitude of the book value is itself larger.

[5] Note that without any cost of holding a mental account, reducing a mental account offers no benefit. Thus, absent this cost, a consumer's tendency to incur the "cost" of using the product, and the consumer's dependence on the mental account, appears unreasonable. Also, it is interesting that assuming only a cost of closing an account in deficit appears to be not completely satisfactory, especially for Thaler's (1985) example of ill-fitting shoes, because a consumer need not close the mental account even if he chose not to wear the shoes. Hence, it appears more plausible that the cost is incurred whenever the consumer's attention is focused on an account that is in deficit, especially in situations where there might be a chance that he might have to close the account in the future while still in deficit (Thaler 2011). Although the assumption of a convex cost of holding a mental account in deficit was made only to develop a model for the case of base product add-on pairs, this model can also explain other past findings. (More details are provided in the online appendix, at http://dx.doi.org/10.1287/mksc.1120.0731).

[6] Indeed, if we consider budget-constrained consumers, this reasoning for traditional demand models becomes even stronger because spending more on the base product leaves less to be spent on the add-on and, consequently, will always serve to depress its demand.

To answer our research questions about the existence of the postulated bias and its normative implications, we take the following two-pronged approach: First, we conduct two experimental studies aimed at testing the hypothesized role of mental accounts in driving a consumer's add-on purchase decision. Second, we formulate an analytical model to examine the implications for a firm that sells a base product and an add-on to a market where consumers employ their mental accounts in the hypothesized manner when making add-on purchase decisions.

This paper makes three key contributions. First, our experiments offer evidence consistent with our hypothesized model of how mental accounts affect a consumer's add-on purchase decisions, and thus they allow for a richer understanding of demand for sequentially purchased complementary products. Specifically, we find evidence that a consumer's likelihood of purchasing the add-on increases with the price she paid—and, more broadly, her book value—for the base product.

Second, analytical modeling of the consumer's decision calculus allows us to identify a novel tradeoff that firms selling base product add-on pairs face: charging a higher price for the base product decreases the demand for the base product and consequently reduces the potential pool of consumers who will find use for the add-on. However, the same higher price for the base product will induce a (given) consumer to have greater willingness to pay for the add-on, which may subsequently be exploited by the firm to gain greater profits from the add-on.

Third, from a practical perspective, our analysis of a firm's optimal pricing strategies offers several managerial guidelines. Our results clarify the influence of the identified bias on the firm's optimal pricing strategies and show that whether or not a firm employs a penetration pricing strategy that aims at increasing the market coverage depends critically on the strength of consumer bias. Specifically, with greater consumer bias, the firm may benefit from not employing a penetration pricing strategy but instead by raising the base product price, selling it to fewer consumers, and then exploiting these consumers' increased willingness to pay for the add-on through a higher add-on price. Furthermore, this insight is shown to be robust even when the base product market is competitive or when the quality choice is endogenous. Specifically, in the presence of this bias, the firm should spend more resources toward enhancing both base product and add-on quality, and especially so when the firm plans to offer the add-on before the consumer has had a chance to use the base product extensively.

The rest of this paper is organized as follows. We describe the experimental studies to test the hypothesized relationship and its results in §2. Subsequently, §3 discusses the consumer model and some of its broader implications. In §§4 and 5, we formulate and solve a formal model to understand the pricing implications for a firm that sells a base product and an add-on to a market where consumers' decision making is influenced by the postulated bias. Extensions that check the robustness of the key normative results and examine the product development implications from the postulated consumer bias are offered in §6. Finally, §7 summarizes the main normative results and their managerial implications, and §8 concludes.

2. Mental Book Value of Base Products and Willingness to Pay for Add-ons

In this section, we offer three experiments aimed at testing the hypothesized relationship between the purchase likelihood of the add-on and book value (deficit) associated with the base product.

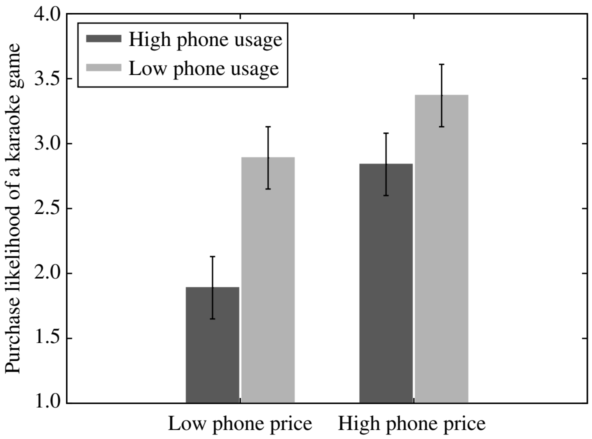
2.1. Study 1

A smartphone and a karaoke game were chosen as the base product add-on pair in this study. The two determinants of book value deficit—price paid for the smartphone p and its past usage V—were manipulated. The method, results, and a discussion of the main empirical findings follow.

2.1.1. Method. Participants in the experiment were 148 undergraduate students who received partial credit in psychology courses. The experiment was conducted in a laboratory setting. The experimenter handed them a short survey that outlined the following hypothetical scenario. Participants were informed that they purchased a smartphone 12 weeks ago either at a low price (=\$250) or at a high price (=\$350). Next, we manipulated the usage by telling the subjects that, because of some network problems at their workplace, they were *unable* to use email on their phones either for a low time (=1 week) or for a high time (=4 weeks). Subsequently, the subjects were asked to indicate their likelihood of purchasing—on a scale of 1 to 7—a karaoke game that can be used on the smartphone (see the complete instructions in Appendix B).

Thus, in our 2×2 design, a participant assigned to the low price condition would have paid less for the phone compared to one assigned to the high price condition. Similarly, a participant assigned to the low time condition would have obtained greater benefit (because she is able to use the email feature for longer) compared to one assigned to the high time condition. For ease of exposition, and to map these manipulations cleanly to our hypotheses, we redefine the *time* variable as *usage* and low time and high time conditions as high usage and low usage conditions,

Figure 1 **Average Purchase Likelihood of a Karaoke Game**



respectively. Note that Equation (1) predicts a main effect of *price* and a main effect of *usage*. Participants were randomly assigned to one of the four cells; each condition had 37 participants.

2.1.2. Results and Discussion. A 2 (*price*: low price, high price) $\times$ 2 (*usage*: low usage, high usage) analysis of variance (ANOVA) was conducted with the purchase likelihood of a karaoke game as the dependent variable. Figure 1 shows the average likelihood of purchasing the game in each of the four cells.

Consistent with the hypothesized role of mental accounts, the main effect of the smartphone price is significant ($F(1,144) = 9.08, p < 0.01$). The mean purchase likelihood of the game in the low price condition was 2.39 (SE = 0.16) and in the high price condition was 3.11 (SE = 0.17). Furthermore, the main effect of prior usage (of the smartphone) is significant ($F(1,144) = 10.51, p < 0.01$). The mean purchase likelihood of the game in the low usage condition was 3.14 (SE = 0.16) and in the high usage condition was 2.36 (SE = 0.17). No other effects were significant. The results show that when people pay more for the smartphone (the base product) or when the (value derived from the) prior usage of the base product is low, they are significantly more likely to purchase the game (the add-on). The empirical finding is consistent with the mental accounting explanation we presented.

Next, we explicitly discuss the two alternative explanations: (i) the price paid for the smartphone influences one's perception about the quality of the smartphone or possibly its lifetime, which, in turn, influences one's assessment of the added value of obtaining the game; and (ii) the price paid for the smartphone forms a reference price and influences one's belief about the "fair" price for the game.

The first explanation argues that consumers use the price of the base product to (rationally or otherwise) infer its quality and ownership duration. Then, given that an add-on should be more valuable when the base product is higher quality or has longer ownership duration, the demand for the add-on must be positively related to the price of the base product. The second explanation points to the issue that a higher base product price may upwardly bias a consumer's perception of the fair price for the add-on and thus enhance his acquisition utility from the add-on (see Thaler 1985 for an explanation of acquisition utility). These explanations rely on alternative mechanisms for how the base product price affects one's willingness to pay for the add-on. Indeed, although both these explanations are plausible, and they may explain the main effect of *price*, neither (individually or together) can explain the main effect of *usage*.[7] In contrast, the mental accounting-based explanation we proposed predicts the main effects of both *price* and of *usage*.

The study reported in the next section serves two goals: (i) to offer an additional test in a different context (while explicitly controlling for the base product lifetime) and (ii) to explicitly manipulate the extent to which the consumer pays attention to the base product mental account and assigns the benefits from add-on usage to this mental account (i.e., the degree of coupling χ between the base product and the add-on), and thus to manipulate the γ parameter in Equation (1).

2.2. Study 2

The experiment reported in this section used a two-day ski pass and a "queue-skipping voucher" as the base product add-on pair. In addition to the manipulation of the price of the base product and its past usage (as in the previous study), the coupling between the voucher (add-on) and the ski pass (base product) was manipulated by having two types of vouchers: the first that can be used only today and the second that can be used any one day within the next year. For the first type, usage of the voucher (add-on) must occur simultaneously with usage of the ski pass (base product). Hence, the benefits from the voucher can be unambiguously assigned to the mental account associated with base product, making the voucher tightly *coupled* with the ski pass. In contrast, the second type of voucher (that can be used any day within the next year) is *decoupled* because such simultaneous use, although possible, is not necessary.

