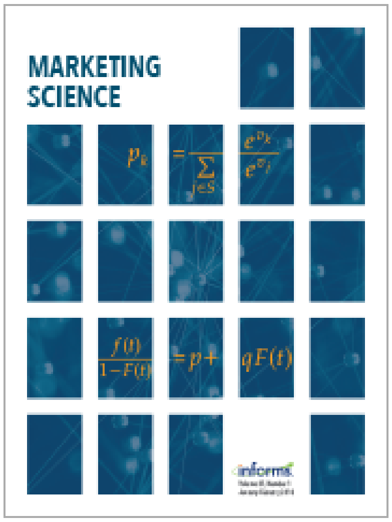

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Wilfred Amaldoss, Chuan He,

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Direct-to-Consumer Advertising of Prescription Drugs: A Strategic Analysis

Wilfred Amaldoss
Fuqua School of Business, Duke University, Durham, North Carolina 27708,
wilfred.amaldoss@duke.edu

Chuan He
Leeds School of Business, University of Colorado, Boulder, Colorado 80309,
chuan.he@colorado.edu

Consumers cannot purchase a prescription drug without a prescription from a physician, yet many prescription drugs are promoted to consumers with the help of direct-to-consumer (DTC) advertising. In this paper, we propose and test a competitive model of DTC advertising. We find that the brand specificity of DTC advertising can have an inverted U-shaped relationship with detailing, DTC advertising, and profits. Furthermore, an increase in the cross-price sensitivity between competing prescription drugs is not always detrimental to firm profits. A laboratory test lends qualitative support to some of our model predictions. We also discuss potential implications of DTC advertising for generic drugs and over-the-counter drugs.

Key words: direct-to-consumer advertising; pharmaceutical marketing; experimental economics; game theory
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1. Introduction

Traditionally, pharmaceutical companies have promoted prescription drugs by detailing their product to physicians and by advertising in medical journals. Indeed, these drugs cannot be purchased by consumers without a prescription from a physician. However, many pharmaceutical companies have begun to engage in direct-to-consumer (DTC) advertising. Following the Food and Drug Administration's relaxation of the guidelines for pharmaceutical advertising in the mass media, DTC advertising expenditure has grown from a meager \$0.84 billion in 1997 to \$4.1 billion in 2004 (Anantharaman et al. 2005). Now drugs with high DTC spending are among the best-selling drugs. In 2000, the oral antihistamines Claritin, Allegra, and Zyrtec accounted for 86% of all oral antihistamine sales, and all three were among the 15 most heavily advertised drugs. Furthermore, 22 of the 50 drugs with the highest DTC spending in 2000 were among the 50 best-selling drugs (Duhamel et al. 2002).

The surge in DTC advertising has drawn the attention of marketing scholars, and they have studied the role and effectiveness of DTC advertising. Upon analyzing the promotion expenditures of antiallergy drugs, Narayanan et al. (2004) find that DTC advertising significantly influences category sales, whereas detailing plays a crucial role in determining the market share of a brand (see also Iizuka and Jin 2005, Rosenthal et al. 2003, Wosinska 2002). In the case of cholesterol-lowering drugs, Wosinska (2005) finds that DTC advertising improves patient compliance with prescribed therapy. However, the additional sales resulting from compliance are no more than 15% of the advertising expenditure. After studying 400 brands, Neslin (2001) reports that the return on investment (ROI) for DTC advertising is \$0.19. A later study by Wittink (2002) clarifies that DTC advertising could have an ROI of more than \$1 in the case of brands with sales over \$500 million. Accordingly, the ROI for DTC advertising is higher for antiallergy drugs and ranges from \$3.70 to \$2.79 (Narayanan et al. 2004). Our focus, however, is different from this small but growing body of marketing literature on DTC advertising.

We seek answers to a few questions about the strategic implications of DTC advertising. For instance, consumer surveys indicate that DTC advertising motivates people to play a more active role in their treatment (Weissman et al. 2004). Furthermore, DTC advertising seems to encourage consumers to inquire about a specific brand of prescription drug with their physicians, and the physicians in turn often prescribe it. In a Food and Drug Administration (FDA) survey, half of the patients surveyed claimed that they were prescribed the drug they asked about (Aikin et al. 2004). This observation raises the question: How does the level of brand specificity of DTC advertising affect promotion expenditures, drug prices, and firm's profits? We note that the market for some categories of prescription drugs is more price sensitive than others. For example, the market is more sensitive to the prices of antiarthritis drugs and anticholesterol drugs but less sensitive to the prices of colon cancer drugs. It is natural to expect firm's profits and prices to decline in cases where consumers are more sensitive to prescription drug prices. In such cases, however, firms could use DTC advertising to soften competition. This leads to the next question: In the presence of DTC advertising, can an increase in consumer sensitivity to prescription drug prices improve firm's profits? We note that DTC advertising helps branded prescription drugs to build goodwill among consumers, and typically generic drug manufacturers compete against branded drugs on the basis of price. This begs the question: Is it possible that brand-specific DTC advertising by prescription drug manufacturers may help generic drug manufacturers to charge higher prices and earn more profits? When a prescription drug is regarded as safe for self-medication, the FDA approves the drug to be sold over the counter. For example, Prilosec and Claritin can now be purchased without a prescription. This raises yet another question: How does the possibility of transitioning a prescription drug to over-the-counter (OTC) status affect DTC advertising?

Overview

The purpose of this paper is to take an initial step in experimentally investigating the phenomenon of DTC advertising. Building on the empirical literature on DTC advertising and attitude research, we propose and test a parsimonious model of DTC advertising. Consistent with the finding that DTC advertising may motivate some consumers to specifically seek the advertised prescription drug (Aikin et al. 2004 and Weissman et al. 2004), we allow for the possibility that DTC advertising could be brand specific to varying levels. In our duopoly model, firms compete using three marketing variables: DTC advertising, detailing, and price. Our analysis shows that drug prices, DTC advertising, detailing, and profits have an inverted U-shaped relationship with the level of brand specificity of DTC advertising (Proposition 1). This result suggests that moderate levels of brand-specific DTC advertising are conducive for firm's profits and could well stimulate increased use of DTC advertising. Typically, increased consumer sensitivity to price hurts firm profits. In the presence of DTC advertising, however, we find that sometimes an increase in cross-price sensitivity improves firm's profits (Proposition 2).

In an extension, we examine how brand-specific DTC advertising may influence generic drug prices and profits. In our formulation, the prescription drug manufacturers are Stackelberg leaders, whereas the generic drug manufacturer is a follower. In this setting, there is room to fear that the goodwill built by prescription drugs through brand-specific DTC advertising could hurt generic drug prices and profits. However, our analysis shows that if firms act strategically, the outcome may benefit generic drug manufacturers through better prices and profits. In another extension we examine the strategic implications of OTC drugs. Consistent with Proposition 2, we find that if cross-price sensitivity is low, then OTC drug prices and expenditures in DTC advertising may be higher.

Next we assess the predictive accuracy of the model. Study 1 examines how the brand specificity of DTC advertising influences price, detailing, advertising, and firm profits. Observed behavior is qualitatively consistent with the inverted U-shaped relationship predicted by Proposition 1. In Study 2, we investigate how cross-price sensitivity impacts firm decisions and profits. Consistent with Proposition 2, firms earn more profits as cross-price sensitivity increases. In an attempt to illustrate that our model can potentially inform managerial decision making, we estimate our model parameters using the summary statistics reported in Narayanan et al. (2004) and make some conjectures about the antiallergy drug market.

Related Literature

The literature on DTC advertising is small and recent (e.g., Narayanan et al. 2004, Neslin 2001, Wittink 2002, Wosinska 2005), but there is a large body of empirical research that investigates how firms promote prescription drugs among physicians rather than consumers. Rizzo (1999) challenges the conventional wisdom that drug purchasers are generally price insensitive. In an analysis of branded antihypertensive drugs marketed in the United States during the period 1988–1993, he finds that the demand for these drugs responds quite elastically to changes in price in the absence of detailing, but that detailing reduces price responsiveness. The sales promotion of branded drugs also serves an important strategic purpose by helping to defend branded drugs from generic drugs (Hurwitz and Caves 1988). Typically, a branded drug price declines with the number of generic entrants, but the rate of decline is small (Caves et al. 1991).

In an interesting multimarket study, Chintagunta and Desiraju (2005) examine how the nature of both within- and across-market interfirm strategic interactions affect the prices and detailing expenditures of Zoloft, Paxil, and Prozac in five countries (see also Desiraju et al. 2004). They report evidence of a home-market advantage and a tendency to be more aggressive in defending the home market and to be more cooperative in overseas markets.

