DIRECT TO CONSUMER ADVERTISING IN PHARMACEUTICAL MARKETS

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Abstract

We study effects of direct-to-consumer advertising (DTCA) in the prescription drug market. There are two pharmaceutical firms providing horizontally differentiated (branded) drugs. Patients differ in their susceptibility to the drugs. If DTCA is allowed, this can be employed to induce (additional) patient visits. Physicians perfectly observe the patients' type (of illness), but rely on information to prescribe the correct drug. Drug information is conveyed by marketing (detailing), creating a captive and a selective segment of physicians. First, we show that detailing, DTCA and price (if not regulated) are complementary strategies for the firms. Thus, allowing DTCA induces more detailing and higher prices. Second, firms benefit from DTCA if detailing competition is not too fierce, which is true if investing in detailing is sufficiently costly. Otherwise, firms are better off with a ban on DTCA. Finally, DTCA tends to lower welfare if insurance is generous (low copayments) and/or price regulation is lenient. The desirability of DTCA also depends on whether or not the regulator is concerned with firms' profit.

JEL Code: I11, L13, L65, M37.

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1 Introduction

The pharmaceutical industry is one of the most advertising-intensive industries (see e.g., Scherer and Ross, 1990). Promotional expenditures often amount to 20-30 percent of sales, sometimes well exceeding expenditures on R&D.[1] However, contrary to most other industries promotional spending is not targeted at consumers, but rather at prescribing physicians. While this can be explained by the important role of the physician as the patient's agent, another important reason lies with the regulatory restrictions on direct-to-consumer advertising (DTCA) of prescription drugs that are present in most countries.

Recently, however, there has been a trend towards a more liberal legislation on DTCA. In the US, the Food and Drug Administration issued new guidelines in 1997 for broadcast advertising of prescription drugs directly to consumers, facilitating the use of television for DTCA. A similar liberalisation is carried through in New Zealand. In the European Union a 5-year pilot project of allowing DTCA for three long-term and chronic diseases (diabetes, AIDS and asthma) was recently proposed, though rejected.

The role of DTCA has generated a controversial debate (see e.g., Wilkes et al., 2000). Opponents claim that DTCA causes physicians to waste valuable time during encounters with patients and encourages the use of expensive and sometimes unnecessary medications. Proponents argue that DTCA increases the consumers' awareness and knowledge about available medical treatments, and this may enable them to detect a possible disease at an earlier stage and take part more actively in the choice of medication.

This paper aims at contributing to the debate about DTCA along two different dimensions: First, the debate seems to focus on isolated effects of DTCA, and ignore that pharmaceutical companies already spend tremendous amounts of money on promotion aimed at influencing the physicians' prescription choices.[2] In this paper we therefore explicitly

[1] According to Schweitzer (1997) the marketing expenses for three of the largest US pharmaceutical companies - Merck, Pfizer, and Eli Lilly - ranged from 21 to 40% of annual sales, while the R&D expenses varied between 11 and 15%. Similar figures are reported from Novartis and Aventis, the largest pharmaceutical companies in Europe. See also Hurwitz and Caves (1988) for US data or Zweifel and Breyer (1997) for figures in Germany and Switzerland.

[2] Rosenthal et al. (2002) report that annual spending on DTCA for prescription drugs in the US tripled between 1996 and 2000, when it reached $2,5 billion. Despite this increase, DTCA accounts for only 15%

analyse the interaction between advertising directed at consumers, on the one hand, and physician-oriented marketing, on the other.

Second, a number of empirical studies have recently addressed various aspects of DTCA (e.g., Berndt et al., 1995, 1997, Calfee et al., 2002, Iizuka, 2004, Iizuka and Jin, 2005, Ling et al., 2002, Rosenthal et al., 2002). Theoretical studies of DTCA are scant. Taking into account the specific market conditions and institutional arrangements in the prescription drug market, we aim at filling this gap in the literature.

In this paper we analyse how the availability of DTCA affects firms' spending on detailing, the drug prices, and eventually profits. We are also interested in the effects of DTCA on the physicians' prescription decisions, the benefit to the patients, and eventually social welfare. We consider both the case of price competition and the case of price regulation. This enables us to compare the effects of DTCA across health care systems in which firms compete on price (e.g., in the US) and systems in which prices are regulated (e.g., in Europe).[3]

We restrict attention to competition between patented (or branded) drugs.[4] More precisely, we consider a particular therapeutic market with two pharmaceutical firms offering horizontally differentiated drugs. If we think of high cholesterol, for instance, the two firms could be Merck and Pfizer offering their drugs Zocor and Lipitor, respectively. In the pharmaceutical industry a patent is granted for a drug's novel chemical composition rather than its therapeutic properties. Many new pharmaceuticals receive patents in spite of being functionally similar to existing drugs. As such, their introduction expands physicians' choices and can pose a competitive threat to established drugs with the same or similar

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of the total drug promotion expenses. Promotion to professionals (e.g., office-based promotion, journal advertising, free samples) accounts for the residual 85%, with a spending of $13,241 billion in 2000. Note that spending on conferences, meetings, events and also gifts are not included, so the figures underestimate total promotional expenditures on physicians.