[7] We would be remiss if we did not note that the first explanation can be modified to account for this effect of usage. Specifically, not using the base product may, in fact, lengthen the useful life of the base product itself, thus making the add-on more valuable. Given our context, it appears somewhat implausible (in our view) that not using the email feature on the smartphone can increase its useful life. Still, in the case of some base product add-on pairs, this issue of unspecified lifetimes does present the possibility of a confound, and it shall be explicitly addressed in the next experiment.

Because the *add-on type* (decoupled versus coupled add-on) would alter the extent to which the add-on brings to mind the mental account associated with the base product, as well as extent to which the add-on benefits are uniquely assigned to the base product account, we expect χ, and thus the γ parameter, to be lower for a decoupled add-on (compared with a coupled add-on). Hence, based on Equation (1), and in addition to the main effects of price and usage (as in previous study), we also expect an interaction between the *add-on type* and *price* as well as between the *add-on type* and *usage*. More precisely, we expect the effects of *price* and of *usage* to be stronger for the coupled add-on compared with the decoupled add-on. The method, results, and a discussion of the main empirical findings follow.

2.2.1. Method. Participants in the online experiment were 321 subjects recruited from Amazon's Mechanical Turk (see Paolacci et al. 2010 for some recent evidence that Mechanical Turk subjects are a reliable source of experimental data; see also Ipeirotis 2010 for data on the sample demographics on Mechanical Turk). Only subjects based in the United States were allowed to participate, and they received a small token payment (of \$0.25) for their participation.

The subjects were asked to read a hypothetical scenario: They were informed that they purchased a two-day ski pass either at a low price (=\$130) or at a high price (=\$230). Next, we manipulated the usage by telling the subjects that on the first day, because of a weather-related closure of the ski slopes, they were unable to ski either for low time (all of the morning) or for high time (most of the day). Subsequently, the subjects were asked to indicate their likelihood of purchasing—on a scale of 1 to 7—a voucher that would allow them to skip queues or lengthy waits to get on the ski slopes. As explained earlier, the coupling between the voucher (add-on) and the ski pass (base product) was manipulated by telling the subjects that the voucher, if purchased, can be used either today only or any one day within the next year. In the first case, the voucher is coupled (can only be used today), whereas in the second case, the voucher is decoupled (can be used any one day within the next year) (see the complete instructions in Appendix B).

As in the previous study, redefine low time and high time as the high usage and low usage conditions, respectively. In our 2 (*price*: low price, high price) × 2 (*usage*: low usage, high usage) × 2 (*add-on type*: coupled, decoupled) design, participants were randomly assigned to one of the eight cells. Consistent with the accepted practice in online experiments, we also employed two control questions to ensure that participants were paying attention to the instructions (Paolacci et al. 2010). After removing 26 participants who got the control question wrong,we were left with 295 subjects, and the number of subjects per cell ranged from 28 to 42.

Table 1 Average Purchase Likelihood in the Eight Conditions

	Low usage	High usage
	Coupled add-on	
High price	5.49 (0.27)	5.05 (0.3)
Low price	5.00 (0.32)	3.82 (0.27)
	Decoupled add-on	
High price	4.60 (0.28)	4.76 (0.27)
Low price	4.61 (0.28)	4.59 (0.26)

Note. Standard errors are shown in parentheses.

2.2.2. Results and Discussion. A 2 (*price*: low price, high price) × 2 (*usage*: low usage, high usage) × 2 (*add-on type*: coupled, decoupled) ANOVA was conducted with the purchase likelihood of a voucher as the dependent variable. Table 1 shows the average likelihood of purchasing the voucher in each of the eight cells.

The main effect of base product price is significant ($F(1,287) = 5.52, p = 0.02$). The mean purchase likelihood of a voucher in the low price condition was 4.51 (SE = 0.14) and in the high price condition was 4.98 (SE = 0.14). Furthermore, the main effect of prior usage of the ski pass is significant ($F(1,287) = 3.32, p = 0.07$). The mean purchase likelihood of a voucher in the high usage condition was 4.56 (SE = 0.13) and in the low usage condition was 4.92 (SE = 0.14).

The interaction between *price* and *add-on type* is significant ($F(1,287) = 3.78, p = 0.05$), as is the interaction between *usage* and *add-on type* ($F(1,287) = 4.74, p = 0.03$). Table 2 illustrates the nature of these interactions. Consistent with the hypothesized role of mental accounts, the effect of book values on the decision to purchase an add-on is greatest when the add-on is more tightly coupled to the base product.

All the key results found in the prior study—namely, the effects of prices and past usage—are found in the current study as well. Thus, despite the fact that the context of the first experiment (a durable product pair) is quite different from that of the second experiment (a time-limited experience of a product/service), the results are broadly consistent with our proposed role of mental accounts in the consumers' decision making.

Table 2 Average Purchase Likelihood Showing the Interaction of ***Price*** × ***Add-on Type*** (Top) and ***Usage*** × ***Add-on Type*** (Bottom)

	Coupled add-on	Decoupled add-on
High price	5.27 (0.20)	4.68 (0.20)
Low price	4.41 (0.21)	4.60 (0.19)
High usage	4.44 (0.20)	4.68 (0.19)
Low usage	5.24 (0.21)	4.60 (0.20)

Note. Standard errors are shown in parentheses.

3. General Discussion of the Consumer Model and Its Implications

Our paramorphic model of consumer decision calculus is, by and large, parsimonious in having a single exogenous parameter γ and employing the behavioral assumption that consumers incur a cost of holding a mental account in deficit. Still, the results from Studies 1 and 2 are consistent with the hypothesized effect that a book value deficit has on a consumer's likelihood of purchasing the add-on. Furthermore, the results from Study 2, in addition to being consistent with our hypothesized model, also help to clarify the boundaries of the phenomenon by demonstrating that the coupling between add-ons and the base product is important in determining the magnitude of γ.

We had designed the decoupled add-on in Study 2 to have a lower γ. It appears that our manipulation was strong enough to, in fact, drive γ all the way to 0; specifically, price and usage play no significant role for the decoupled add-on (see Table 2). Thus, it appears that the proposed mechanism occurs not necessarily because the add-on complements the base product, per se, but only because (in some cases) the contingent nature of the add-on brings to mind the mental account connected to the base product. And when the setting is such that the add-on does not immediately bring to mind the mental account associated with the base product (or when it brings to mind other mental accounts), the proposed mechanism is no longer active.

It is also interesting to see in Study 2 that the decoupled add-on (single-day voucher that expires in a year) has objectively more value compared with the coupled add-on (single-day voucher that expires today). Indeed, a small within-subject study (not reported in this paper) verified that when faced with both types of add-ons, people will almost never be more willing to purchase the coupled add-on compared with the decoupled add-on. Still, the higher γ for the coupled add-on causes the willingness to pay for the objectively worse coupled add-on to be larger (compared with the decoupled add-on).

To illustrate, consider two add-ons, A and A', of utilities u_H and u_L (with $u_H \geq u_L$). Suppose the bias parameter when A (A') is offered is γ_L (γ_H); also, let $\gamma_L \leq \gamma_H$. Then, the difference between the two utilities for A and A' is given by $u_L(1+\gamma_H BV) - u_H(1+\gamma_L BV) = BV(\gamma_H u_L - \gamma_L u_H) - (u_L - u_H)$, which (assuming $\gamma_H u_L \geq \gamma_L u_H$) is positive if and only if $BV > (u_H - u_L)/(\gamma_H u_L - \gamma_L u_H)$. That is, for sufficiently large book value deficits, the consumer would, surprisingly, be more likely to purchase the objectively worse but more tightly coupled add-on (compared with the objectively better decoupled add-on).

Indeed, we do observe (in the between-subjects experiment reported in Table 1) that when the base product book value is low, the purchase likelihood for an objectively worse coupled add-on is less than the purchase likelihood for the objectively better decoupled add-on (3.82 versus 4.59), but when the base product's book value is high, the purchase likelihood for the objectively worse coupled add-on is more than the purchase likelihood for the objectively better decoupled add-on (5.49 versus 4.60).

Next, we develop a normative model in §4 that considers a firm selling a base product and add-on pair to a market where consumer demand for the add-on exhibits the empirical regularity identified in the previous section. The full characterization of the firm's optimal pricing decision is offered in §5.

4. Model Setup

Consider a monopolist firm that *sequentially* sells two products: a base product B of quality q_B that is made available to consumers immediately and an add-on A of quality q_A that is sold at a later stage. Two assumptions are noteworthy: (i) this is a monopolist firm and (ii) it carries exogenously specified qualities. First, we assume that this is a monopolist firm to focus the modeling effort and main analysis on the effect of consumer bias. Still, we show in §6.2 that the effects of consumer bias identified through the monopoly model are robust even when we consider competition in the base product market. In a similar vein, the assumption of exogenously specified qualities, which we relax in §6.1, is made in the base model so as to keep the initial focus purely on the pricing decision.

The firm sets p_B, the price of the base product, and makes the base product available to the consumers. The consumers then make their purchase decisions regarding the base product, after which the firm chooses p_A, the price of the add-on, and makes the add-on available to the consumers. This basic formulation, although stylized, is broadly consistent with several of the examples (automobiles, consumer electronics, the travel industry, etc.) used earlier in the paper.