Our work is related to the literature on generic advertising (e.g., Krishnamurthy 2000, Bass et al. 2005). Krishnamurthy (2000) uses a static model, whereas Bass et al. (2005) use a dynamic model to investigate how a firm should allocate its resources between two types of advertising: generic advertising and brand advertising. In these models, a firm's brand advertising influences its market share, whereas its generic advertising expands the overall market and has a positive spillover effect on its competitor. The issue of spillover is also studied in the research and development (R&D) literature (see Amir 2000, Grünfeld 2003, Kamien and Zang 2000). As in these R&D models, we allow investments to have firm-specific effects, but study a different phenomenon and address a different set of issues. We examine how DTC advertising influences the behavior of prescription drug marketers.

The literature on brand advertising is also related to our research. Persuasive advertising influences consumer preference for a product, and this effect has been modeled in different ways in the literature (Becker and Murphy 1993, Soberman 2004). For example, persuasive advertising may work by increasing the perceived value of a product, shaping consumer preferences to fit the characteristics of a product, or moderating the weights consumers attach to different product attributes. Informative advertising, on the other hand, increases consumer awareness without affecting their preferences (Nelson 1974, Grossman and Shapiro 1984, Meurer and Stahl 1994). In contrast to these individual-level models of advertising, the extant empirical research on DTC advertising attempts to investigate the phenomenon using aggregate demand functions (e.g., Narayanan et al. 2004, Wosinska 2005). Consequently, the extant literature does not distinguish between the informative and the persuasive roles of DTC advertising. In the tradition of this body of literature, we also use an aggregate demand model to study the implications of DTC advertising.

Contribution

Our work adds to the marketing literature on DTC advertising in several ways. First, we propose a parsimonious model of DTC advertising that is consistent with prior research on DTC advertising and consumer attitude. Second, we show that the brand specificity of DTC advertising has a nonlinear relationship with prices, profits, and promotion expenditures. Third, we find that an increase in the cross-price sensitivity of consumers can improve firm profits, if firms engage in DTC advertising. Fourth, in contrast to prior empirical literature on DTC advertising, we use a laboratory experiment to test our model predictions. Such tests could be a useful complement (not substitute) to the marketing literature on DTC advertising, which largely relies on analysis of pharmaceutical sales data. Finally, we show how our model can be extended to consider generic drugs and OTC drugs.

The rest of the paper is organized as follows: Section 2 introduces a simple demand model, then extends the model to reflect some important characteristics of DTC advertising, and examines its equilibrium implications. Section 3 presents and discusses the results of an experimental investigation. Finally, §4 summarizes the findings and concludes by providing a few directions for further research.

2. A Model of DTC Advertising

In this section, we first present a simple aggregate demand model that is grounded in a well-defined utility function. Next we discuss a few salient empirical findings on DTC advertising. Based on these findings, we extend the simple demand model to allow for DTC advertising and detailing. Then we analyze how the level of brand specificity of DTC advertising influences firm's profits, prices, and promotional expenditures. We also examine the impact of consumer price sensitivity on firm's profits and prices.

A Simple Demand Model. Shubik and Levitan (1980, p. 132) proposed a utility function that can be used to derive an aggregate demand function. The utility function accounts for substitutability among goods, and it is concave in that consumption utility increases at a decreasing rate. The Shubik and Levitan utility function is given by

$$U(q, m) = V\sum_{i=1}^{n} q_i - \frac{1}{2\beta(1+\gamma)}\left[\sum_{i=1}^{n}\frac{q_i^2}{w_i} + \gamma\left(\sum_{i=1}^{n} q_i\right)^2\right] + \lambda m, \quad (1)$$

where $V = \alpha/\beta$, with α being the demand intercept and β being the own-price coefficient, γ measures the degree of substitutability of the goods, w_i is the market share weight of firm i such that $\sum w_i = 1$, m is the amount of money held by the consumers, λ is the marginal worth of money, and q is the vector of demand for all the n goods.

The first part of Equation (1) shows that the total utility depends on all the goods consumed. The second part of the equation suggests that the utility function is concave and that the function discounts the total utility for substitutability among goods. Now assuming that consumers maximize their utility subject to their budget constraint, we obtain the following aggregate demand function for a duopoly:

$$q_i = \alpha - p_i + \theta(p_j - p_i), \quad (2)$$

where α is a firm's base demand, p_i and p_j are the wholesale prices, and $\theta = \frac{1}{2}\gamma$ is a measure of cross-price sensitivity between the two drugs.[1] Equation (2)

[1] For a proof for this claim, please see Appendix B. All appendices are available in the Technical Appendix, which can be found at http://mktsci.pubs.informs.org.

is similar in spirit to the demand formulation of Raju et al. (1995). Whereas Raju et al. (1995) build on this simple demand model to investigate competition between national brands and store brands in the retail industry, we extend this basic demand structure to study competition in the pharmaceutical industry. However, before adapting the simple demand model, we outline some key empirical findings on DTC advertising.

Salient Empirical Findings on DTC Advertising. The following four findings form the bases of our model of DTC advertising.

DTC advertising increases traffic to clinics. Many patients neither recognize the early warning signs of illnesses nor do they know that new medicines are available to improve their health condition. Consequently, patients often fail to consult their physicians. Zachry et al. (2002) report that DTC advertising improved consumer awareness of colon cancer from 6% to 30% and thereby significantly increased the number of patients seeking medical advice on colon cancer (by approximately 75%). They present evidence of similar effects of DTC advertising for health conditions such as seasonal allergies and peptic ulcers. An FDA study reports that physicians concur that DTC advertising promotes better awareness of both potential medical conditions and alternative treatments among patients (Aikin 2003), which suggests that DTC advertising can be category specific. On analyzing antiallergy drug sales, Narayanan et al. (2004) found that DTC advertising has a significant positive effect on category sales. Detailing, on the other hand, has been found to be far more effective in determining brand share.

DTC advertising may help the sponsoring brand more than the competing brand. Weissman et al. (2004) report that in 39.1% of doctor visits, where patients engaged in DTC advertising-based discussion, the physicians actually prescribed the advertised drug. However, in another 22.4% of the occasions the doctors prescribed drugs that were not featured in the DTC advertising discussed by patients. These empirical findings suggest that DTC advertising need not be purely category specific, but could be brand specific to some extent. It is important to note that a patient, however much motivated by DTC advertising, cannot purchase an advertised prescription drug without a physician's prescription. The extent to which a physician is open to accommodate a patient's request for an advertised prescription drug may depend on the degree to which the side-effects profile and the effectiveness of the advertised drug are comparable to alternative drugs in the product category. Thus, it seems that the brand-specific effect of DTC advertising may vary across drug categories.

DTC advertising of competing firms could have synergistic effects on consumers. Attitude research in psychology suggests that when consumers are exposed to multiple sources of persuasion they are more persuaded (Harkins and Petty 1981). This increased persuasion could be a consequence of several factors. Consumers exposed to multiple sources of persuasion apply more effort in processing the information, generate more favorable thoughts, and thus elaborate on the message more (Petty et al. 1981, Cacioppo et al. 1986). Consumers may also conclude that there is a larger pool of favorable arguments because of the multiplicity of sources. An implication of this body of research is that the synergy between the DTC advertising of competing firms has a positive effect on consumers over and above the direct effect of the DTC advertising of each firm. This synergy is likely to grow and increase traffic to clinics as the DTC advertising becomes more category specific rather than brand specific.

Demand for prescription drugs is sensitive to price. It is useful to take note of another feature of the prescription drugs market: consumers buy health insurance, which allows them to purchase branded prescription drugs for a fixed copayment, implying that consumer payment does not vary with prescription. This makes one wonder whether consumer demand, in turn, is sensitive to prescription drug prices. Although purchasing prescription drugs is a complex decision process involving health management organizations and physicians, Chintagunta and Desiraju (2005, pp. 68–69; see also Rizzo 1999) show that drug prices affect consumer demand. Furthermore, they establish that firms use wholesale price as a strategic variable in marketing prescription drugs. Thus, the demand for a prescription drug depends not only on its detailing and advertising expenditures, but also on its price. Next we extend the simple demand model discussed earlier.

Extended Demand Model. We extend the basic demand structure in two important ways by incorporating the effect of DTC advertising and detailing.

DTC advertising. We would like to extend the simple demand formulation such that it captures the essence of the empirical findings on DTC advertising. In principle, the impact of a firm's own DTC advertising on its demand should be concave. That is, $\partial q_i/\partial a_i > 0$ and $\partial^2 q_i/\partial a_i^2 \leq 0$, where a_i denotes the DTC advertising level of firm i. As DTC advertising tends to expand the market, it is preferable that competitor's advertising has a nonnegative effect on the firm's demand, implying $\partial q_i/\partial a_j \geq 0$. However, competitor's DTC advertising should *decrease* a firm's market share, namely, $q_i/(q_i + q_j)$, provided the advertising is brand specific. Furthermore, the functional form of DTC advertising should be well defined for all possible levels of brand specificity of DTC advertising.