[3] Most European countries exercise some form of price regulation on prescription drugs. See e.g. Mossialos (1998) for an overview of the different ways drug prices are regulated in Europe.

[4] Generic drugs are rarely advertised to any great extent. Studies of generic competition have mostly been concerned with the issue of whether advertising act as a barrier for generic entry. See, for instance, the empirical work by Hurwitz and Caves (1988), Grabowski and Vernon (1992), and Scott Morton (2000).

indications.[5] Patented drugs have by definition different chemical compounds, potentially involving different effectiveness, contraindications and side-effects to which patients may react differently. Thus, optimal treatment depends on the individual case and is therefore a matter of *matching*. As there is typically no strict ranking of the drugs within therapeutic markets, the familiar Hotelling-model of product differentiation proves to be suitable for our purposes.

The informational structure is important in pharmaceutical markets. We assume that patients cannot observe their disease type nor the treatment effects of the different drugs.[6] A fraction of the individuals suffering from the disease in question actually seeks a physician's advice. The remaining fraction is also ill, but for some reason does not visit a physician.[7] These individuals are 'potential' drug consumers and the fraction measures the size of the potential market.[8] If allowed by the health authorities, the pharmaceutical firms can advertise their drugs directly to consumers. We assume that DTCA affects the *potential* patients' decision of whether or not to seek medical advice by a physician. An ad from, say, firm 1 (Merck), informs the patient about the existence of a condition (high cholesterol), possible symptoms (high blood pressure) and risks (e.g., coronary heart disease, diabetes), as well as the existence of a treatment (Zocor). Besides this the ads provide no valuable information to the patient. Thus, in our model DTCA merely prompts physician visits. This approach follows closely the empirical work by Iizuka and Jin (2005) who find that DTCA leads to a

[5] Lu and Comanor (1998) find that all but 13 of 148 new branded chemical entities introduced in the US between 1978-87 had at least one fairly close substitute; the average number of substitutes being 1.86. Scherer (2000) reports that the number of drugs per symptom group ranged from 1 to 50, with a median of 5 drugs and a mean of 6.04.

[6] There are several justifications for this. First, (most) patients have not taken medical training and are thus not capable of diagnosing. Second, drugs are typically not search goods, implying that treatment effects cannot be easily inferred from reading about a drug's chemical compounds, effectiveness, etc.

[7] There may be several reasons for why not everybody suffering from a condition seeks medical care. First, some individuals receive weaker symptoms than others. In fact, some persons do not receive any signal of being ill at all. Second, individuals may have different skills or experience in interpreting symptoms. For complicated diseases this may lead to a large fraction of non-visiting patients.

[8] It is well known that several illnesses are substantially underdiagnosed (or undertreated). Iizuka (2004) present such measures, showing wide variation between various therapeutic areas.

large increase in the number of patient visits, a moderate increase in the time spent with physicians, but to no effect on physicians' choice among prescription drugs within a therapeutic class.[9] Another empirical study by Iizuka (2004) finds that firms spend more on DTCA when the number of potential patients, rather than the number of currently treated patients, is large. This is also an outcome of our model, as will be shown later in this paper.

Physicians are *a priori* uninformed about the two drugs. In order to be able to prescribe the most suitable treatment, they require information about the available drugs. Obviously, physicians may search for drug information, for instance, by reading medical journals. In this paper, we focus on another, and less costly, source of information for the physicians, namely marketing.[10] Since physician-oriented marketing is costly, firms are unable to reach every physician in the market. Thus, there are potentially three types of physicians in the market: 'captive' physicians who have received information by only one of the firms, 'selective' physicians who have received information by both firms, and uninformed physicians who have received information by neither firm.[11] Selective physicians trade off the two available drugs (say, Zocor against Lipitor). Captive physicians trade off the drug they are aware of (say, Zocor) against an outside treatment (say, physical exercise), while uninformed physicians prescribe the outside treatment. Thus, the firms face a monopolistic (captive) and a competitive (selective) market segment.

This modelling approach builds on the advertising framework introduced by Butters (1977) and developed for differentiated products by Grossman and Shapiro (1984). Moreover, it is also consistent with the empirical evidence provided by Berndt et al. (1995, 1997) for the anti-ulcer industry. Applying a method that distinguishes between "industry-expanding" and "rivalrous" marketing efforts, they find that physician-oriented marketing

[9] We thank an anonymous referee for drawing our attention to the empirical findings on this issue.

[10] Azoulay (2002) finds that both marketing and scientific evidence directly influence physicians' prescription choices, with marketing having a more pronounced influence. He also finds that clinical outputs positively affect firms' marketing efforts, and concludes that drug advertising may perform an important informative function.