To simplify the exposition while focusing primarily on the effect of the previously identified bias in consumer demand, we abstract away from supply-side considerations such as capacity constraints or production costs. Specifically, we assume that the marginal costs of production for the base product and the add-on are constant, which we normalize to 0. This assumption is not restrictive because the fundamental results regarding the interaction between consumer choices and the firm's optimal strategies only require that marginal production costs be nondecreasing.

The consumer market is assumed to be composed of two distinct segments denoted by H and L; H

represents a high-valuation segment that has a high willingness to pay for quality, and L represents a low-valuation segment with a low willingness to pay for quality. Suppose that the total number of consumers is N, a fraction α of whom are of type H.

Let v_{ij} represent the utility derived by consumer i ($i \in \{H, L\}$) if he uses product j ($j \in \{B, A\}$). This utility depends on the quality of the product as well as his utility from a unit of quality. Furthermore, we assume that the add-on is a true contingent product, i.e., the add-on has no utility in isolation, and that a consumer obtains utility from the add-on *only* if he has previously purchased the base product. To keep the analysis simple, we assume that the utility derived from the base product as well as the add-on (contingent on having purchased the base product) is as follows:[8]

$$v_{ij} = \theta_{ij} q_j, \quad \text{where } \theta_{ij} \text{ is consumer } i\text{'s utility per-unit quality of product } j.$$

Consistent with our definition of high- and low-valuation segments, we assume that $\theta_{HB} \geq \theta_{LB}$ and $\theta_{HA} \geq \theta_{LA}$. That is, the high-valuation segment obtains greater utility for each unit of quality from the add-on as well as the base product. Furthermore, for ease of exposition and convenience in interpretation, let

$$\eta_A \stackrel{\text{def}}{=} \frac{\theta_{HA}}{\theta_{LA}},$$
$$\eta_B \stackrel{\text{def}}{=} \frac{\theta_{HB}}{\theta_{LB}}.$$

Note that these ratios are greatest (least) when the heterogeneity in the consumer valuations are high (low). Hence, these ratios may be interpreted as a normalized metric measuring the (valuation) heterogeneity, with higher values of η_A and η_B representing greater market heterogeneity for the add-on and the base product, respectively. Without loss of generality, we also assume that $\theta_{LA} = \theta_{LB}$.

When a consumer obtains utility v_{iA} from the add-on, she should "rationally" be willing to pay up to v_{iA} for the add-on. However, consistent with our proposed consumer decision model (Equation (1)), we assume that consumer i's willingness to pay for the add-on is

$$\hat{v}_{i,A} = v_{iA}(1 + \gamma BV_{iB}), \tag{2}$$

where γ (≥ 0) represents the strength of a consumer's bias and BV_{iB} is consumer $i's$ book value (deficit) corresponding to the base product.

Let ϕ be the fraction of the value of the base product that the consumer has obtained by the time the add-on is introduced. Hence, consumer $i's$ book value deficit, given that she has purchased the base product, is $BV_{iB} = p_B - \phi v_{iB}$. Since ϕ captures the value derived from the base product before the add-on is offered, situations where the add-on is offered soon after the base product is purchased would likely have a smaller ϕ compared with situations where the add-on is offered much later.

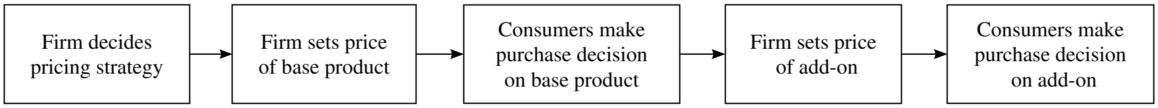
The consumer bias parameter γ moderates the book value deficit, and as we noted earlier, it is possibly determined by the context; for instance, it is likely to be higher if the consumer is more uncertain about the useful life remaining in the base product and needs to quickly amortize the book value, or it is lower because the add-on is a "general" one and fails to bring to mind the account associated with the base product. For ease of exposition, we denote γBV_{iB}, representing the increase in a consumer's willingness to pay, the *mental accounting effect*. To rule out the less interesting and somewhat implausible cases in which the add-on valuation of the low-end segment might become higher than that of the high-end segment, we assume that ϕ is not too high; i.e., $\phi < 1/\eta_B$. Finally, we assume that consumers are myopic in that they ignore any potential choices they might make in the future when making their current purchase decisions.[9] So consumer i has a willingness to pay for the base product given by v_{iB} and a willingness to pay for the add-on given by $\hat{v}_{iA}$.

The sequence of decisions is given in Figure 2. In the first period, the firm makes the base product available to consumers at price p_B. Consumer i ($i \in \{L, H\}$) then decides whether or not to purchase the base product depending on whether his willingness to pay for the base product (v_{iB}) exceeds its price (p_B). In the second period, the firm makes the add-on available at price p_A. All consumers who purchased the base product previously now form the potential consumer base for the add-on. As before, depending on how the willingness to pay for the add-on ($\hat{v}_{iA}$) compares to the price charged for it (p_A), consumers choose whether or not to purchase the add-on. Note that we have assumed that a consumer may purchase at most one unit of the add-on. The assumption is made purely for ease of exposition, and although not strictly true

[8] Note that a consumer derives utility $v_{iA} = \theta_{iA} q_A$ from the add-on only if she has previously purchased the base product. If she did not purchase the base product, her utility from the add-on is $v_{iA} = 0$.

[9] More specifically, we assume that the consumer does not consider the choice of add-ons when making his decision about purchasing the base product. Alternatively, we can use the same model even if we assume that consumers are nonmyopic but that they are unaware of their (future) bias when making their base product purchase decision. Still, it is worthwhile to point out that the assumption that all the consumers are myopic is not critical for our results (as we show in the online appendix). In addition, there is also a conceptual reason to focus on nonstrategic consumers. Specifically, because our goal is to understand the pricing and product development implications of an "irrational" behavioral bias, it appears logically inconsistent to then assume foresightful and/or strategic behavior on the part of consumers.

Figure 2 **Sequence of Decisions**



in some markets (such as printers and toners), it may be observed that relaxing the assumption will only serve to make the add-ons more important and, consequently, the role of bias parameter γ even more critical in determining the firm's strategies.

5. Characterization of Optimal Pricing Strategies

Consistent with existing literature, we assume that the firm has to charge the same price for both segments, and we allow for the possibility that consumers would self-select and purchase a product only if their willingness to pay for it exceeds the price being charged. This assumption implies that the firm can never induce only low-valuation consumers to purchase a product and results in the following three feasible pricing strategies:

1. *Saturation*: Sell the base product and add-on to both low- and high-valuation consumers.
2. *Niche*: Sell the base product and add-on only to high-valuation consumers.
3. *Metering*: Sell the base product to both low- and high-valuation consumers, and sell the add-on only to high-valuation consumers.

Next, we address the profits obtained by the firm under each of these three strategies.

5.1. Profit Maximization

5.1.1. Saturation. Under this strategy, the firm prices the base product such that both low- and high-valuation consumers purchase it. Thus, $p_B \le v_{LB}$. The willingness to pay for the add-on, based on Equation (2), among low- and high-valuation consumers is given by $v_{LA}(1+\gamma BV_{iB})$ and $v_{HA}(1+\gamma BV_{iB})$, respectively. Thus, to induce both low- and high-valuation consumers to purchase the add-on, the firm must set the price of add-on to $p_A \le v_{LA}(1+\gamma BV_{iB})$. The profit for the firm under these prices is given by $\hat{\Pi}_s = p_B + p_A$. It follows that the prices set by the firm that maximize profits under the saturation strategy will be

$$p_B^s = v_{LB},$$
$$p_A^s = v_{LA}(1+\gamma BV_{iB}) = v_{LA}(1+\gamma(p_B - \phi v_{LB})) = v_{LA}(1+\gamma v_{LB}(1-\phi)),$$

and the corresponding profits are

$$\Pi_s = Nv_{LB} + Nv_{LA}(1+\gamma v_{LB}(1-\phi)). \quad (3)$$

5.1.2. Niche. Here, the firm prices the base product and add-on such that only high-valuation consumers purchase them. Again, it may be shown easily that the prices that maximize profits in this approach are

$$p_B^n = v_{HB} = \eta_B v_{LB},$$
$$p_A^n = v_{HA}(1+\gamma v_{HB}(1-\phi)) = \eta_A v_{LA}(1+\gamma\eta_B v_{LB}(1-\phi)),$$

and the corresponding profits are

$$\Pi_n = \alpha N(v_{HB} + v_{HA}(1+\gamma v_{HB}(1-\phi))) = \alpha N(\eta_B v_{LB} + \eta_A v_{LA}(1+\gamma\eta_B v_{LB}(1-\phi))). \quad (4)$$

5.1.3. Metering. Here, the firm prices the base product to appeal to both low- and high-valuation consumers, but the add-on is priced to induce only high-valuation consumers to purchase it. As before, it may be shown fairly easily that the prices that maximize profits under this approach are

$$p_B^m = v_{LB},$$
$$p_A^m = v_{HA}(1+\gamma(v_{LB} - \phi v_{HB})) = \eta_A v_{LA}(1+\gamma v_{LB}(1-\phi\eta_B)),$$

and the corresponding profits are

$$\Pi_m = Nv_{LB} + \alpha N v_{HA}(1+\gamma(v_{LB} - \phi v_{HB})) = N(v_{LB} + \alpha\eta_A v_{LA}(1+\gamma v_{LB}(1-\phi\eta_B))). \quad (5)$$

The overall optimal strategy depends on which of these—saturation, niche, or metering—yields the greatest profits.