Formally, we incorporate the notion of brand specificity of DTC advertising in Equation (2) as follows:

$$q_i = \alpha + \gamma[a_i + (1-\delta)a_i^{\delta}a_j^{1-\delta}] - p_i + \theta(p_j - p_i). \quad (3)$$

In Equation (3), $\gamma \in (0, \infty)$ measures the efficacy of DTC advertising and $\delta \in [0, 1]$ captures the brand specificity of DTC advertising. In our formulation, the direct effect of firm i's DTC advertising is given by γa_i, whereas the indirect effect because of synergy with the other firm's advertising is given by $\gamma(1-\delta)a_i^{\delta}a_j^{1-\delta}$. To understand the meaning of δ, note that when DTC advertising is completely brand specific, that is, $\delta = 1$, one firm cannot benefit from the advertising of the other firm as the indirect effect is reduced to zero. However, when $\delta \in (0, 1)$, the advertising of competing firms interact and augment the indirect market expansion effect of DTC advertising.[2] Note that our model of DTC advertising has additional properties that are also desirable. For example, the benefit from a firm's own DTC advertising exhibits diminishing returns. Specifically, for $a_i \geq 0$, we have

$$\frac{\partial q_i}{\partial a_i} = \gamma[1 + \delta(1-\delta)a_i^{\delta-1}a_j^{1-\delta}] > 0 \quad (4)$$

and

$$\frac{\partial^2 q_i}{\partial a_i^2} = -\gamma\delta(1-\delta)^2 a_i^{\delta-2}a_j^{1-\delta} \leq 0. \quad (5)$$

Competitor's DTC advertising also produces diminishing marginal returns.[3] Furthermore, an increase in competitor's DTC advertising increases q_j and thereby indirectly hurts firm i's market share when DTC advertising is brand specific. Our formulation of DTC advertising is consistent with R&D models that allow for technology spillover (Grünfeld 2003, Kamien and Zang 2000). We assume that the cost function for DTC advertising is convex, and it is given by ta_i^2. The effect of such a convex cost function for DTC advertising is analogous to that of a concave advertising response function.

Detailing. In keeping with prior empirical research on DTC advertising, we assume that detailing influences market share but not category sales (Iizuka and Jin 2005, Narayanan et al. 2004, Rosenthal 2000). As physicians diagnose the ailments that afflict patients and prescribe appropriate drugs for treating the medical conditions, firms invest in detailing their products to physicians. We denote by d_i the level of detailing of firm i. We assume that the cost of detailing is kd_i^2, implying that it increases at an increasing rate. On incorporating the effect of detailing in Equation (3), we have

$$q_i = \alpha + \gamma[a_i + (1-\delta)a_i^{\delta}a_j^{1-\delta}] - p_i + \phi(d_i - d_j) + \theta(p_j - p_i). \quad (6)$$

One can view detailing as an effort to "push" a prescription drug to physicians, and DTC advertising as an attempt to create a "pull" for the drug (e.g., Gerstner and Hess 1995). In this parsimonious model, we assume that detailing and DTC advertising have independent effects on the demand for a drug. Furthermore, cross-price sensitivity is not related to brand specificity of DTC advertising. Like Chintagunta and Desiraju (2005), we also abstract away from the finer details of the multiperson medical decision-making unit and focus on the influence of strategic variables on the aggregate demand. Using this extended demand model, we next examine the strategic implications of DTC advertising.

Analysis

Consider two firms (i and j) competing to market a prescription drug for a common ailment. These firms use DTC advertising to generate traffic to clinics, and employ detailing to promote their products to physicians. As discussed earlier, a_i, d_i, and p_i denote the DTC advertising, detailing, and price of firm i, respectively. The costs of advertising and detailing are ta_i^2 and kd_i^2, respectively. We normalize the marginal cost of production to zero without loss of generality. The two symmetric firms simultaneously make their decisions on detailing, DTC advertising, and pricing. We initially view the level of brand specificity of DTC advertising as a characteristic of the drug category and treat it as an exogenous variable in our model but later we examine the strategic implications of making it an endogenous variable (Shugan 2004). When brand specificity is an endogenous variable, we allow firms to decide on the level of brand specificity along with price, advertising, and detailing decisions.

Impact of Brand Specificity of DTC Advertising. Upon studying the effect of brand specificity of DTC advertising on equilibrium prices, profits, and promotion expenditures, we have the following proposition.

Proposition 1. *Firm prices, detailing, DTC advertising, and profits have an inverted U-shaped relationship with the brand specificity of DTC advertising. That is, there exists $\delta_0 \leq \delta_1 < \delta_2$, such that π_i^* is increasing for $\delta \in [0, \delta_0]$, p_i^*, and d_i^* are increasing for $\delta \in [0, \delta_1)$, and a_i^* is increasing for $\delta \in [0, \delta_2)$ and decline thereafter.*

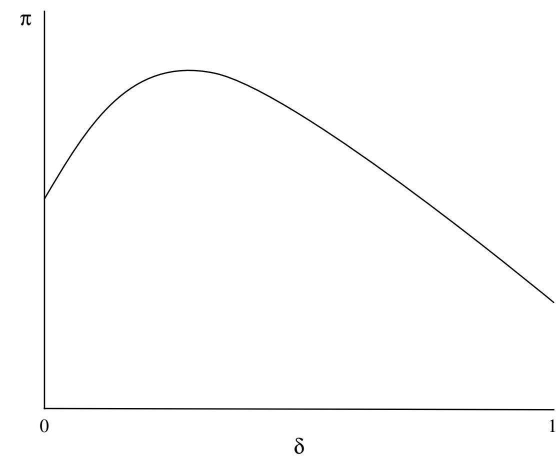
[2] An analysis of the effect of DTC advertising of antihistamines shows that it expands the market (Iizuka and Jin 2005) but does not have a significant brand-specific effect (Iizuka and Jin 2006), implying that δ tends to zero in this therapeutic category. On the other hand, the DTC advertising of Lamisil, a drug used to treat fungal infections of toenails, helped to double its prescriptions within one month of the ad campaign, although the prescriptions for its competing product declined during that period (Jong et al. 2004, see also Mintzes 2006, p. 21). This implies that the brand specificity of Lamisil's DTC advertising was significantly higher.

[3] $\partial q_i/\partial a_j = \gamma(1-\delta)^2 a_i^{\delta}a_j^{-\delta} \geq 0$. Further, $\lim_{a_i \to 0}\lim_{\delta \to 0} a_i^{\delta} = 1$, and $\lim_{\delta \to 0}\lim_{a_i \to 0} a_i^{\delta} = 0$.

The intuition for this finding is as follows. When DTC advertising is not brand specific, the advertising efforts of a firm help to expand the overall market, and the other firm can compete for a share of the expanded market. Thus, there is an opportunity for one firm to free ride on the DTC advertising of the other firm. When the brand specificity of DTC advertising increases from zero to δ_1, it dampens the tendency to free ride on the DTC advertising of the competing firm. Hence, firms spend more on DTC advertising to develop the market, increase detailing expenditures to improve market share, and charge higher prices to raise profits. Next, as the brand specificity of DTC advertising increases further from δ_1 to δ_2, firms invest more in DTC advertising because of further reduction in free riding. However, the increased brand specificity makes DTC advertising less synergistic and hence less effective in expanding the market. The resulting market is less attractive, and hence firms spend less on detailing, but instead compete on prices. Finally, firm's profits hinge on the two countervailing effects of brand-specific DTC advertising. On one hand, a higher level of brand specificity reduces the ability of a competitor to free ride on a firm's advertising expenditure, and, consequently, the firm spends more on advertising and detailing. On the other hand, as brand specificity increases there is less synergy between the DTC advertising of the two firms, and hence its market expansion effect is reduced. On balance, firm profits increase as δ increases from zero to δ_0, but decline thereafter.