[11] In our model physicians are captive since they have received information from one firm only. However, an alternative interpretation is that these physicians actually ignore or reject information from one of the firms for the purpose of, for instance, receiving future benefits like sponsored conference trips, etc. This more persuasive view of advertising has been employed by Fudenberg and Tirole (1984).

involves both elements. In our model physician-oriented marketing expands the monopolistic segment(s) vis-a-vis the outside drug (market-expansion), but, as an element of rivalry, it also expands the competitive segment at the expense of the monopolistic segment (business-stealing).

Based on this modelling approach, we derive the following results. First, we find that detailing and DTCA are complementary strategies for the pharmaceutical firms. DTCA triggers more patient visits, which makes it profitable for the firms to spend more on detailing to get the physicians to prescribe their drug. Thus, allowing DTCA leads to higher levels of detailing. This result is consistent with empirical findings. For instance, Rosenthal et al. (2002) demonstrate that spending on DTCA increased dramatically after the new FDA guidelines in 1997, and tripled for the whole period of 1996 and 2000, ending on $2,5 billion. For the same period they also show that promotional spending on physician increased from $8,3 to $13,2 billion.

If firms are allowed to set price, we show that the complementarity between the two marketing strategies is reinforced. The reason is that physician-oriented marketing enables the firms to charge higher prices. This result is interesting for two reasons: First, it contrasts Grossman and Shapiro's (1984) finding that informative advertising leads to lower prices. The basic difference between the two models is that we assume *elastic* demand in the monopolistic segment, while they assume *inelastic* demand in this segment. In our model a firm faces two effects of lowering its price; (i) it steals some consumers from the rival in the competitive segment; and (ii) it increases the demand in the monopolistic segment. In the Grossman-Shapiro (1984) model only the first effect is present. Interestingly, it turns out that this assumption qualitatively changes the effect of marketing upon prices.

Second, the price effect of detailing is consistent with empirical findings. In the context of branded competition, Rizzo (1999) analyses the demand for antihypertensive drugs for 1988-1993, and finds that detailing lowers the price elasticity. This effect is attributed to detailing being persuasive rather than informative.[12] We show that informative advertising can also lead to higher prices. One cannot, therefore, conclude from the empirical observation of a less price elastic demand that promotion to physicians is necessarily persuasive.

[12]There has been quite an extensive debate on whether physician-oriented marketing is persuasive or informative, see e.g., Leffler (1981) and Hurwitz and Caves (1988).

Turning to profitability, we find that firms benefit from DTCA if detailing competition is not too fierce, which is true if detailing investments are sufficiently costly. This is true under both price regulation and price competition, the restriction being less severe in the latter case. If detailing is not sufficiently costly, firms actually prefer a ban on DTCA. This type of result is not unfamiliar to the advertising literature. Grossman and Shapiro (1984) arrive at a similar conclusion. There is also empirical evidence that firms can be better off with restrictions on advertising. For instance, Eckard (1991) found that cigarette companies benefited from the ban on TV advertising.

Finally, considering welfare we first show that a regulator in general cannot achieve first-best but needs to trade off the following three inefficiencies: suboptimal DTCA, excessive detailing, and under-treatment. DTCA is suboptimal due to its public good nature, while detailing is excessive due to its business-stealing effect. Second, we find that the desirability of DTCA depends on the degree of insurance coverage (the copayment rate), and, if pharmaceutical prices are regulated, the strictness of this regulation. In particular, if copayments are small (and price regulation is lenient), firms compete excessively in terms of detailing. An allowance of DTCA will in this case amplify detailing competition, and thus lead to a reduction in welfare. The reverse is true if copayments are high (and price regulation is strict). We also show that the scope for beneficial DTCA increases in the weight on firms' profits. While we assume that medical expenditure as such is welfare neutral, excessive promotional activity arises as an indirect social cost of moral hazard under generous insurance. In this case a ban on DTCA is warranted.

There are few other theoretical papers on marketing in the pharmaceutical market.[13] Rubin and Schrag (1999) analyse the effect of DTCA on the provision of drugs to their patients by HMOs. They show that a monopolist supplier of a drug can mitigate the incentive for the HMO to supply a cheaper but less effective alternative supplied by competitive firms by using DTCA to inform patients about its product. Using a 'competitive fringe' model, they do not consider competition in terms of advertising and prices. Neither are they concerned about the role of detailing nor the interaction between the two forms of advertising, which are key issues of our paper. Konrad (2002) analyses how detailing may distort

[13] Cabrales (2003) and Königbauer (2004) are two recent theoretical studies of advertising in the context of generic competition. Since we analyse branded competition, these papers differ from ours.

prescription choices and lead to mismatching. He models detailing as purely persuasive and competition as a rent-seeking contest. His work differs significantly in that neither DTCA nor the pricing of drugs are considered.

The rest of the paper is organised as follows. Section 2 sets out the model. In section 3 and 4 we analyse marketing competition in the case of price regulation and price competition, respectively. Section 5 is devoted to the welfare analysis and section 6 concludes.