5.2. Impact of Market Size and Mental Accounting Effects on Optimal Pricing Strategy

Before characterizing the firm's optimal pricing strategy, it is useful to understand the two distinct roles played by the base product price in our model. The first is a *market size effect* whereby a higher base product price shrinks the potential market for the add-on and negatively impacts the overall profits. The second is a *mental accounting effect* whereby the higher base product price allows the firm to exploit the consumer bias by charging a higher price for the add-on. Thus, the optimal pricing strategy, characterized next, must manage the trade-off between these two effects.

Proposition 1. *The effect of γ, ϕ, and η_A on the optimal strategy is as follows*:

1. *If $\eta_A < \eta_{A0}$, then there exists thresholds γ_1 and γ_2 such that metering is optimal iff $\gamma < \gamma_1$, saturation is optimal iff $\gamma \in [\gamma_1, \gamma_2)$, and niche is optimal iff $\gamma \ge \gamma_2$.*
2. *γ_1 and γ_2 are increasing in ϕ.*

3. *If $\eta_A \geq \eta_{A0}$, then there exists a threshold γ' such that metering is optimal iff $\gamma < \gamma'$, and niche is optimal otherwise.*

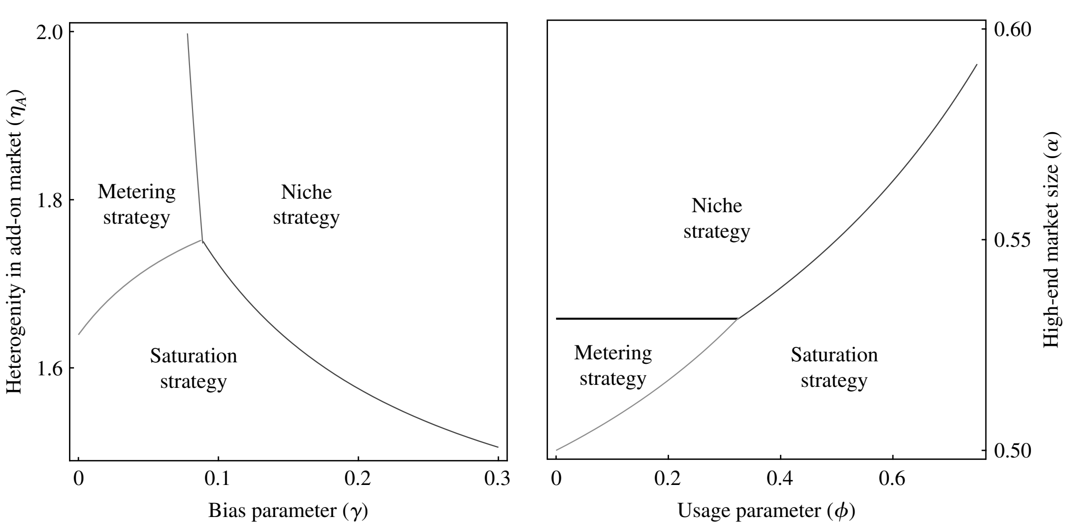
All proofs are given in Appendix A. The economic intuition underlying these results may be understood in terms of the above-mentioned market size and mental accounting effects. Specifically, the mental accounting effect, in addition to its dependence on base product price, also depends on the bias parameter γ and on the past usage ϕ, increasing in the former and decreasing in the latter. When the bias parameter is sufficiently high ($\gamma \geq \gamma_2$) or when past usage ϕ is sufficiently low, the mental accounting effect dominates the market size effect, and the firm finds it optimal to set a higher price and sell the base product to fewer, but higher-valuation, consumers.

If the bias parameter is moderate ($\gamma_1 \leq \gamma < \gamma_2$) and/or when past usage ϕ is moderate, the optimal approach involves adopting a saturation strategy. This switch from niche to saturation when γ changes from above γ_2 to below it (or when ϕ increases from very low to moderate values) can be understood in terms of the market size and mental accounting effects identified earlier. Specifically, these two effects are not independent. That is, if the market size for the add-on is small, then the *total* benefit from the mental accounting effect is also by necessity small. As an example, suppose the potential market size for the add-on is very small. Then, the mental accounting effect (especially when it is moderate) has only a limited effect on the profits. Hence, for intermediate values of bias parameter and/or past usage, whereas the higher base product price pushes the mental accounting effect higher, that effect is realized from only a small fraction of the market. So instead, the firm finds it beneficial (when $\gamma \in [\gamma_1, \gamma_2]$) to reduce the base product price and increase the market size for the add-ons. This increased market size allows the firm to exploit the mental accounting effect even among the low-valuation consumers.

Finally, for very low values of the bias parameter γ and/or very high values of past usage ϕ, the firm may find it beneficial to use the metering approach, wherein the pricing strategy of the firm induces low-valuation consumers to purchase only the base product, whereas the high-valuation consumers are induced to purchase both the base product and add-on. This is because, under these conditions, the mental accounting effect is so weak that the firm benefits more from discriminating between consumers—selling the base product to all consumers while restricting access of the add-on only to the high-end segment—than by attempting to exploit the consumer bias.

Claim 3 of Proposition 1 and Figure 3 further clarify the role of heterogeneity on a firm's pricing strategy. When market heterogeneity is low ($\eta_A < \eta_{A0}$), the two segments value the add-on similarly, and the firm does not benefit from discriminating between the segments. As a result, saturation can be optimal. In contrast, for higher values of heterogeneity ($\eta_A \geq \eta_{A0}$), the firm will naturally find it optimal to move away from a saturation strategy and restrict access of the add-on to only the high-end consumers. However, whether it does that by pursuing a metering strategy or a niche strategy depends on the strength of the mental accounting effect. Specifically, for high bias parameter γ and high heterogeneity, the firm benefits from a niche strategy because it allows them to exploit the mental accounting effect by charging higher prices for the base product, consequently extracting greater willingness to pay for the add-on. On the other hand, for low bias γ, the mental accounting effect is not strong

Figure 3 **Optimal Pricing Strategy Contingent on Heterogeneity and Consumer Bias**



enough for the firm to completely forgo the base product revenues from the low-end segment. Consequently, the firm chooses to discriminate between the consumers only in the add-on market and sells the base product to all consumers.

Until now, we assumed that there are two distinct parameters, η_A and η_B, summarizing the heterogeneity in the add-on and base product markets, respectively. Corollary 1 examines the consequence of forcing $\eta_A = \eta_B = \eta$ (i.e., the heterogeneity in the base product market is identical to that in the add-on market).

Corollary 1. *When $\eta_A = \eta_B = \eta$, the effect of γ, ϕ, and η on the optimal strategy is as follows*:

1. *There exists a threshold τ such that saturation is optimal if $\gamma(1-\phi) < \tau$, and niche is optimal if $\gamma(1-\phi) \geq \tau$.*
2. *The threshold τ is nonincreasing in η.*

There are two points to note in terms of how the insights from Proposition 1 change when we make the additional assumption restricting $\eta_A = \eta_B = \eta$. First, the main structural insights are retained, in that increasing γ or decreasing ϕ does induce the firm to sell to fewer consumers, both in the base product and the add-on markets. Second, under the assumptions of the above corollary (specifically, $\eta_A = \eta_B = \eta$), metering is never optimal. A firm undertakes a metering strategy when it wants to discriminate between consumers *only* in the add-on market and not in the base product market. However, when $\eta_A = \eta_B = \eta$, the distribution of consumers in the add-on market and base product market are identical, and hence, it is not prudent for the firm to follow different strategies in each market. As a result, there are only two possibilities: When the heterogeneity η is high, the firm would wish to discriminate in both the add-on and base product markets (in which case, she follows a niche strategy). When the heterogeneity is low, she would wish not to discriminate in either the add-on or market base product market (so she follows a saturation strategy). In either case, metering is not employed.

6. Extensions

The base model and its associated analysis outlined in §§4 and 5 demonstrates that the base product price has two effects on a firm's profits from the add-on: First, a higher base product price results in lower market size for the add-on and possibly reduces the add-on profits. Second, the same higher base product price will enhance the willingness to pay for the add-on (among the consumers who purchased the base product), resulting in greater profits from the add-on. Our model shows that the firm has a greater incentive to set a high price (instead of a low penetration price) for the base product so as to fully exploit the consumer's mental accounting bias.

The purpose of the current section is to understand the robustness of this key result and derive insights into the limits and further implications of this identified effect. Specifically, we consider two extensions of the base model: (i) in §6.1, we relax the assumption of an exogenously specified quality of the base product and add-on, and we consider the effect of the consumer bias on the firm's optimal quality choice; and (ii) in §6.2, we relax the assumption that the firm is a monopolist, and we consider the case of an oligopoly in the base product market.

To keep the model simple, we assume throughout the extensions that $\eta_A = \eta_B = \eta$ (i.e., the heterogeneity in the base product market is identical to that in the add-on market). It should be noted that this simplification implies that metering is never an optimal strategy (see Corollary 1). However, this simplification loses little in qualitative insights, as Proposition 1 shows that metering is, in any case, never optimal in the contexts we are interested in (where the bias parameter is sufficiently high).