In the preceding analysis we assumed that brand specificity of DTC advertising is a characteristic of the drug category. However, perhaps firms can control the emphasis given to drug category benefits (e.g., alleviation of category-specific symptoms) vis-à-vis brand-specific benefits (e.g., brand-specific side-effect profile) in its DTC advertising campaign.[4] To the extent that firms can influence the brand specificity of DTC, it is useful to reflect on the following question: What should be the optimal level of brand specificity if firms can control the degree of brand specificity of DTC advertising? Furthermore, how will

Figure 1 **Profits as an Implicit Function of δ**



the efficacy of DTC advertising, cross-price sensitivity, and efficacy of detailing influence the optimal level of brand specificity, namely, δ^*? To explore this issue, we assumed that firms simultaneously decide on prices, detailing, DTC advertising, and its brand specificity. Then we derived π^*, p^*, d_i^*, and a_i^* as implicit functions of δ (see Technical Appendix A, found at http://mktsci.pubs.informs.org). To appreciate the complexity involved in solving for δ^*, consider the equilibrium profit as a function of δ:

$$\pi^* = \frac{t\alpha^2[4kt(\theta+1) - k\gamma^2(-\delta^2+\delta+1)^2 - t\phi^2]}{k[2t(\theta+2) - \gamma^2(\delta^3 - 3\delta^2+\delta+2)]^2}. \quad (7)$$

Clearly, a closed-form solution of δ^* that maximizes π^* does not exist because of the fact that δ appears as high-powered polynomials in π^*. However, we can illustrate the properties of δ graphically. Figure 1 shows how profits vary with δ for given α, θ, γ, ϕ, k, and t. It is easy to see that profits are a concave function of δ as asserted in Proposition 1, and the peak of the profit function gives the optimal level of brand specificity, namely, δ^*. It is of interest to consider some comparative statics of δ^*. Our analysis shows that when cross-price sensitivity parameter θ increases from 1 to 5, the corresponding δ^* increases 29%, implying that firms increase the level of brand specificity of their DTC advertising if cross-price sensitivity increases. We observe a similar increase in brand specificity as the effectiveness of DTC advertising increases. For example, if γ increases from 0.6 to 1, the corresponding δ^* increases 75%. In both of these cases, firms increase brand specificity to internalize the benefits of its DTC advertising. However, as the effectiveness of detailing increases, firms are more open to reducing the brand specificity of their advertising. For instance, when ϕ grows from 0.6 to 1, the corresponding δ^* declines by 7%, implying that advertising becomes more synergistic. Thus, firms may use the market expansion effect of DTC

[4] It is useful to note that patients need a prescription from a physician to purchase these drugs. Furthermore, physicians are legally responsible for their prescriptions. A physician will accommodate a patient's request for an advertised drug if the drug is also the physician's preferred remedy for the patient. In other instances, physicians may convince patients that other drugs better fit the patient's medical needs. For example, a study shows that on 22.4% of the occasions physicians prescribed drugs not featured in DTC advertising (Weissman et al. 2004). Thus, although DTC advertising can generate traffic to a clinic, the upper bound on its brand-specific influence may vary by product category depending on the side effect profile and effectiveness of the drugs in the category.

advertising to counterbalance the increased market share appropriation effect of detailing, and thereby optimize firms' profits. We summarize these findings in the following result.

Result 1. The optimal brand specificity of DTC advertising increases with cross-price sensitivity and effectiveness of DTC advertising but decreases with effectiveness of detailing.

Impact of the Degree of Market Sensitivity to Price. The market is more sensitive to the prices of some prescription drugs than others. For example, the market is less price sensitive to the colon cancer drug Erbitux by Imclone and the lung cancer drug Tarceva by Genentec, which are more distinctive in their therapeutic classes. On the other hand, the market is more sensitive to the prices of antiarthritis drugs and anticholesterol drugs. In our formulation the parameter θ measures how sensitive the market is to changes in relative price (see Equation (6)). As θ increases, the cross-price elasticity strictly grows in size.

Proposition 2. *If $t/\gamma^2 > (k/\phi^2)(1-\delta)^2(1+\delta-\delta^2)$, then firm's profits increase for $\theta \in (0, \theta^*]$, where θ^* is given by*

$$\theta^* \equiv \frac{1}{2kt}[t\phi^2 - k\gamma^2(1-\delta)^2(1+\delta-\delta^2)].$$

Note that DTC advertising becomes less cost efficient as t/γ^2 increases. Therefore, the condition $t/\gamma^2 > (k/\phi^2)(1-\delta)^2(1+\delta-\delta^2)$ refers to situations where DTC advertising is less cost efficient than detailing. According to Proposition 2, in such situations an increase in cross-price sensitivity may lead to higher profits. Furthermore, if t increases or γ decreases, the value of t/γ^2 will increase and consequently the firm will be able to enjoy higher profits over a wider region of θ. Consistent with this observation, we find that

$$\frac{\partial\theta^*}{\partial t} = \frac{\gamma^2}{2t^2}(1-\delta)^2(1+\delta-\delta^2) > 0,$$
$$\frac{\partial\theta^*}{\partial\gamma} = -\frac{\gamma}{t}(1-\delta)^2(1+\delta-\delta^2) < 0.$$

On the other hand, an increase in k or a decrease in ϕ makes detailing less cost efficient and reduces the range of θ over which profits increase as shown below:

$$\frac{\partial\theta^*}{\partial k} = -\frac{\phi^2}{2k^2} < 0,$$
$$\frac{\partial\theta^*}{\partial\phi} = \frac{\phi}{k} > 0.$$

These findings may run counter to some of our intuitions as we typically expect profits to decline as cross-price sensitivity increases. Furthermore, one may naively believe that an increase in γ is always beneficial to a firm. Proposition 2 clarifies when such beliefs may not be valid. Note that profits depend on both revenues and costs. When cross-price sensitivity is small, changes in price have a modest effect on equilibrium sales. Hence, we see a marginal reduction in firms' revenues when the level of price sensitivity grows slightly above its low level. On the cost side, $t/k > (\gamma^2/\phi^2)(1-\delta)^2(1+\delta-\delta^2)$ implies that the relative costs of advertising and detailing are high compared to the corresponding benefits. In this case, as cross-price sensitivity increases, firms would cut back on these expenditures. Thus, when $\theta \in (0, \theta^*)$, firm profits increase as the cost savings outweigh the corresponding loss in revenues.

Discussion

Using Shubik and Levitan's (1980) utility function as a foundation, we developed an aggregate demand formulation that reflects some important characteristics of the pharmaceutical market. Then we analyzed the strategic implications of DTC advertising and cross-price sensitivity. Proposition 1 showed that the brand specificity of DTC advertising has an inverted U-shaped relationship with firm prices, profits, and detailing expenditures. Proposition 2 highlights that sometimes an increase in price competition improves firm profits. Next we illustrate how our model can be extended to consider the potential interaction between DTC advertising and detailing, the possible entry of a generic prescription drug, and likely transition to OTC status. In the process of extending our model to consider these additional phenomena, we also demonstrate the robustness of the results reported in Propositions 1 and 2.

Interaction Between DTC Advertising and Detailing. In formulating our model, we assumed that DTC advertising and detailing have independent effects on a firm's demand and costs. In the case of antiallergy drugs, Narayanan et al. (2004) observe a positive interaction effect between DTC advertising and detailing, implying that detailing is more effective in the presence of DTC advertising. One way to model such a phenomenon is to let the cost of detailing decline as DTC advertising increases, and similarly let the cost of DTC advertising reduce as detailing increases. Accordingly, we model the cost of DTC advertising and detailing as $(t-\mu d_i)a_i^2$ and $(k-\rho a_i)d_i^2$, respectively. We assume that $0 \le \mu < t/d_i$ and $0 \le \rho < k/a_i$ so that the interaction effect is nonnegative. Firm i's demand remains as shown in Equation (6), and its profit maximization problem is given by

$$\max_{p_i, d_i, a_i} \pi_i = p_i q_i - (k-\rho a_i)d_i^2 - (t-\mu d_i)a_i^2. \qquad (8)$$

We find that the interaction of DTC advertising and detailing impacts firm behavior as follows:

$$\frac{\partial p_i}{\partial a_i} = \frac{\gamma(2-\delta)}{\theta+2} > 0,$$

$$\frac{\partial a_i}{\partial d_i} = \frac{1}{2(t-\mu d_i)^2}[\rho d_i(2t-\mu d_i) + \gamma\mu p_i(1+\delta-\delta^2)] > 0, \tag{9}$$

$$\frac{\partial d_i}{\partial a_i} = \frac{1}{2(k-\rho a_i)^2}[\mu a_i(2k-\rho a_i)+\phi\rho p_i] > 0.$$

In essence, a positive interaction between DTC advertising and detailing increases the benefit-to-cost ratio of DTC advertising and detailing, and motivates firms to spend more on promoting their products. The increased expenditure on DTC advertising and detailing, in turn, attenuates price competition. We also find that Propositions 1 and 2 hold even in the presence of a positive interaction between DTC advertising and detailing. In Tables 2 and 3 (see Technical Appendix B, found at http://mktsci.pubs.informs.org), we summarize the impact of brand specificity and price sensitivity for varying levels of the interaction effect.