2 Model

Consider a particular therapeutic market, where a continuum of individuals are distributed uniformly on the line segment $[0,1]$ with mass 1. Assume all individuals require medical treatment. The location of an arbitrary patient, $x \in [0,1]$, is associated with his/her disease type and/or personal characteristics. There are two pharmaceutical firms, indexed by $i = 0,1$, in this market, where firm i sells drug i at a uniform price p_i. The drugs are located at either end of the unit interval, reflecting their (differing) chemical compounds and associated treatment effects.

The surplus (utility) derived by patient x from consuming one unit of drug i is

$$U(x,i,p_i) = v - t|x-i| - \tau p_i, \tag{1}$$

where $v > 0$, $t > 0$, and $\tau \in (0,1]$. The parameter v represents the gross "effectiveness" (or quality) of drug i. The two drugs have the same gross effectiveness, but patients vary with respect to their susceptibility to treatment with the two (chemically) differentiated drugs. The parameter t captures the utility loss ('mismatch cost') per unit distance between drug i and a patient's most suitable drug. The mismatch cost, represented by the term $t|x-i|$, can be thought of as reflecting side-effects, contraindications, etc., that reduce the effectiveness of the drug. Finally, the parameter τ denotes the copayment rate.[14]

We assume that patients cannot observe the type of their condition nor the treatment effects of the different drugs. We let $z \in [0,1]$ be the fraction of patients that attend the

[14] Alternatively, we can think of τ as a measure of the extent to which physicians take prices into account when making prescription choices. Generally, τ can then be interpreted as a measure of (ex post) moral hazard.

physician's practice either because they have developed symptoms of their condition or as part of a regular check-up. The remaining fraction $(1-z)$ have the condition but do not visit the physician as, for instance, they do not have developed strong symptoms (yet). These individuals are 'potential' consumers of the two drugs.

If allowed by the health authorities, the pharmaceutical firms can advertise directly to consumers. We assume that DTCA influences the 'potential' patients' decision of whether or not to seek medical advice by a physician. Let $\Phi_i \in [0,1]$ denote the fraction of patients who receive an ad from firm i. We assume that the ads inform the patient about the possible symptoms that are associated with the condition in question and about the existence of a drug. Other than that the ads provide no valuable information to the patient. Since all patients are ill and in need of one of the drugs, we assume that a patient who has seen at least one ad will visit the physician. Only potential patients who have not been exposed to an ad do not seek medical advice. This fraction is given by $(1-z)(1-\Phi_0)(1-\Phi_1)$. The fraction of individuals attending a physician for medical advice is then given by:

$$N(\Phi_0, \Phi_1) = z + (1-z)[1-(1-\Phi_0)(1-\Phi_1)]. \tag{2}$$

Physicians are *ex ante* identical and face the same distribution of patients. They have the skills to identify a patient's type of condition, i.e., the location $x \in [0,1]$. Physicians are perfect agents for the patients, but are assumed to be *a priori* uninformed about the two drugs. The relevant information on drug i is (perfectly) provided through the marketing activities of firm i. For simplicity, we will continue to refer to marketing towards physicians as detailing. Normalising the number of physicians to one, we denote by θ_i the fraction of physicians who have been exposed to detailing by firm i. Since detailing is costly, firms are unable to reach every physician in the market. Thus, there are potentially three types of physicians in the market: (i) 'captive' physicians who have been detailed by only one of the firms, i.e., $\theta_i(1-\theta_j)$; (ii) 'selective' physicians who have been detailed by both firms, i.e., $\theta_0\theta_1$; and (iii) 'non-prescribing' (uninformed) physicians who have not been detailed by any firm, i.e., $(1-\theta_0)(1-\theta_1)$.

Consider a captive physician who has been exposed to detailing by firm i only. This physician trades off drug i against an outside (or no) treatment for every visiting patient.

More precisely, drug i is prescribed to patient x if the following is true:[15]

$$U(x,i,p_i) \geq 0 \quad \Leftrightarrow \quad v - t|x-i| - \tau p_i \geq 0.$$

If $U(.) < 0$, then the physician recommends an outside treatment (e.g., physical exercise) or no treatment at all (e.g., "just wait until it gets better"). The benefit of an outside (or no) treatment is normalised to zero. Letting $\widetilde{x}_i$ denote the patient that is indifferent between drug i and the outside treatment, we obtain

$$\widetilde{x}_0 = \frac{v - \tau p_0}{t} \quad \text{and} \quad \widetilde{x}_1 = 1 - \frac{v - \tau p_1}{t}, \tag{3}$$

respectively. Thus, physicians who have received information by firm 0 only, prescribe drug 0 to every visiting patients within the interval $[0, \widetilde{x}_0]$. Likewise, physicians who have received information by firm 1 only, prescribe drug 1 to every visiting patient within the interval $[1-\widetilde{x}_1, 1]$. Thus, the captive physicians constitute a *monopolistic* segment for the respective firm. Note from (3) that if the copayments become sufficiently small relative to v, then $\widetilde{x}_0 = 1$ and $\widetilde{x}_1 = 0$, implying that every patient will be prescribed a drug. In most of the analysis we restrict attention to the case of elastic demand, which implies $\tau p_i > v - t$.