6.1. Optimal Provisioning of Quality

We endogenize the firm's product development decision by considering a development cost. Specifically, when the firm develops a base product of quality q_B and an add-on of quality q_A, she incurs costs $C_A(q_A)$ and $C_B(q_B)$, respectively, where $C_A(\cdot)$ and $C_B(\cdot)$ are arbitrary nondecreasing functions. We assume that this product development decision occurs prior to the firm's pricing decisions. That is, the firm first decides on the quality of the base product and add-on, after which the sequence of the events in the base model given in Figure 2 is played out.

Proposition 2 verifies the robustness of the previously identified pricing regimes and characterizes the sensitivity of the optimal base product quality q_B^*, the optimal add-on quality q_A^*, and the optimal development costs. To this end, let $R_{\text{tot}}^* \stackrel{\text{def}}{=} C_A(q_A^*) + C_B(q_B^*)$, where R_{tot}^* is the total development cost of obtaining the optimal quality levels of q_A^* and q_B^*.

Proposition 2. *The regions defining the optimal pricing strategy have the same structure as those given in Corollary 1 even when the quality decision is endogenized. Furthermore,*

1. *q_B^* is nondecreasing in $\gamma(1-\phi)$, and q_A^* is nondecreasing in $\gamma(1-\phi)$.*
2. *R_{tot}^* is nondecreasing in $\gamma(1-\phi)$.*

Proposition 2 verifies that the optimal pricing strategy continues to exhibit a similar structure as that characterized in Corollary 1 even when the quality of both the base product and add-on is endogenized. The intuition mirrors the explanation provided in §5. The proposition thus offers evidence that our results are not merely an artifact of any simplifying assumption but are driven by the previously explained fundamental trade-off between the mental accounting effect and the market size effect.

To understand why q_B^* is nondecreasing in γ and nonincreasing in ϕ, consider the following: The quality of the base product, keeping its price constant, influences the number of people who purchase it and hence the market size for the add-on. With greater bias (higher γ) or lesser past usage (lower ϕ), the firm obtains greater value from an increase in market size, because the two effects are complementary in their action on the profits. Hence, with higher γ, the firm should increase the quality of the base product.

In a similar manner, when the quality of the add-on increases, the total benefit of the mental accounting effect is larger (for instance, suppose the add-on has zero quality; in this situation, the mental account would play no role, and no consumer would purchase the add-on). Stated differently, the quality of the add-on and the mental accounting effect are complementary in their action on the firm's profits. Thus, with greater γ or lower ϕ, the firm should optimally increase the quality of the add-on.

The last claim in Proposition 2 trivially follows from the preceding two: an increase in γ or a decrease in ϕ results in greater quality (of the base product and add-on) and thus greater total cost of development. Thus, when consumers are more biased, the firm should optimally spend more resources on development.

6.2. Competition in the Base Product Market

We have so far assumed that the firm has a monopoly over the base product market. Indeed, this stylized assumption was made for analytical convenience and has its limitations. More importantly, it is unclear ex ante whether relaxing this assumption would affect key results: namely, with competition present, does the firm still charge a high base product price and pursue a niche strategy when consumers employ mental accounting in their decision making about add-ons? In this extension, we examine the robustness of this result when there is competition in the base product market.

In §4, we had explicitly modeled consumer decision making. In this section, we could easily start with consumer preferences as primitives, but because our goal is to understand the role of competition, we shall offer a more parsimonious, yet very general, reduced-form model of competition. Specifically, consider n firms selling base products to a common (or overlapping) consumer market. Let firm i's base product have quality q_{iB}, and let the price charged for it be p_i. We assume that (consumers have preferences over the base products such that) the base product demand for firm i is given by $D_i = D(p_i, p_{-i})$ and has the following two characteristics.[10]

Assumption A1. *The total number of consumers who purchase the base product is nonincreasing in the base product price. That is, for all* $i \in \{1, \dots, n\}$, *the following holds*: $\partial \sum_k D_k / \partial p_i \leq 0$.

Assumption A2. *The elasticity of demand is a nonincreasing function of competitors' prices. That is, for all* $i \in \{1, \dots, n\}$, *and* $j \neq i$, *the following holds*: $(\partial/\partial p_j)(-\partial \ln D_i / \partial \ln p_i) \leq 0$.

Assumption A1 states that the total number of consumers choosing to remain in the base product market (purchasing any of its products) cannot increase when any one of the firms increases its price. The intuition for this assumption is explained as follows. The total number of consumers purchasing any of the base products, $\sum_k D_k$, can only increase when consumers who were previously not purchasing the base product join the market. Intuitively, increasing any of the base product prices p_i would not cause consumers who were outside the base product market to suddenly join the market. This implies $\partial \sum_k D_k / \partial p_i \leq 0$, the statement in Assumption A1.[11]

Assumption A2 is a relatively standard one in models of differentiated Bertrand oligopoly. Intuitively, because the base products offered by the firms are substitutes, elasticity of demand is smaller when the competitor's prices are higher.[12]

We assume that the add-on market is *not* competitive. Thus, consumers who have purchased the base product from firm i will only consider purchasing the add-on offered by the same firm i. This assumption reflects the reality that add-ons provided by firms are often such that they can be used only in the base products made by the same firms. For instance, for some add-ons such as "room service" or "Wi-Fi service" (in the context of a "hotel room"), only the add-on provided by the firm that sold the base product is meaningful.

[10] Note that $D(p_i, p_{-i})$ is the demand given the specific base product qualities q_i and q_{-i}.

[11] Another way to understand this assumption is by relying on an argument about the consumer's outside option. Specifically, because the consumer's outside option is a substitute with respect to the offered base products, increasing the price of the base product can only attract demand away from these base products toward the outside option, once again implying Assumption A1.

[12] It is trivial to confirm that both these assumptions are satisfied by a variety of demand systems such as multinomial logit (where $D_i = A_i \exp(-p_i)/(A_0 + \sum_j A_j \exp(-p_j))$, where $A_i \geq 0$), constant elasticity of substitution demand (where $D_i = p^{\phi-1} / \sum_j p_j^{\phi}$, where $\phi < 0$), and linear demand systems (where $D_i = A_i - p_i + \sum_{j \neq i} \theta_{ij} p_j$, where $1 > \theta_{ij} \geq 0$). The online appendix offers an illustration that a multinomial logit demand model satisfies both assumptions.

We assume that every consumer who purchased the base product from firm i obtains utility v_i from the add-on provided by that same firm. Furthermore, the value derived by every consumer from past usage of firm i's base product is ψ_i. Thus, consistent with our previous model, such consumers would be willing to pay $\hat{v}_i = v_i(1+\gamma(p_i - \psi_i))$ for the add-on. By assumption, each firm is selling its add-on to a captive market segment. Hence, firm i should optimally charge add-on price $p_{iA} = \hat{v}_i$ and sell the add-on to all those consumers who purchased the base product from it.

Given the demand we just outlined, the profits of each firm i can be characterized easily. Specifically, when firm i sets the base product price at p_i, its first-period profit from selling the base product is given by $D_i p_i = D(p_i, p_{-i})p_i$, and its second-period profit from selling the add-on is given by $D_i p_{iA} = D(p_i, p_{-i}) \cdot v_i(1+\gamma(p_i - \psi_i))$. Thus, the total profits for firm i are

$$\Pi_i = D(p_i, p_{-i})((1+\gamma v_i)p_i + v_i - \gamma v_i \psi_i).$$

Proposition 3 characterizes how consumer bias alters firm i's Nash equilibrium base product price (p_i^*) and the Nash equilibrium total market coverage ($\sum_i D_i$).

Proposition 3. (a) *p_i^* is increasing in γ, and* (b) *$\sum_i D_i$ is decreasing in γ.*

This proposition verifies that the main result we obtained for the monopoly model—namely, that the firm exploits the consumer bias by raising the price of the base product and consequently selling it to fewer consumers—is robust even under a competitive base product market. Intuitively, with competition, decreasing one's own price may enhance the demand for the base product (by attracting consumers from competitors); however, because such a decrease also results in a lower mental accounting effect, it hurts the firm's potential future profits from the add-on. Hence, the firm prefers to keep its base product prices high, even at the cost of not being able to attract competitors' consumers. Furthermore, because every firm keeps its base product price high, the fraction of consumers who purchase the base product would be smaller compared with the case where consumers do not exhibit bias.

Although it is not crucial for evaluating the effects of competition on the main insights, we can also easily show that whether a firm that offers a high-quality add-on should charge a high or low price for the base product depends on the consumer bias (full proofs are offered in the appendix). Specifically, when consumers exhibit a sufficiently large bias, firms that offer add-ons of better quality to exploit the mental accounting effect will charge higher base product prices compared with firms that offer lower-quality add-ons. However, when the bias parameter is very small, this result reverses, and it is those firms that offer better-quality add-ons that would choose to have a lower base product price. This is because doing so locks in a larger consumer segment to whom firms can offer the better add-on.

7. Discussion of Mental Accounting and Firm's Decisions

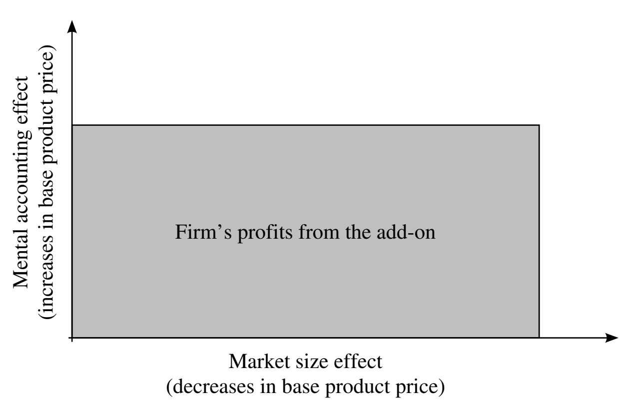
The pricing and sales of base product add-on pairs is an important decision for firms in many industries. This paper posits that, in the context of sequential purchase of such product pairs, a consumer's decision of whether to purchase an add-on product is influenced by the book value deficit (price paid minus past benefit) associated with the base product. We formulated a normative model with the goal of understanding how a firm's optimal decisions are impacted by this identified consumer bias. The main results and their implications for a firm's optimal strategies are summarized below.