Generic Drugs. In our previous analysis we focused on branded prescription drugs. However, the prescription drug market also includes generic prescription drugs, which account for approximately 50% of the drug market (Wittner 2004).[5] To understand such a market, consider a therapeutic product category comprised of two branded drugs and a generic drug. We assume that the branded drug manufacturers are Stackelberg leaders, whereas the generic drug manufacturer is a follower. Hence, the branded drug manufacturers first decide their prices and levels of DTC advertising and detailing, anticipating the likely reaction of the generic drug manufacturer. After observing the decisions of the branded drug manufacturers, the generic drug manufacturer sets its price. The demand for the two branded drugs q_i ($i = 1, 2$) and the demand for the generic drug q_g are as follows:

$$q_i = \alpha + \gamma[a_i + (1-\delta)a_i^{\delta}a_j^{1-\delta}] - p_i + \phi(d_i - d_j) + \tfrac{1}{2}[\theta(p_j - p_i) + (\hat{\theta}p_g - \theta p_i)], \tag{10}$$

$$q_g = \beta + \gamma(1-\delta)(a_i + a_j) - p_g - \tfrac{1}{2}\phi(d_i + d_j) + \tfrac{1}{2}[(\theta p_i - \hat{\theta}p_g) + (\theta p_j - \hat{\theta}p_g)]. \tag{11}$$

In this formulation, each branded drug competes with the other branded drug and the generic drug (compare with Equation (6)). Consumers could be less sensitive to the price difference between the two branded drugs compared to the price difference between the generic drug and a branded drug, implying that $\hat{\theta} > \theta$.[6] In our model, the base demand for each branded drug is α and the corresponding demand for the generic drug is β, so that the base category demand is $2\alpha + \beta$. It is quite likely that the base demand for a branded drug is more than that for the generic drug, implying $\alpha > \beta$. We rule out the trivial case where the branded drug manufacturers' detailing efforts are so effective that the generic drug has no positive demand. To facilitate exposition, we assume that the marginal cost of producing the branded drugs and the generic drug is the same and set it equal to zero. Furthermore, ϕ and k are set to 1 so that γ and t are indices of the relative effectiveness and relative cost of DTC advertising.

We first discuss the equilibrium behavior of the branded and generic drug manufacturers when DTC advertising is category specific. We find that the generic manufacturer's price and profits increase as the effectiveness of DTC advertising, namely, γ, increases. The intuition for this finding is simple. When DTC advertising is category specific, an increase in the size of γ motivates the branded drug manufacturers to spend more on DTC advertising. The increased DTC advertising expands the market, encouraging the branded drug manufacturers to charge higher prices and earn more profits. These changes provide an important side benefit to the generic drug manufacturer, who may also now set higher prices and earn more profits.

When DTC advertising is brand specific, the generic manufacturer's price and profits increase only if γ is greater than $\gamma(\theta)^*$ and $\gamma(\theta)^{**}$, respectively. This finding suggests that the price and profit of the generic drug manufacturer depend on the interaction effect of γ and θ when DTC advertising is brand specific. Consistent with Proposition 2, when consumer sensitivity to the price difference between the branded drug manufacturers increases, firms respond by spending more on DTC advertising to expand the market and thereby soften competition. Because DTC advertising is brand specific, the generic drug manufacturer cannot take advantage of the expanded market. However, the generic drug manufacturer benefits from the reduced price competition. Furthermore, an increase in θ reduces the relative size of $\hat{\theta}$, implying that the importance of the price competition between the generic drug and the branded drugs is reduced. Thus, the generic drug manufacturer's price and profits can increase. We prove these claims in Technical Appendix B, found at http://mktsci.pubs.informs.org.

[5] The principal reason for the high penetration of generic drugs is that they often offer the same therapeutic chemicals as branded drugs, but at far lower prices. Also note a key difference between generic prescription drugs and private-label drugs. In the pharmaceutical business, generic prescription drugs cannot be purchased over the counter in a grocery/drug store. Furthermore, generic prescription drugs are not store brands; hence, the retailer does not play a critical strategic role in the marketing of these drugs.

[6] See Raju et al. (1995) for a similar assumption in the case of store brands.

OTC Drugs. When the FDA deems that a prescription drug is safe and effective for self-medication, it allows the drug to be purchased over the counter without a prescription. For example, Prilosec was initially a prescription drug but now can be purchased over the counter. The FDA approved this transition to OTC drug status while the drug enjoyed patent protection. Consequently, Prilosec OTC did not face immediate competition from generic drug manufacturers. We capture such a transition of a patented prescription drug to an OTC drug using a two-period model. Compared to the original demand formulation (see Equation (6)), the demand for the prescription drug marketed by firm i in period 1 (see Equation (12)) and the corresponding demand for the OTC drug in period 2 (see Equation (13)) are as follows:

$$q_{i1} = \alpha + \gamma[a_i + (1-\delta)a_i^{\delta}a_j^{1-\delta}] - p_{i1} + \phi(d_{i1} - d_{j1}) + \theta(p_{j1} - p_{i1}), \tag{12}$$

$$q_{i2} = \hat{\alpha} + \gamma[\dot{a}_i + (1-\delta)\dot{a}_i^{\delta}\dot{a}_j^{1-\delta}] - p_{i2} + \tilde{\theta}(p_{j2} - p_{i2}), \tag{13}$$

where $\dot{a}_i = (ra_{i1} + a_{i2})$, $r \in [0, 1)$, and $\tilde{\theta} > \theta$. Note that when a drug can be sold over the counter, the firm gains access to additional channels such as grocery stores and mass merchandisers to sell its drugs. Furthermore, the potential market expands because consumers can now try these drugs without visiting a physician, implying that $\hat{\alpha} > \alpha$. Because consumers have to pay the full price for OTC drugs, they are likely to be more sensitive to the prices of these drugs, suggesting that $\tilde{\theta} > \theta$. As DTC advertising of prescription drugs could have a lagged effect on OTC sales, we let $r \in [0, 1)$. Note that there is no detailing in the second period because OTC drugs can be purchased without a prescription.[7] Using this framework, we investigate how the possibility of converting a prescription drug to an OTC drug affects firm behavior. We find that there exists a $\tilde{\theta}_0$ such that the OTC drug prices and DTC advertising are higher when $\tilde{\theta} \in (\theta, \tilde{\theta}_0]$, but are lower when $\tilde{\theta} \in (\tilde{\theta}_0, \infty)$. This finding corroborates with Proposition 2.[8] These extensions show that our model formulation can be extended to study interesting aspects of the pharmaceutical markets such as generic drugs and OTC drugs.

[7] The seemingly innocuous simple dynamics introduced by the lagged effect greatly complicates the analysis. For analytical tractability, we set γ, ϕ, t, and k to one so that the benefit to cost ratios of DTC advertising and detailing are identical. This simplification helps us to to focus attention on the interaction between the lagged effect of DTC advertising and the demand shock caused by the OTC status.

[8] In some cases, when a prescription drug becomes an OTC drug, it may not enjoy patent protection and may face competition from generic OTC drugs. We can model such a transition using a two-period game. The second period, however, will consist of two stages, with the branded OTC drug manufacturers being the Stackelberg leaders and the generic drug manufacturer being the follower. We illustrate the corresponding demand formulation in Technical Appendix B, found at http://mktsci.pubs.informs.org.

3. Experimental Investigation

The theoretical model captures some key empirical regularities in pharmaceutical drug sales (e.g., Narayanan et al. 2004, Wosinska 2002) and in consumer and physician surveys (e.g., Aikin 2003, Weissman et al. 2004). Some anecdotal evidence was also presented in support of the model predictions. Now, in controlled laboratory conditions, we investigate whether boundedly rational players can behave in a manner consistent with the theory (e.g., Wang and Krishna 2006, Ho et al. 2006). The principal advantage of laboratory experimentation is that it provides, ceteris paribus, observations of economic agents that may be difficult to obtain in a field setting. Thus, a laboratory test forms a useful first step in validating the qualitative insights drawn from a theoretical model. Indeed, if a theory fails in the laboratory, it is probably too much to expect it to survive in a noisy field setting. However, theories that survive experimental tests should be further challenged, to the extent possible, with field data. Thus, our experimental study is a useful complement (not a substitute) to analyzing pharmaceutical sales data.

Clearly, it is not a foregone conclusion that boundedly rational agents will behave as predicted by the model. Note that players do not arrive at equilibrium behavior through introspection. On the contrary, initially participants are likely to form their decisions based on some simple decision-making rules. For example, some participants may aggressively cut prices and potentially make more competitive investments in DTC advertising and detailing as the market's sensitivity to price increases. Furthermore, in contrast to the theory, participants may not modify their DTC advertising and detailing as the brand specificity of advertising changes. Thus, it is useful to assess the predictive accuracy of the model.