Consider now a selective physician who has been exposed to detailing from both firms. This physician is fully informed and capable of deciding which drug is the more suitable for every visiting patient. A selective physician prescribes drug 0 to patient x if the following is true:

$$U(x,0,p_0) \geq U(x,1,p_1) \quad \Leftrightarrow \quad v - tx - \tau p_0 \geq v - t(1-x) - \tau p_1.$$

Letting $\widehat{x}$ denote the patient who is indifferent between the two drugs, we have:

$$\widehat{x} = \frac{1}{2} - \frac{\tau(p_0 - p_1)}{2t}. \tag{4}$$

A selective physician would thus prescribe drug 0 to every patient in the interval $[0, \widehat{x}]$ and drug 1 to every patient in $(\widehat{x}, 1]$. As these physicians trade off the two drugs, the fraction $\theta_0\theta_1$ constitutes a *competitive* segment for the two firms. Note that if the copayments are sufficiently high, the two firms become local monopolists. In order to restrict attention to

[15] There is empirical evidence that physicians do care about patients' expenditures when deciding which drug to prescribe (Lundin, 2000). Moreover, Rizzo (1999) estimates that in absence of detailing effort demand responds quite elastically to changes in prices.

the competitive regime, we assume that $U(\widehat{x}, 0, p_0) = U(1-\widehat{x}, 1, p_1) > 0$, which is satisfied if $\tau(p_0 + p_1)/2 < v - t/2$.

From the prescription choices described above, we can now derive the shares of (attending) patients who receive drug 0 or 1, respectively

$$M_0 = \theta_0 [\theta_1 \widehat{x} + (1-\theta_1)\widetilde{x}_0] \quad \text{and} \quad M_1 = \theta_1 [\theta_0 (1-\widehat{x}) + (1-\theta_0)(1-\widetilde{x}_1)]. \tag{5}$$

Firm i faces thus the following demand for its drug:

$$Q_i(\mathbf{\Phi}, \boldsymbol{\theta}, \mathbf{p}) = N(\mathbf{\Phi}) \cdot M_i(\boldsymbol{\theta}, \mathbf{p}), \tag{6}$$

where $\mathbf{\Phi} = (\Phi_0, \Phi_1)$, $\boldsymbol{\theta} = (\theta_0, \theta_1)$ and $\mathbf{p} = (p_0, p_1)$.

The pharmaceutical firms face identical and constant marginal production costs, which we normalise to zero. The R&D costs are considered sunk at the time marketing and price decisions are taking place and play no role in the analysis. Building on the framework introduced by Butters (1977), we assume that the cost of reaching a fraction θ_i of physicians and a fraction Φ_i of patients is given by the following general advertising cost function, $K(\theta_i, \Phi_i)$. The function $K(.)$ is increasing and convex in both detailing and DTCA. As the two marketing strategies are distinctly different, we assume that detailing and DTCA are separable in the cost function, i.e., $\partial^2 K / \partial\theta_i \partial\Phi_i = 0$. We can now specify firm i's profit function:

$$\pi_i(\mathbf{\Phi}, \boldsymbol{\theta}, \mathbf{p}) = p_i Q_i(\mathbf{\Phi}, \boldsymbol{\theta}, \mathbf{p}) - K(\theta_i, \Phi_i). \tag{7}$$

The following sequence of moves is considered:

- Stage 1: The regulator decides on whether or not to allow DTCA.
- Stage 2: The pharmaceutical firms determine spending on detailing, and, if allowed, they set prices and the level of DTCA.
- Stage 3: The physician prescribes drug 0, drug 1 or the outside treatment to the patients.

As usual, the game is solved by backward induction.[16]

[16] One could argue that marketing is more of a long-term decision than price setting, and should therefore

3 Price regulation

Let us first examine the firms' marketing strategies in the absence of price competition. This captures the situation in most European countries, where prices of prescription drugs are subject to governmental regulation. Firm 0 maximises (7) with respect to θ_0 and Φ_0, anticipating the number of patients attending the physicians, as given by (2), and the physicians' prescription choices, as given by (5). The solution to the problem follows from the first-order conditions:[17]

$$\frac{\partial \pi_0}{\partial \theta_0} = p_0 N \left[\theta_1 \widehat{x} + (1-\theta_1)\,\widetilde{x}_0\right] - \frac{\partial K}{\partial \theta_0} = 0, \tag{8}$$

$$\frac{\partial \pi_0}{\partial \Phi_0} = p_0 M_0 \,(1-z)\,(1-\Phi_1) - \frac{\partial K}{\partial \Phi_0} = 0. \tag{9}$$