7.1. Trade-off Between Enhancing Mental Accounting Effect and Market Size

Our analytical results demonstrate that the price of the base product has two distinct effects on a firm's profits, as illustrated in Figure 4.

The first effect is the well-known market size effect, represented by the length of the rectangle, whereby the higher base product price shrinks the potential market for the base product (and hence, by extension, the market for the add-on) and may thus reduce profits of a firm. The second, which is unique to our model, is the mental accounting effect (γBV), represented by the height of the rectangle. Here, the higher base product price allows the firm to exploit consumer bias by charging a higher price for the add-on. These two effects, although separate, are not independent of each other; in fact, they interact with each other in a complementary manner. As a result, the total profits (area of the rectangle) depend on the price of the base product in a nontrivial manner.

Figure 4 **Effect of Base Product Price on a Firm's Profits**



7.2. Optimal Pricing/Development Choices

The model and analysis that we propose in this paper characterize how firms should manage the trade-off between market size and mental accounting effects. Depending on the relative strength of these effects, a firm can choose between two different pricing strategies: a strategy that induces only a part of the overall market to buy the base product (i.e., the niche strategy) versus one that induces most of the consumers to buy the base product (i.e., penetration pricing strategy, including the metering or saturation strategy). In addition, our results demonstrate the important link between development choices and mental accounting biases.

Table 3 summarizes key normative pricing and development guidelines. Our analysis reveals higher consumer bias or lower past usage of the base product is exploited by charging a higher price for the base product even at the cost of reducing the market coverage of the base product. This key insight that identifies the limits of penetration pricing is shown to be robust even when the base product market is competitive; specifically, we found that as consumer bias increases or past usage decreases, the prices charged by firms competing in the base product market may increase, resulting in fewer consumers purchasing the base product.

The past usage of base product ϕ is likely to smaller if the add-on is introduced soon after offering the base product. Thus, our results suggest that if the firm intends to offer the add-on soon after the base product has been purchased, the firm may be ill-served by reducing the base product prices and attempting a penetration pricing strategy. Similarly, offering the add-on soon after the base product is purchased (low ϕ) makes it optimal for the firm to offer higher-quality add-ons.

Although we considered the bias γ as an exogenous parameter in our normative model, our results from Study 2 (together with our pricing results) suggest a means by which firms may profit by manipulating coupling. Specifically, our experiments demonstrated that the coupling between the add-ons and the base product plays an important role in the magnitude of γ, which, as our normative model illustrated, influences a firm's optimal strategies. Thus, marketers may find it valuable to offer "specific" add-ons that directly bring to mind the corresponding base product and its associated account to a niche market (compared with "generic" add-ons that fail to do so, which are offered to larger markets). For instance, for an e-book reader and an e-book product pair, it seems possible that two add-ons—an e-book that can viewed only on an e-book reader versus an e-book that can be viewed on the e-book reader or a computer—would have a different extent of coupling (i.e., the degree to which the account associated with the e-book reader is uniquely associated with the add-on benefits) and should be offered under a different pricing strategy.

Another instance in which we believe our mental accounting explanation is consistent with observed practice is ancillary services provided at hotels. For instance, Wi-Fi at budget hotels tends to be cheaper (or even free) compared to hotels with higher-priced rooms. The *New York Times* suggests that "travelers have been willing to pay extra at high-end properties, [and so] those hotels continue to charge [more]" (Higgins 2009). Similar comments were echoed by an article in the *Financial Times* that compared Internet rates at luxury hotels across the world (Greene 2011). Our model offers an explanation that goes beyond the typical argument that relies on consumer heterogeneity—namely, that after paying a high price for a hotel room, people are then more willing to pay for the higher-priced Wi-Fi service.

Our model and discussion assumes that a single firm sets the price of both the base product and the add-on. Still, it is instructive to look at the smartphone market, with its channel structure for base product add-on pairs, to see how the basic insight revealed through our model plays out. Android phones are typically sold at much lower prices compared with Apple's iPhones. No doubt, this price difference is related to the competition among phone manufacturers in the Android market compared with Apple's monopoly in the iPhone market. Still, it is interesting to observe that the apps supplied by third parties for Android phones (on average) tend to not only be cheaper compared with those supplied for iPhones but have many more free apps compared with iPhones (Wauters 2010). And even when we compare the price of an app for the iPhone versus the price for that same app for an iPad (a more expensive product), we observe that iPad apps are higher priced compared to similar iPhone apps (Brown 2010). These observations are indeed consistent with our model, where the higher price of the base product, as a result of the mental accounting effect, can allow an add-on seller to charge higher prices for its add-ons.

Table 3 Optimal Pricing and Development Strategy

Past usage of base product	Consumer bias (γ): High	Consumer bias (γ): Low
High	Moderate base product and add-on quality	Penetration pricing Low base product and add-on quality
Low	Niche pricing High base product and add-on quality	Moderate base product and add-on quality

8. Conclusions

We formulated a simple (paramorphic) model to formalize how (and why) the mental account associated with a base product impacts a consumer's add-on purchase decision. Subsequently, we offered a normative model of a firm's behavior to understand how the firm's optimal pricing and development decisions would be affected by the proposed consumer bias. Before concluding, we briefly discuss some of the limitations of the current study and possible directions for future research.

The results from our experiments are consistent with the proposed bias, but because the bias was tested in an experimental design that involved participants making scenario-based choices, all the caveats associated with the methodology apply to our study as well. Still, ample precedent for the methodology in prior literature and a significant body of research that has found support for mental accounting in consumer choices from the field (for instance, see Gourville and Soman 1998 for a test of payment depreciation) suggest that the proposed effect may indeed be relevant. Studies employing field data would be necessary to gain greater confidence about the effect.

In the context of a particular base product add-on pair (razor and razor blades), Hartmann and Nair (2010, p. 382) found that people have a psychological switching cost of around $0.11, which they suggest is not "quantitatively large enough." It is interesting to observe that, in the context of base product add-on pairs, the γBV term in Equation (1), which we interpreted as the mental accounting effect, is identical to a switching cost in its effect on the consumers' willingness to pay. We do not claim that switching costs are economically significant for every single base product add-on pair, but our experimental results do at least suggest that it may be relevant to estimate a switching cost that is a function of price and past usage (possibly proxied through time since purchase).

The analytical model was deliberately kept simple to allow ease of interpretation of the implications. There are, however, two individual elements of our model that merit further discussion: (i) assumed independence between γ and consumer segment and (ii) exogenously specified bias parameter γ.

Regarding the first assumption, one may argue that a consumer's bias may also depend on her valuation of the base product or, more generally, on her "type." We intentionally kept our model simple and assumed a common γ across all consumers so as to understand the first-order effects of the consumer bias. Still, it is feasible that high-type consumers also have greater bias. However, to the extent that the bias is positively correlated with consumer type, higher bias will only increase the relative value of the high-valuation segment. As a result, we should expect a firm to respond with even more limited coverage of only the high-valuation segment.

The second assumption that γ is an exogenous known parameter was made so as to retain focus on a firm's optimal pricing strategy. Still, as our experiment illustrates, the coupling between the add-on and the base product is an important determinant of the magnitude of the identified bias. Formally developing the implications of endogenizing the bias, possibly as being determined by a firm's design decision, would be a valuable extension for the future. It is also possible that a firm might not have precise information about the strength of bias (γ) that influences a consumer's choices. Although we have laid out some qualitative thoughts on some of the determinants of γ, a formal estimation of γ is beyond the scope of this research.

This paper examines the normative implications for a firm's pricing and development decisions by a specific behavioral bias. Despite the wealth of studies that illustrate that actual purchase decisions often exhibit systematic deviations from normative models of consumer behavior, not many analytical studies have explicitly examined what (if any) implications such biases have on firm decisions. Indeed, as our analytical model illustrates, the implications may often be nontrivial, and careful modeling may be required to unearth them. A fruitful avenue for future normative research in product development and pricing would be to explicitly incorporate more of such descriptive models of consumer demand that explicitly factor in consumers' decision-making processes.