The goal of this initial experimental investigation is confined to assessing the qualitative implications of Propositions 1 and 2. Specifically, we attempt to answer two empirical questions:

1. *Do DTC advertising, detailing, prices, and firm profits have an inverted U-shaped relationship with the brand specificity of advertising*? We find support for such a nonlinear relationship in the experimental results of Study 1 (see Figure 2). In our experiment, each participant had to optimize on a three-dimensional strategy space (price, detailing, and DTC advertising) while being uncertain about the likely behavior of her competitor. Given the complexity of the decision-making task, we observe differences from the point predictions

Figure 2 **Effect of Brand Specificity on the Aggregate Behavior of Duopolies (Study 1)**

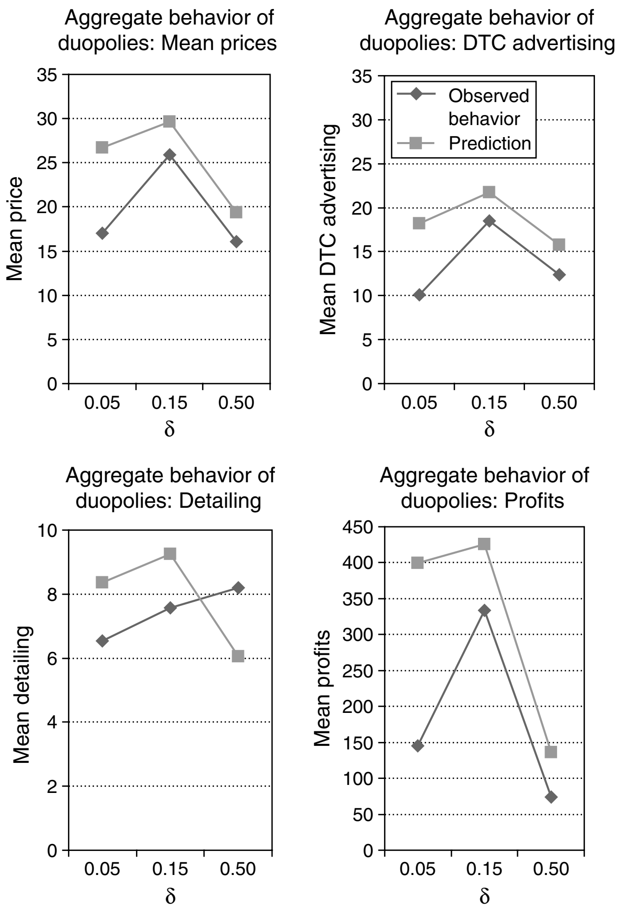
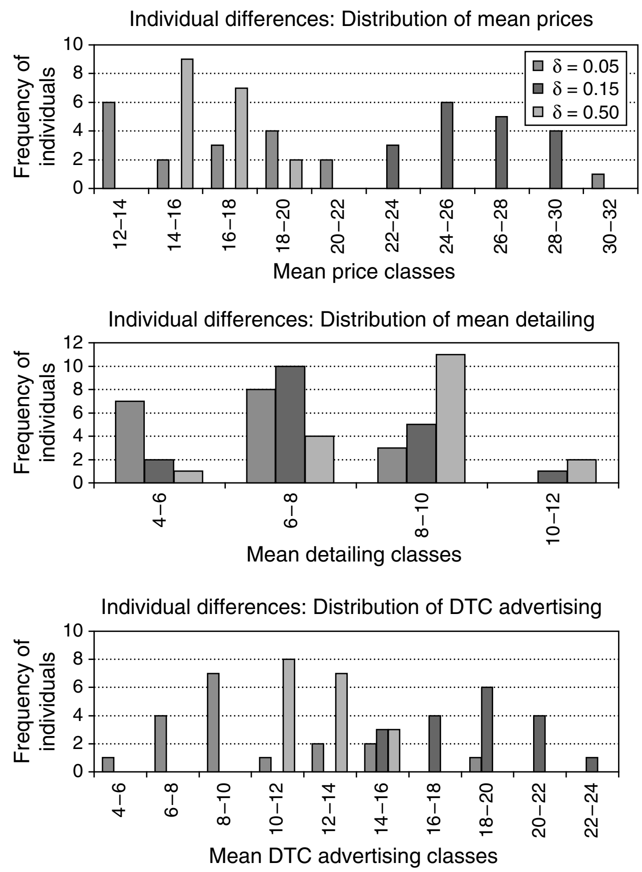


Figure 3 **Behavior of Individual Participants in Study 1**



of the model. As in past research (e.g., Rapoport and Boebel 1992; Rapoport and Amaldoss 2000, 2004), we also find individual-level differences (see Figure 3).

2. *In the presence of DTC advertising, do firms earn more profits as consumers become more sensitive to relative prices of prescription drugs*? The results of Study 2 are closely aligned with the qualitative predictions of Proposition 2 (see Figure 4). As in Study 1, we again observe departures from the point predictions of the model and heterogeneity in the decisions of individual participants (see Figure 5).

Next we present and discuss the results of our two studies. Study 1 examined how the brand specificity of DTC advertising affects firm behavior and profits, whereas Study 2 investigated how the market's sensitivity to relative prices affects prices, profits, DTC advertising, and detailing.

Study 1: Effect of Brand Specificity of DTC Advertising

In this study we considered three levels of brand specificity, namely, $\delta \in \{0.05, 0.15, 0.5\}$, while keeping the other parameters of the demand function fixed (see Equation (6)). We chose these three levels of brand specificity so that we could better discriminate among the resulting equilibrium behavior and demonstrate the inverted U-shaped relationship predicted by Proposition 1. In the empirical model, the demand for the prescription drug marketed by firm i was given by

$$q_i = 10 + 1.3[a_i + (1-\delta)a_i^{\delta}a_j^{1-\delta}] - p_i + 0.5(d_i - d_j) + 0.1(p_j - p_i). \quad (14)$$

In the above demand function, the base demand $\alpha = 10$, the sensitivity to relative prices $\theta = 0.1$, the effectiveness of DTC advertising $\gamma = 1.3$, and the sensitivity to relative detailing efforts $\phi = 0.5$. Further, we let the cost of DTC advertising be ta_i^2 with $t = 1$ and the cost of detailing be kd_i^2 with $k = 0.8$.

In theory, if $\delta = 0.05$, each firm should advertise $a_i = 18.21$ units, detail $d_i = 8.37$ units, charge a price of $p_i = 26.74$, and earn a profit of $\pi_i = 399.16$. The equilibrium predictions increase when brand specificity grows to $\delta = 0.15$. Now each firm should advertise $a_i = 21.72$ units, detail $d_i = 9.26$ units, set price $p_i = 29.64$, and make a profit of $\pi_i = 425.75$. However, if the brand specificity increases further to $\delta = 0.5$, then the equilibrium predictions decline to $a_i = 15.76$, $d_i = 6.06$, $p_i = 19.39$, and $\pi_i = 136.05$. Hence, as implied by Proposition 1, we should observe an inverted U-shaped relationship between brand specificity of DTC advertising and any of the following variables: a_i, d_i, p, or π_i. Next we proceed to assess the descriptive validity of this qualitative prediction.

Participants. Business school students volunteered to participate in this study for a payoff contingent on performance. They were paid a show-up fee of \$5 in addition to monetary reward based on their performance. The mean individual payoff was approximately \$20.

Experimental Design. We used a between-participants design with three different levels of brand specificity. Each participant played 30 trials of the game, and competed against a randomly chosen opponent in each trial so there was no scope for reputation effects. Eighteen individuals participated in each session and a total of 54 individuals participated in the entire study.

Procedure. At the beginning of each session of the experiment, the participants were randomly assigned to a computer booth. They were then asked to read the instructions, which included a detailed example. After all the participants completed reading the instructions, the supervisor entertained questions about the instructions. Then participants played five practice trials to familiarize them with the decision task.

The experiment was framed as a competition between two pharmaceutical firms, where each participant played the role of a firm. In marketing its prescription drug, each firm needed to decide on three marketing variables: DTC advertising level, detailing level, and price. The DTC advertising helped to inform consumers about the ability of the drug to treat medical conditions, motivated consumers to consult with their doctor, and encouraged them to seek the advertised drug. Detailing, on the other hand, promoted the drug among physicians, and influenced the relative market share of the two competing prescription drugs. Both firms simultaneously made their decisions.

To help participants understand the implications of their decisions, we provided participants with a calculator. The calculator displayed the likely firm profits and competitor's profits for a given set of actions of the firm and expected actions of the competitor. Note that the projected profits would be correct only to the extent that a participant was able to accurately predict the actions of her competitor. Thus, using the calculator helped to avoid common computational errors and reduce the cognitive complexity of the game without assuring equilibrium play.

In each trial, after all the participants had communicated their decisions, the computer displayed the decisions of the competing firms and the resulting profits. After participants read the results, they proceeded to play the next trial with a different competitor. During the course of the experiment, communication between participants was not permitted. At the end of the experiment, participants were paid according to their cumulative earnings, and were then debriefed and dismissed.

Results. In each trial, the 18 participants were randomly paired to form nine duopolies. Because we ran a separate session for each level of brand specificity, and each session lasted for 30 trials, we obtained information about the behavior of 810 duopolies (9 duopolies $\times$ 3 levels of brand specificity $\times$ 30 trials $= 810$). Using the mean price, DTC advertising, detailing, and profits of each of these duopolies, we assessed the impact of brand specificity on firm behavior. We find support for the key qualitative implications of Proposition 1. We also, however, see substantial individual-level differences.