Firm 1 faces a symmetric problem and a symmetric set of first-order conditions. We assume that the regulator imposes the same price on both drugs, i.e., $p_0 = p_1 = p$. This is a reasonable assumption since the drugs/firms are fully symmetric. With identical prices, the physicians will prescribe the two drugs according to:

$$\widehat{x} = 1 - \widehat{x} = \frac{1}{2} \quad \text{and} \quad \widetilde{x}_0 = 1 - \widetilde{x}_1 = \frac{v - \tau p}{t}. \tag{10}$$

To simplify exposition let us define $\widetilde{x} = \frac{v-\tau p}{t}$. In the following, we restrict attention to the case with a competitive region and a monopolistic region with elastic demand, i.e., $\widehat{x} < \widetilde{x} < 1$. For this to be true, we need to assume the following:

$$v - t < \tau p < v - \frac{t}{2}. \tag{11}$$

The symmetric detailing and DTCA equilibrium levels are then (implicitly) defined by

be determined at a stage previous of the price game. As this only complicates the analysis without providing any qualitatively different results, we follow Butters (1977), Grossman and Shapiro (1984), and others, by assuming marketing and price decisions to take place at the same stage of the game.

[17] For the second order conditions to be fulfilled, the following must hold:

$$\left(\frac{\partial^2 K}{\partial \theta_0^2}\right)\left(\frac{\partial^2 K}{\partial \phi_0^2}\right) > \left(p\,(1-z)\,(1-\phi_1)\left[(1-\theta_1)\,\widetilde{x} + \theta_1 \widehat{x}\right]\right)^2$$

the following set of equations:[18]

$$pN\left[\left(1-\theta^r\right)\widetilde{x}+\frac{\theta^r}{2}\right]-K_\theta\left(\theta^r\right)=0, \tag{12}$$

$$pM\left(1-z\right)\left(1-\Phi^r\right)-K_\Phi\left(\Phi^r\right)=0, \tag{13}$$

where

$$N=z+\left(1-z\right)\left[1-\left(1-\Phi\right)^2\right],$$

$$M=\theta\left[\left(1-\theta\right)\widetilde{x}+\frac{\theta}{2}\right].$$

The superscript (r) denotes the equilibrium under price regulation. Note that symmetry allows us to drop the indexing of the variables. For notational convenience, we will use K_θ and K_Φ instead of $\partial K/\partial\theta$ and $\partial K/\partial\Phi$, respectively, in the following.

Let us explore the interaction between the two marketing variables. By total differentiation of (12), we obtain the following:

$$\frac{d\theta^r}{d\Phi}=\frac{2p\left(1-z\right)\left(1-\Phi\right)\left[\left(1-\theta\right)\widetilde{x}+\frac{\theta}{2}\right]}{pN\left(\widetilde{x}-\frac{1}{2}\right)+K_{\theta\theta}}>0. \tag{14}$$

Noting that $\widetilde{x}>1/2$, it is easily verified that DTCA has a positive effect on detailing. The intuition is that a higher level of DTCA induces more patient visits. Facing a larger market, it then becomes more profitable for the firms to promote their drugs to the physicians in order to increase their market share.

The effect of a change in detailing on the equilibrium level of DTCA is found by differentiating (13):

$$\frac{d\Phi^r}{d\theta}=\frac{p\left(1-z\right)\left(1-\Phi\right)\left[\left(1-2\theta\right)\widetilde{x}+\theta\right]}{pM\left(1-z\right)+K_{\Phi\Phi}}>0 \tag{15}$$

Noting that $\left(1-2\theta\right)\widetilde{x}+\theta>0$ for all valid values, it is easily verified that the sign is positive. Thus, a higher level of detailing increases the firms' incentives to spend money on DTCA. To understand this recall that physicians who have not been exposed to detailing are unaware of the available drugs and thus recommend an outside treatment. Low levels of detailing mean low individual demand for the drugs, which in turn provides weak incentives for the firms to prompt patient visits via DTCA. We may sum up the results in the following proposition:

[18] Provided that $K_{\Phi\Phi}$ and $K_{\theta\theta}$ are positive and sufficiently large the system (12) and (13) has a unique and stable equilibrium. Also note that $\theta\leq 1$ implies $pN\leq 2K_\theta\left(1\right)$.

Proposition 1 *DTCA and detailing are complementary marketing strategies for the firms in the case of price regulation.*

Thus, our model predicts that allowing DTCA would lead to more detailing. Vice versa, a stricter regulation of detailing would reduce firms' spending on DTCA. Empirical evidence suggests a positive relationship between DTCA and detailing. In the US, DTCA was liberalised in 1997. Based on US marketing data, Rosenthal et al. (2002) find that spending on DTCA for prescription drugs tripled between 1996 and 2000. For the same period promotional spending to physicians also increased (except for journal advertising). Our model provides an intuition for a positive correlation between the two marketing strategies.