Electronic Companion

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Appendix A. Proofs

Proof of Proposition 1

The niche strategy is superior to metering iff $\Pi_n > \Pi_m$. Substituting the values of Π_n and Π_m we obtain from Equations (4) and (5), niche is superior to metering iff

$$\alpha(\eta_B v_{LB} + \eta_A v_{LA}(1+\gamma\eta_B v_{LB}(1-\phi))) > v_{LB} + \alpha\eta_A v_{LA}(1+\gamma v_{LB}(1-\phi\eta_B)). \quad \text{(A1)}$$

Similarly, saturation is superior to niche iff $\Pi_s > \Pi_n$. Substituting the values of Π_s and Π_n we obtain from

Equations (3) and (4), saturation is superior to niche iff

$$v_{LB}+v_{LA}(1+\gamma v_{LB}(1-\phi)) \\ >\alpha(\eta_B v_{LB}+\eta_A v_{LA}(1+\gamma\eta_B v_{LB}(1-\phi))).$$

That is, saturation is superior to niche iff

$$v_{LB}(\alpha\eta_B-1)+\alpha v_{LA}\eta_A<v_{LA}+\gamma v_{LB}(1-\phi)(1-\alpha\eta_B). \quad \text{(A2)}$$

Finally, saturation is superior to metering iff $\Pi_s>\Pi_m$. Substituting the values of Π_s and Π_m we obtain from Equations (3) and (5), saturation is superior to metering iff

$$v_{LB}+v_{LA}(1+\gamma v_{LB}(1-\phi))>v_{LB}+\alpha\eta_A v_{LA}(1+\gamma v_{LB}(1-\phi\eta_B)).$$

That is, saturation is superior to metering iff

$$1+\gamma v_{LB}(1-\phi)>\alpha\eta_A(1+\gamma v_{LB}(1-\phi\eta_B)). \quad \text{(A3)}$$

To evaluate the optimal strategy, we look at four possible cases: (1) $\alpha\eta_A\eta_B\le 1$; (2) $\alpha\eta_A\eta_B>1$, $\alpha\eta_B\ge 1$; (3) $\alpha\eta_A\eta_B>1$, $\alpha\eta_B<1$; and (4) $\alpha\eta_A\eta_B>1$, $\alpha\eta_B<1$, $\alpha\eta_A<1$.

Case 1 ($\alpha\eta_A\eta_B\le 1$). Comparing profits (Equations (A2) and (A3)), it can be seen that saturation is always optimal in this range. Hence, define $\gamma_1=0$ and $\gamma_2=1$ for this case.

Case 2 ($\alpha\eta_A\eta_B>1$, $\alpha\eta_B\ge 1$). First, from Equation (A1), we can see that niche is superior to metering iff

$$\gamma>\gamma_{nm}=\frac{1-\alpha\eta_B}{\alpha\eta_A v_{LA}(\eta_B-1)}. \quad \text{(A4)}$$

Obviously, constraint (A4) is always satisfied since $\gamma\ge 0$. Thus, niche is always superior to metering. Hence, to find the optimal strategy, we only need to check between niche and saturation (i.e., constraint (A2)). Comparing profits, we have that saturation is optimal iff

$$v_{LB}(\alpha\eta_B-1)+\alpha v_{LA}\eta_A<v_{LA}+\gamma v_{LB}(1-\phi)(1-\alpha\eta_B).$$

This is the same as the following condition:

$$\gamma<\gamma_{ns}=\frac{(1-\alpha\eta_A)v_{LA}+(1-\alpha\eta_B)v_{LB}}{(1-\phi)v_{LA}v_{LB}(\alpha\eta_A\eta_B-1)}. \quad \text{(A5)}$$

Thus if $\gamma<\gamma_{ns}$, saturation is optimal, and if $\gamma>\gamma_{ns}$, niche is optimal. Hence, define $\gamma_1=0$ and $\gamma_2=\gamma_{ns}$ for this case. In addition, note that γ_{ns} is positive only if η_A is sufficiently low; i.e., $\eta_A<v_{LA}-v_{LB}(\alpha\eta_B-1)/\alpha v_{LA}$. So when η_A is sufficiently high, saturation is not optimal in this range.

Case 3 ($\alpha\eta_A\eta_B>1$, $\alpha\eta_B<1$, $\alpha\eta_A<1$). From Equation (A3), it can be seen that saturation dominates metering. In restricting the comparison to saturation and niche, saturation dominates niche when $\gamma<\gamma_{ns}$, i.e., $\gamma_1=0$ and $\gamma_2=\gamma_{ns}$, for this case.

Case 4 ($\alpha\eta_A\eta_B>1$, $\alpha\eta_B<1$, $\alpha\eta_A>1$). From Equation (A3), metering dominates saturation when

$$\gamma<\gamma_{ms}=\frac{\alpha\eta_A-1}{v_{LB}((1-\phi)-\alpha\eta_A(1-\phi\eta_B))}. \quad \text{(A6)}$$

This, in conjunction with Equation (A4), implies that there exists a threshold $\gamma_1=\min[\gamma_{ms},\gamma_{nm}]$ such that if $\gamma<\gamma_1$, metering is optimal.

Second Equations (A4) and (A5) imply that there exists a threshold $\gamma_2=\max[\gamma_{nm},\gamma_{ns}]$ such that if $\gamma>\gamma_2$, niche is optimal. Hence, for $\gamma_1\le\gamma<\gamma_2$, saturation dominates niche and saturation dominates metering; hence, saturation is the optimal strategy. Again, note that γ_{ms} is positive only if $\alpha\eta_A<1$. If $\alpha\eta_A>1$, saturation is not optimal. Claims 1 and 3 follow directly from this characterization.

For sensitivity with respect to (w.r.t.) ϕ, note that

$$\frac{\partial\gamma_{ns}}{\partial\phi}=\frac{(1-\alpha\eta_A)v_{LA}+(1-\alpha\eta_B)v_{LB}}{(1-\phi)^2 v_{LA}v_{LB}(\alpha\eta_A\eta_B-1)}\ge 0,$$

$$\frac{\partial\gamma_{ns}}{\partial\phi}=\frac{(\alpha\eta_A-1)(\alpha\eta_A\eta_B-1)}{(\alpha\eta_A v_{LB}(\phi\eta_B-1)+v_{LB}(1-\phi))^2}\ge 0,$$

$$\frac{\partial\gamma_{mn}}{\partial\phi}=0.$$

It follows that γ_1 and γ_2 are nondecreasing in ϕ.

Proof of Corollary 1

When $\eta_A=\eta_B=\eta$, note that metering is not optimal because we cannot have the condition that $\alpha\eta_A>1$ and $\alpha\eta_B<1$ simultaneously. So we can restrict our attention to the comparison between niche and saturation. By rearranging Equation (A5), we can see that niche dominates saturation when

$$\gamma(1-\phi)\ge\frac{(1-\alpha\eta)(v_{LA}+v_{LB})}{v_{LA}v_{LB}(\alpha\eta^2-1)}=\tau'.$$

Note that τ' is positive and valid only if $1-\alpha\eta>0$ and $\alpha\eta^2-1>0$. So when $\alpha\eta>1$, $\tau=0$; when $\alpha\eta^2<1$, $\tau=1$. Thus τ can be represented as $\min[\max[0,\tau'],1]$. So, to determine the sensitivity of τ w.r.t. η, we have to differentiate τ' w.r.t. η, which yields

$$\frac{\partial\tau'}{\partial\eta}=\frac{\alpha(1-2\eta+\alpha\eta^2)(v_{LA}+v_{LB})}{v_{LA}v_{LB}(\alpha\eta^2-1)^2}.$$

This expression is negative when $\alpha\eta^2-1>0$. It follows that τ is nonincreasing in η.

Proof of Proposition 2

Given our multiplicative profit functions (specifically, profits have a term q_Aq_B in them), the profits can exhibit convexity, making standard first-order conditions insufficient. To overcome this issue, we work with an additional constraint—specifically, we assume that $q_A\in[K,2K]$ and $q_B\in[K,2K]$ for an arbitrary K.[13]

Define the profits associated with different strategies after taking into consideration the development costs. Let $\pi_x=\Pi_x-C_B(q_B)-C_A(q_A)$, where $x\in\{m,s,n\}$ denote the strategies of metering, saturation, and niche, respectively.

First note that from Corollary 1, we know that metering can never be optimal. (Specifically, suppose q'_A and q'_B are the optimal qualities under metering. Then, if we use the same qualities in either a niche or saturation strategy, the corollary guarantees us that at least one of these should give us higher profits compared with the optimal metering strategy. That is, metering is never optimal.)

Hence, we need to only consider π_s and π_n. Define a new variable, $\psi=\gamma(1-\phi)$. Examining them (from Equations (3)

[13] Although one can find alternative, and possibly weaker, constraints that will yield the same results, we note that this assumption mostly involves only a rescaling of qualities, which can always be accomplished by rescaling the arbitrary cost functions.

and (4)) shows that both of these profits are supermodular in (q_A, q_B), (q_A, ψ), and (q_B, ψ).

Next, consider

$$\begin{aligned}\Pi_n - \Pi_s &= (v_{LA}+v_{LB})(\alpha\eta-1)+\gamma v_{LA}v_{LB}(1-\phi)(\alpha\eta^2-1)\\ &= (v_{LA}+v_{LB})(\alpha\eta-1)+\psi v_{LA}v_{LB}(\alpha\eta^2-1).\end{aligned}$$

When $\alpha\eta^2<1$ (which immediately implies $\alpha\eta<1$), we have that saturation (if it uses the qualities optimal under the niche strategy) will always result in higher profits. Hence, when $\alpha\eta^2<1$, saturation is always optimal. Furthermore, in this region (given the supermodularity of π_s identified earlier), the optimal quality is always nondecreasing in γ.

Similarly, when $\alpha\eta>1$ (which immediately implies that $\alpha\eta^2>1$), we have the niche strategy always being optimal. Furthermore, in this region (given the supermodularity of π_n identified earlier), the optimal quality is always nondecreasing in ψ.