Aggregate Behavior of Duopolies. Averaging across the 270 duopolies in each treatment, the mean price charged by the duopolies increased from 17.05 to 25.86 and then declined to 16.04 when brand specificity was 0.05, 0.15, and 0.5, respectively. We can reject the null hypothesis that these mean prices are the same ($F_{(2,807)} = 629.82$, $p < 0.0001$). Similarly, the mean DTC advertising was 10.8, 18.48, and 12.39 corresponding to the three levels of brand specificity ($F_{(2,807)} = 546.42$, $p < 0.0001$). Likewise, mean duopoly profits were 145.21, 333.33, and 73.99 when brand specificity was 0.05, 0.15, and 0.50, respectively ($F_{(2,807)} = 1{,}037.68$, $p < 0.0001$). It is easy to see in Figure 2 that price, DTC advertising, and profits have an inverted U-shaped relationship with brand specificity.[9] However, we do not observe such a relationship in the case of detailing. The actual detailing corresponding to the three levels of brand specificity were 6.53, 7.57, and 8.20. The departure from the predicted pattern was a consequence of duopolies not scaling down detailing when δ was 0.5. Perhaps, when brand specificity was high, participants focused more attention on competition. Such a focus could lead them to use more than the predicted level of detailing to wean sales away from their competitors.

Although the observed behavior is directionally consistent with the qualitative predictions of Proposition 1, it systematically differs from the point predictions (see Figure 2)—duopolies earned less profits, charged lower prices, and used less DTC advertising ($p < 0.001$). Although we observed a

[9] On regressing each of the dependent variables against δ and δ^2, we obtain a significant positive coefficient corresponding to δ (price: $t = 30.37$, $p < 0.001$; DTC advertising: $t = 32.52$, $p < 0.001$; profits: $t = 34.21$, $p < 0.001$) and a significant negative coefficient corresponding to δ^2 (price: $t = -32.64$, $p < 0.001$; DTC advertising: $t = -33.03$, $p < 0.001$; profits: $t = -38.07$, $p < 0.001$).

higher expenditure in detailing when brand specificity was $\delta = 0.5$, across the three treatments the observed mean expenditure in detailing was lower than the equilibrium prediction ($p < 0.001$). We report in Technical Appendix D, found at http://mktsci.pubs.informs.org, the trends in the decisions of individual participants.

Individual Differences. Across the 30 trials, we computed the average price, DTC advertising, and detailing for each individual participant. Figure 3 presents the distribution of these means. The mean prices ranged from 12 to 22 when δ was 0.5 or 0.05, except for one subject when δ was 0.05. However, when $\delta = 0.15$, the mean individual prices ranged from 22 to 32, implying minimal overlap between the mean prices charged when $\delta = 0.5$ and corresponding prices when δ was either 0.05 or 0.15. We also note such a separation in the distribution of DTC advertising, but not detailing.

To check for the robustness of the results observed in the aggregate behavior of duopolies, we conducted analysis of variance using the average behavior of individual participants. We can reject the null hypothesis that the mean price is the same under the three levels of brand specificity ($F_{(2,51)} = 63.28$, $p < 0.0001$). Similarly, detailing, advertising, and profits vary across the three experimental conditions (detailing: $F_{(2,51)} = 7.37, p < 0.0015$; DTC advertising: $F_{(2,51)} = 54.95, p < 0.0001$; profits: $F_{(2,807)} = 571.32$, $p < 0.0001$).[10] Thus the overall behavior of individual participants is also directionally consistent with the predictions of Proposition 1. An implication of this analysis is that, although individuals are heterogeneous in their behavior, the model predictions survive at the aggregate level.

Discussion. In general, the results of Study 1 are in accordance with the qualitative predictions of Proposition 1. It is a nontrivial exercise to optimize on a three-dimensional strategy space, especially when there is uncertainty about the likely actions of the competitor. Understandably, we see departures from the point predictions. These deviations, however, are quite systematic: participants compete more on price and invest less on DTC advertising and detailing. Furthermore, the departures are stronger in the treatment where $\delta = 0.05$. This is also the treatment in which firms have a strong incentive to free ride on the DTC advertising of their competitors. Consequently, firms invest less in DTC advertising. The resulting market size is small and encourages more price-based competition.

[10] Furthermore, we find support for the nonlinear relationship because δ has a positive coefficient (price: $t = 9.63$, $p < 0.001$; DTC advertising: $t = 10.31$, $p < 0.001$; profits: $t = 25.42$, $p < 0.001$), and δ^2 has a negative coefficient (price: $t = -10.35$, $p < 0.001$; DTC advertising: $t = -10.47$, $p < 0.001$; profits: $t = -28.29$, $p < 0.001$).

Study 2: Effect of Market's Sensitivity to Relative Prices

To test the predictions of Proposition 2, we considered an empirical model where the demand for the prescription drug of firm i was given by

$$q_i = 50 + 0.5[a_i + (0.75)a_i^{0.25}a_j^{0.75}] - p_i + 1.3(d_i - d_j) + \theta(p_j - p_i). \tag{15}$$

The value of θ was varied to be either 0.1 or 1.2 in two experimental sessions. In both sessions, the costs of DTC advertising and detailing were a_i^2 and $0.8d_i^2$, respectively.

In theory, when $\theta = 0.1$, each firm should advertise $a_i = 8.07$ units, detail $d_i = 22.08$ units, set a price of $p = 27.17$, and earn a profit of $\pi_i = 357.11$. Consistent with Proposition 2, when θ increases to 1.2, each firm should earn more profits. According to the equilibrium solution, now each firm should advertise $a_i = 5.05$ units, detail $d_i = 13.82$ units, charge a price of $p = 17$, and make a profit of $\pi_i = 457.82$.

As in Study 1, we used a between-participants design. Eighteen students participated in each session of the experiment and each session lasted for 30 trials. The experimental protocol closely followed the previous study.

Results. In this study we have information about 540 duopolies (2 levels of $\theta \times 9$ duopolies in each trial $\times$ 30 trials $= 540$). On analyzing this body of information, we find that the aggregate behavior of duopolies is consistent with the major qualitative predictions of Proposition 2. As in the previous study, we note heterogeneity in the behavior of individual participants.

Aggregate Behavior of Duopolies. Upon examining the average behavior of the 270 duopolies in each treatment, we note that average price charged declined from 28.37 to 15.23 as θ increased from 0.1 to 1.2 ($F_{(1,538)} = 7{,}126$, $p < 0.001$). Likewise, the average DTC advertising reduced from 7.37 to 4.56 and detailing dropped from 25.48 to 17.35 as cross-price sensitivity increased (DTC advertising: $F_{(1,538)} = 776.45$, $p < 0.001$; detailing: $F_{(1,538)} = 1{,}303.47$, $p < 0.001$). Further, as predicted, firm profits increased from 200.81 to 313.80 when θ grew from 0.1 to 1.2 ($F_{(1,538)} = 187.47$, $p < 0.001$). Thus, the observed behavior is directionally consistent with the predictions of Proposition 2.

Upon comparing the observed behavior against the point predictions of the equilibrium solution (see Figure 4), we note that participants tend to spend less on DTC advertising and earn lower profits ($p < 0.001$). In contrast to the previous study, participants consistently spent more on detailing ($p < 0.001$). We discuss in Technical Appendix D, found at http://mktsci.pubs.informs.org, the trends in the decisions of our participants.

Figure 4 Effect of Price Sensitivity on the Aggregate Behavior of Duopolies (Study 2)