Consider now the industry-maximising (or cooperative) marketing levels. The profit function under symmetry is given by:

$$\pi(\theta, \Phi) = pN(\Phi) M(\theta) - K(\theta, \Phi). \tag{16}$$

Maximising this with respect to θ and Φ gives us the optimal levels of marketing at the industry level, as defined by the following set of first-order conditions:

$$\frac{\partial \pi}{\partial \theta} = pN[(1-\theta)\widetilde{x} + (1-\widetilde{x})\theta] - K_\theta = 0, \tag{17}$$

$$\frac{\partial \pi}{\partial \Phi} = 2pM(1-z)(1-\Phi) - K_\Phi = 0. \tag{18}$$

Comparing the industry-maximising marketing levels with the duopoly marketing levels, provides the following result.

Lemma 1 *Firms overinvest in detailing and underinvest in DTCA from an industry perspective under price regulation.*

Proof. The result follows by direct inspection, when comparing (12) with (17), while observing $(1-\widetilde{x}) < \frac{1}{2}$, and (13) with (18). ■

The Lemma states that if firms could coordinate their marketing investments, they would choose a lower level of detailing and a higher level of DTCA. Basically, this results from the fact that DTCA is purely market-expanding, while detailing contains elements of both market expansion and business-stealing. Since DTCA induces patients to visit a physician,

but does not affect the choice of drug, there is an incentive for the firms to free-ride on each other. Because of the positive spillover it is hardly surprising that firms tend to underinvest in DTCA.

In contrast to DTCA, detailing tends to shift market shares between the duopolists and the 'outside treatment', and amongst the duopolists themselves. On the one hand, by providing information to some previously uninformed physicians detailing by, say, firm 0 contributes towards expanding the market share of drug 0 at the expense of the outside treatment. This leaves the rival firm 1 unaffected. On the other hand, however, by informing physicians who were previously informed about drug 1 only, detailing by firm 0 also shifts demand from firm 1's monopolistic segment into the competitive segment. This form of business stealing constitutes a negative externality and, thus, implies over-investment.

Let us turn to the issue of whether or not firms benefit from the availability of DTCA. The criterion for DTCA to be profitable for the firms is given by the following condition:

$$\Delta\pi \equiv \pi\left(\theta^r, \Phi^r\right) - \pi\left(\theta^r\left|_{\Phi=0}\right., 0\right) > 0, \tag{19}$$

In general, the value of higher demand due to DTCA must be higher than the net increase in marketing costs. Evaluating (19) for equilibrium detailing and DTCA, we obtain the following result:

Proposition 2 *DTCA unambiguously increases firms' profits if the detailing costs are sufficiently convex, i.e. if*

$$\frac{K_{\theta\theta}}{K_\theta} > \frac{\widetilde{x} - 1/2}{\widetilde{x} - \theta\left(\widetilde{x} - 1/2\right)} \in (0, 1)\,.$$

[19]

A proof is provided in the Appendix.

[19] To examine the condition in the proposition, consider the following class of cost functions: $K(\theta) = \beta\theta^\gamma$, where $\beta > 0$, $\gamma > 1$. Taking the first and the second derivative of this function, we find that

$$\frac{K_{\theta\theta}}{K_\theta} = \frac{\gamma - 1}{\theta} > 1 \text{ iff } \gamma > 1 + \theta.$$

Thus, firms benefit from DTCA for any detailing cost function with a convexity higher than $1 + \theta$, which is a very mild condition, taking into account that θ at maximum is equal to 1.

At first glance it may seem strange that firms should benefit from DTCA only when the detailing cost function is sufficiently convex, especially since DTCA triggers higher levels of detailing. The intuition is, however, closely linked to a *strategic* effect of a costly detailing technology. When detailing costs are very convex, firms spend little on detailing. At low levels of detailing the monopolistic segment of the market is relatively large compared with the competitive segment. Thus, competition is softened by a costly detailing technology. In this case, the direct market-expanding effect of DTCA dominates the (indirect) stiffening of detailing competition, and DTCA is beneficial to the firms.

This type of result is not unfamiliar to the advertising literature, and has been identified by, for instance, Grossman and Shapiro (1984). They demonstrate that a more costly advertising technology has two countervailing effects on profits. First, there is the obvious direct negative cost effect. Second, and more interesting, there is a *strategic* positive effect, namely that a costly advertising technology limits the size of the competitive segment. There are clear parallels between these results.

Finally, let us take a brief look at the comparative statics. We see from (12) and (13) that detailing and DTCA are increasing in v, while decreasing in t and τ. Taking into account the complementarity between the two marketing strategies, then, obviously, v, t and τ have the same qualitative effects in equilibrium. Quantitatively the effects are in fact *amplified* due to the positive interaction between the two marketing strategies. For instance, the negative effect of a higher mismatch cost, t, on detailing is reinforced in the presence of DTCA.

The effects of p and z are more complex. Instead of deriving the comparative statics analytically, we use numerical illustrations, which ease the presentation of the intuition.[20] We will for this part assume that the advertising cost function takes the following form: $K(\theta, \Phi) = \frac{1}{2}\left(\theta^2 + \Phi^2\right)$. Although we restrict ourselves to a relatively small set of numerical examples, several regularities can be identified that shed some light on the mechanisms of the model.