Hence, the only relevant case left to analyze is when $\alpha\eta<1$ and $\alpha\eta^2>1$, in which case

$$\frac{\partial(\Pi_n-\Pi_s)}{\partial\psi}=Nv_{LA}v_{LB}(\alpha\eta^2-1)>0.$$

In this region, saturation is optimal if $\pi_s>\pi_n$, which allows us to find a useful bound for ψ below which saturation is always optimal. Specifically, saturation is always optimal when

$$\psi<\psi'=\min_{V_{LB},V_{LA}}\left\{\left(\frac{1}{v_{LB}}+\frac{1}{v_{LA}}\right)\frac{1-\alpha\eta}{\alpha\eta^2-1}\right\}.$$

Note that the condition is not an if and only if condition; i.e., we know that for sufficiently low ψ (for this case), saturation is optimal.

Since $v_{LB}=\theta_{LB}q_B$ and $v_{LA}=\theta_{LA}q_A$, and since by assumption $q_B\in[K,2K]$ and $q_A\in[K,2K]$, we have

$$\psi'<\left(\frac{1}{2K\theta_{LB}}+\frac{1}{2K\theta_{LA}}\right)\frac{1-\alpha\eta}{\alpha\eta^2-1}=\frac{1}{K\theta_L}\frac{1-\alpha\eta}{\alpha\eta^2-1}.$$

Since we assumed that $\theta_{LB}=\theta_{LA}=\theta_L$, this implies that when $\alpha\eta^2>1$ and $\psi<(1-\alpha\eta)/(K\theta_L(\alpha\eta^2-1))<\psi'$, saturation is optimal.

The last remaining case to examine is when $\alpha\eta<1$ and $\alpha\eta^2>1$, and $\psi>\psi'=(1-\alpha\eta)/(K\theta_L(\alpha\eta^2-1))$:

$$\begin{aligned}&\frac{\partial(\Pi_n-\Pi_s)}{\partial q_B}\\ &=N\theta_{LB}(\alpha\eta-1+\psi v_{LA}(\alpha\eta^2-1))\\ &>N\theta_{LB}\left(\alpha\eta-1+\frac{1-\alpha\eta}{K\theta_L(\alpha\eta^2-1)}\theta_L q_A(1-\phi)(\alpha\eta^2-1)\right)\\ &=N\theta_{LB}(1-\alpha\eta)\left(-1+\frac{q_A}{K}\right)>N\theta_{LB}(1-\alpha\eta)\left(-1+\frac{K}{K}\right)=0.\end{aligned}$$

Similarly,

$$\frac{\partial(\Pi_n-\Pi_s)}{\partial q_A}=N\theta_{LA}(\alpha\eta-1+\psi v_{LB}(\alpha\eta^2-1))>0.$$

That is, if we define the strategy space as $\{s,n\}$ (with the ordering that $n>s$), then the above shows that the profits are supermodular in strategy and qualities and supermodular in strategy and ψ. In addition, recall from earlier that each of the profits (under a given strategy) is supermodular in qualities and supermodular in quality and ψ. Together, this implies that profit function is supermodular, which immediately shows that there exists a threshold on ψ above which niche will dominate saturation. In addition, given the supermodularity, both q_A^* and q_B^* are nondecreasing in ψ. Since both q_A^* and q_B^* are increasing in ψ, $R^*=C_A(q_A^*)+C_B(q_A^*)$ is also increasing in ψ. The proof is completed by observing that ψ defined as $\gamma(1-\phi)$ is increasing in γ and decreasing in ϕ. Hence, the thresholds with respect to ψ can be translated in a straightforward manner to the thresholds on γ and ϕ.

Proof of Proposition 3

Proof of Claim (a). Let G represent the n-person game where person i's payoffs are given by $\Pi_i=D(p_i,p_{-i})((1+\gamma v_i)p_i+v_i-\gamma v_i\psi_i)$. Her strategy is (the price) p_i. Let $\bar{P}$ be an arbitrarily high price at which the demand drops to 0. Hence, to find the equilibria for this game, we only need to focus on prices $p_i\in[0,\bar{P}]$.

Now consider the n-person game G' where person i's payoffs are given by $\Pi_i'=\ln((1/(1+\gamma v_i))\Pi_i)=\ln D(p_i,p_{-i})+\ln(p_i+(v_i-\gamma v_i\psi_i)/(1+\gamma v_i))-\ln(1+\gamma v_i)$. Since the game G' involves a monotonic transformation of G, there is a one-to-one mapping between the equilibrium for the two games. Hence, it is sufficient for us to focus on the game G'.

By Assumption A2, the demand function D_i is such that the elasticity is nonincreasing in competitors' prices. That is,

$$\begin{aligned}0\geq\frac{\partial}{\partial p_j}\left(-\frac{\partial\ln D_i}{\partial\ln p_i}\right)&=-p_i\frac{D_i(\partial^2D_i/\partial p_i\partial p_j)-\partial D_i/\partial p_j}{D_i^2}\\ &=-p_i\frac{\partial^2}{\partial p_i\partial p_j}\ln D_i.\end{aligned}$$

That is, $\partial^2\ln D_i/\partial p_i\partial p_j\geq 0$. Hence, $\ln D_i$ is supermodular in (p_i,p_j) for $j\neq i$. Hence, for the game G', the payoff Π_i' is supermodular in (p_i,p_{-i}). Furthermore, define $\rho=(v_i-\gamma v_i\psi_i)/(1+\gamma v_i)$; straightforward differentiation then shows that $\partial^2\Pi_i'/(\partial p_i\partial\rho)\leq 0$. That is, Π_i' is supermodular in $(p_i,-\rho)$. Finally, noting that ρ is decreasing in γ, we show that Π_i' is supermodular in (p_i,γ).

From the preceding observations, it trivially follows from Theorem 6 of Milgrom and Roberts (1990) that there exists Nash equilibria in pure strategies given by p_i^*. Furthermore, the strategies (corresponding to the Pareto Nash equilibrium) are increasing in γ.

Additional results about the sensitivity of the prices with respect to the parameters can be easily derived. For instance, as noted in §6.2, consider the sensitivity of ρ w.r.t. to add-on quality v_i. Specifically, $d\rho/dv_i=(1-\gamma\psi)/(v\gamma+1)^2$, which is negative for sufficiently high γ and positive otherwise. Stated differently, for sufficiently high bias, the equilibrium price p_i^* is increasing in v_i, whereas for low bias, the equilibrium price p_i^* is decreasing in v_i.

Proof of Claim (b). The total number of consumers who purchase the base product is given by $\sum_k D_k$. Taking the derivative of this with respect to γ, we get

$$\begin{aligned}\frac{d}{d\gamma}\sum_k D_k&=\sum_k\sum_i\frac{\partial D_k}{\partial p_i}\frac{dp_i}{d\gamma}=\sum_i\sum_k\frac{\partial D_k}{\partial p_i}\frac{dp_i}{d\gamma}\\ &=\sum_i\frac{dp_i}{d\gamma}\left(\sum_k\frac{\partial D_k}{\partial p_i}\right)\end{aligned}$$

≥ 0 since $\sum_k \frac{\partial D_k}{\partial p_i} \geq 0$ (by Assumption A1), and

$\frac{dp_i}{d\gamma} \geq 0$ (by claim (a)).

Appendix B. Instructions for the Experiments

Study 1. Instructions (Smartphone and Karaoke Game)
Please read through the scenario outlined below and answer the question given at the end.

Suppose 12 weeks back you bought a smartphone priced at $400 at a sale price of [$250/$350]. In addition to using it to make and receive calls, you were planning on using it for both your work-related emails and as a general video player for your personal use.

As soon as you purchased the phone you could start using it to make and receive calls and to watch videos. However, because of some network firewall issues, you could not immediately start using the phone to check your work-related emails since the IT folks at your school could not immediately correct the network problem.

After you bought the phone, it took the IT folks [2/4] weeks to install a software patch on their server to take care of the network issues, and since then you have not had any problems accessing the email from your phone.

Now, you are thinking of purchasing a new game that costs $20. The game, which can be played on your phone, is a karaoke game that lets players sing along with numerous pop and rock music songs.

How likely are you to purchase the game?

(Circle your choice. 1 represents extremely unlikely and 7 represents extremely likely.)

1 2 3 4 5 6 7

Study 2. Instructions (Ski Resort Pass and Queue-Skipping Voucher)
Welcome to our short survey. Please read the scenario below carefully and answer the question given at the end.

Suppose you are planning on going skiing for two days. You plan on arriving at a ski resort Saturday morning and departing Sunday night.

Before leaving your hometown, you have purchased a single two day ski pass. The price of the ski pass is [$130/$230].

The ski pass allows you unlimited skiing on the resort's slopes for the two days starting on a Saturday morning till Sunday night. On Saturday, when you arrive, the weather is terrible, because of which the ski slopes are closed down for [all of the morning/most of the day] and you are unable to ski during that time.

The weather clears up on the second day. While the ski slopes are getting crowded, you anticipate being able to ski for the whole day. You are heading out to ski, when you see that the general store is having a sale on a voucher for a discounted price of $40.

This voucher allows you to not stand in queues for the ski-lift, and can be used to avoid any lengthy waits to get on the slopes. The voucher is valid for one day, and if purchased may be used [only today/any day within the next one year].

Given the above scenario, on a scale of 1 to 7, how likely are you to purchase the voucher? (Mark your choice. 1 represents extremely unlikely and 7 represents extremely likely.)

1 2 3 4 5 6 7

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