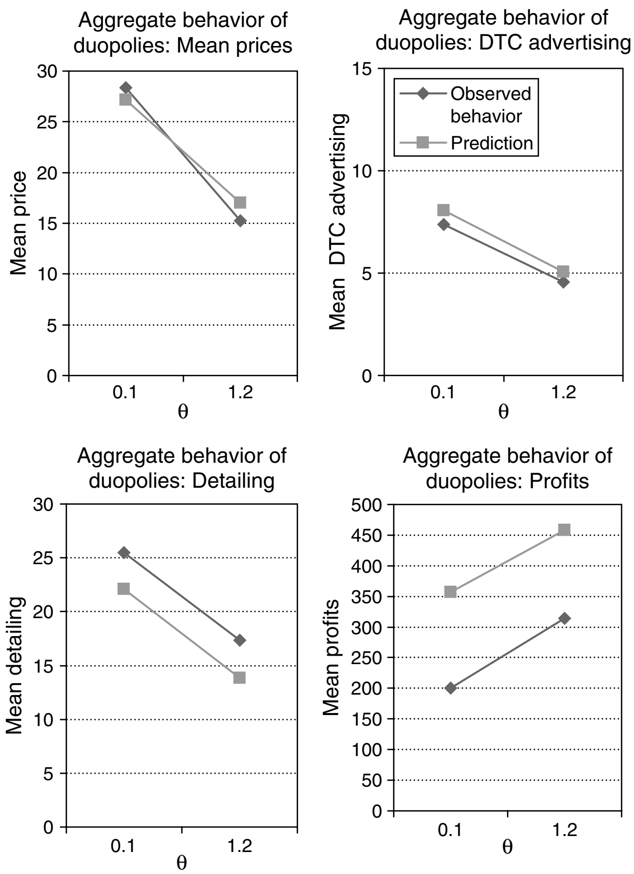
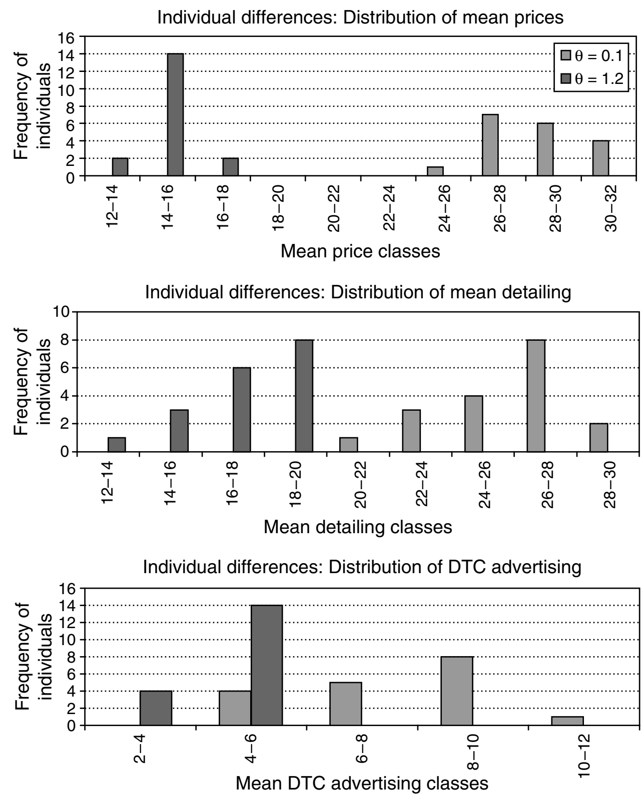


Figure 5 Behavior of Individual Participants in Study 2



Individual Differences. Figure 5 presents the distribution of individual means for prices, DTC advertising, and detailing. As in Study 1, we note that the behavior of individual participants is heterogeneous. However, the distributions of individual means corresponding to the two treatments are nonoverlapping in the case of price and detailing. On average, individual participants charged a price less than 18 when $\theta = 0.1$, but charged more than 24 when $\theta = 1.2$. Similarly, we note that when $\theta = 0.1$, the mean individual detailing is lower than 20 but higher than 20 if $\theta = 1.2$. However, we see some overlap in the distributions of DTC advertising corresponding to the two treatments.

It is reassuring to note that the average behavior of individual participants is consistent with the aggregate behavior of duopolies reported earlier. Profits increased with cross-price sensitivity, whereas prices, DTC advertising, and detailing decreased as θ increased (profits: $F_{(1, 34)} = 144.34$; prices: $F_{(1, 34)} = 790.27$, $p < 0.0015$; DTC advertising: $F_{(2, 34)} = 54.83$, $p < 0.0001$; detailing: $F_{(1, 34)} = 165.71$, $p < 0.0001$).

Discussion. Study 2 provides empirical support for the qualitative predictions of Proposition 2. We also observe departures from the point predictions of the model and variation in the behavior of individual participants. Such individual-level differences have been reported in many experimental tests of game-theoretic models (e.g., Amaldoss and Rapoport 2005). Taken together, the two studies imply that the aggregate behavior of boundedly rational players can be consistent with the qualitative predictions of the model. However, across the two studies players tend to systematically underinvest in DTC advertising. A potential explanation for this behavior could be that our participants were focused on competition. Note that in our experiments, although DTC advertising expands the category sales, it indirectly helps competitors too. In this scenario, paying too much attention to competition and failing to fully appreciate the positive demand effects of DTC advertising might lead participants to invest less in DTC advertising, but more in detailing, and also charge lower prices. We caution readers about extrapolating these findings to a field setting because there is a need to further validate them in a field setting. We later illustrate how our model can be applied to a field setting by using some data on the antiallergy market.

4. Conclusions

The goal of this paper was to understand how DTC advertising shapes the competitive behavior of firms marketing prescription drugs. Toward this end, we proposed and tested a model of DTC advertising. Our theoretical and experimental investigation offered some useful insights about DTC advertising.

1. *How does the brand specificity of DTC advertising impact prescription drug prices, DTC advertising, detailing, and profits*? It is natural to expect that DTC advertising helps to improve category knowledge. However, several researchers note that DTC advertising could help the sponsoring brand more than the competing brands (e.g., Weissman et al. 2004). This is in part facilitated by the willingness of physicians to prescribe the drug requested by the patient. Our theoretical analysis reveals that brand specificity could have an inverted U-shaped relationship with price, DTC advertising, and detailing. In the experimental results of Study 1, we see evidence of such a nonlinear relationship in the case of prices, DTC advertising, and firm profits.

2. *In the presence of DTC advertising, how would increased market sensitivity to prices affect firm behavior*? Typically, increased cross-price sensitivity increases price competition and hurts firm profits. The theoretical analysis, however, shows that increased cross-price sensitivity can sometimes lead to improved firm profits. We find support for this prediction in the experimental results of Study 2.

3. *Can DTC advertising by a prescription drug manufacturer help generic drug prices and profits*? Impending patent expiry and the likely entry of generic drugs is a source of anxiety for many pharmaceutical firms. However, according to a survey of 127 practicing managers, 42% of branded drug manufacturers do not have a defense strategy (Wittner 2004). Clearly, a principal asset of the branded prescription drug manufacturer is the goodwill the brand enjoys in the market, and DTC advertising can help build that goodwill among consumers. Strategic investments in DTC advertising by the branded prescription drug manufacturer can have positive side-effects on generic drugs: In some cases generic drug prices and profits may improve as well.

4. *How does the possibility of transitioning a prescription drug to OTC drug status affect investments in DTC advertising*? If firms anticipate the transition of a prescription drug to OTC status, then they might invest more in DTC advertising and detailing, charge higher prices, and earn more profits from the prescription drug. In practice, we note that AstraZeneca successfully transitioned Prilosec to OTC status with the aid of DTC advertising and the distribution strength of Procter & Gamble (Wittner 2004).

Some Conjectures on the Antiallergy Drug Market

The above-mentioned summary of our findings offers some useful insights on marketing prescription drugs. To illustrate that the model can potentially inform managerial decision making, we performed a preliminary analysis of the antihistamines market using the summary statistics reported in Narayanan et al. (2004). Although we estimated our model parameters using a few aggregate statistics, we encourage managers to estimate the parameters using time-series data. After making a few simplifying assumptions (see Technical Appendix C, found at http://mktsci.pubs.informs.org), we obtained the following best-fitting parameter estimates: $\theta = 7.297$, $\phi = 0.002$, and $\gamma = 0.004$. Note that the estimated value ϕ is greater than that of γ, and it is in keeping with the elasticities reported in Narayanan et al. Furthermore, our estimates of the brand-specific intercepts corresponding to Claritin, Zyrtec, and Allegra are 109.268, 19.689, and 0, respectively. The rank order of the sizes of these intercepts is also consistent with the findings reported in the original work. In light of these estimates, what inferences can we draw about the antiallergy drug market? Our analysis shows that the cross-price sensitivity of the antiallergy market is above the critical level (see Proposition 2). Consequently, if the antiallergy drug market becomes any more price sensitive, firm profits will decline. For instance, a 10% increase in θ would lead to a 7% drop in profits.

We would like to reiterate that we obtained the model parameters using only a few aggregate measures of the market. Despite the limitations of this approach, we took the risk of applying the model to the antiallergy drug market to highlight that our model can be confronted with data and that it can potentially guide managerial decision making.

Directions for Further Research

The marketing of prescription drugs is a complex phenomenon, and our parsimonious model only captured a few salient aspects of the business. There are several avenues for further theoretical research. In the current research, we used an aggregate demand formulation to investigate the strategic implications of DTC advertising. Future research could develop a micromodel of persuasive and informative advertising for prescription drugs. In Manchanda et al. (2008), we see evidence that interpersonal communication among physicians also plays an important role in new product adoption. Ching and Ishihara (2008) suggest that the effectiveness of detailing may change as additional information on drugs is revealed via patients' experiences during a product's life cycle. The theoretical implications of these empirical findings await further research. Also note that the channel design and pricing structure of prescription drugs is more complex than that of fast-moving consumer goods. Researchers have yet to systemically model such institutional details and examine their theoretical implications. As more field data on DTC advertising become available, it would be instructive to compare the efficacy of prescription drug detailing and DTC advertising across multiple therapeutic categories and in different stages of patent protection. Furthermore, as the brand specificity of DTC advertising may vary over a product's life cycle, one could perform a longitudinal analysis of its effect on firm's prices, profits, and promotional expenditures.

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