Consider first the effects of an increase in the fraction of *regular patients* (z). A higher z increases detailing as the number of patient visits grows. However, a higher z also re-

[20] Interested readers can contact the authors for the analytical derivation of the comparative statics.

duces DTCA as the "potential" market shrinks. Since lower DTCA reduces the number of attending patients, this has a negative indirect effect on detailing. Thus, the net effect of a change in z is ambiguous in general. Table 1 provides a numerical illustration of the effects of z.

Table 1: Comparative statics w.r.t. z

z	θ^r	Φ^r	M^r	N^r	π^r
0.0	0.645	0.396	0.437	0.635	0.130
0.2	0.661	0.347	0.443	0.659	0.159
0.4	0.686	0.289	0.451	0.696	0.194
0.6	0.723	0.217	0.462	0.755	0.238
0.8	0.777	0.125	0.475	0.847	0.294
1.0	0.857	0.0	0.490	1.0	0.367

Assumptions: $v = 1.75; t = 1; \tau = 0.5; p = 1.5$

From the table we see that detailing is increasing, while DTCA is decreasing, in the level of z. Thus, the direct effect dominates the indirect complementarity effect for the specific parameter values chosen.[21] This is in line with the empirical findings by Iizuka (2004). Moreover, we see that each firm's market share, M, increases in z. Since the demand in the monopolistic segment is fixed ($\widetilde{x} = 0.75$), the increase in the firms' market shares follow directly from the increase in detailing due to a change in z. The number of patients visiting the physicians, N, is also increasing in z, despite the fact that DTCA is reduced. Since DTCA attracts 'potential' patients only with a probability, this can never exceed the direct effect of one more 'regular' patient with certainty. Finally, we see that profits are increasing in z.

The effects of an increase in the *regulated price* (p), too, are subject to countervailing forces. On the one hand, a higher p increases the revenues from every patient buying the product, boosting the incentives for both detailing and DTCA. On the other hand, a higher p lowers demand in the monopolistic segment, as drug consumption now becomes more

[21] It is possible to show that the direct effect dominates the indirect effect for a wide set of parameter values. The exception is when the copayment rate τ is very low.

expensive. Table 2 provides a numerical illustration.

Table 2: Comparative statics w.r.t. p

p	θ^r	Φ^r	$\widetilde{x}^r$	M^r	N^r	π^r
1.5	0.703	0.255	1.0	0.456	0.722	0.015
1.7	0.752	0.277	0.9	0.451	0.739	0.051
1.9	0.802	0.299	0.8	0.449	0.754	0.093
2.1	0.856	0.322	0.7	0.453	0.770	0.143
2.3	0.921	0.350	0.6	0.468	0.789	0.213
2.4	0.963	0.367	0.55	0.483	0.800	0.397

Assumptions: $v = 1.75; t = 1; z = 0.5; \tau = 0.5$

As expected the demand in the monopolistic segment, $\widetilde{x}$, drops as the price increases. Despite the "demand-reducing" effect, both detailing and DTCA are increasing in p. This means that the direct positive effect of a higher price dominates the negative demand effect for the set of parameter values considered in Table 2.[22] Moreover, we see that the number of patient visits, N, increases in p, which follows straightforwardly from the effect of price on DTCA. The effect on market shares, M, is more complicated, though. At low price levels M is decreasing in p, while at high price levels M is increasing in p. Basically, this is the net result of changes in $\widetilde{x}$ and θ^r due to price increases. Finally, we see that the firms benefit from price increases, implying that the net revenue effect of a higher price more than offsets the increase in marketing costs. However, since profits in general are concave in p, the reverse will be true at higher price levels.

4 Price competition

Let us now consider the case where the Health Authority allows the pharmaceutical firms to set the prices of their products. This situation is relevant for some markets, in particular

[22] It is possible to show that the "mark-up" effect dominates the "reduced-demand" effect for almost every valid set of parameter values. The exception is when the copayment rate is very high.

the US.[23] At stage two of the game, firm 0 maximises (7) with respect to θ_0, Φ_0 and p_0, anticipating the number of patients attending the physicians, as given by (2), and the physicians' prescription choices, as given by (5). The solution to this problem is defined by the set of first-order conditions consisting of (8), (9), and

$$\begin{aligned} \frac{\partial \pi_0}{\partial p_0} &= M_0 + p_0 \left[\frac{\partial M_0}{\partial \widehat{x}} \frac{\partial \widehat{x}}{\partial p_0} + \frac{\partial M_0}{\partial \widetilde{x}_0} \frac{\partial \widetilde{x}_0}{\partial p_0} \right] = 0, \\ &= \theta_0 \left[\theta_1 \widehat{x} + (1-\theta_1)\, \widetilde{x}_0 - p_0 \frac{\tau}{t} \left(1 - \frac{\theta_1}{2} \right) \right] = 0. \end{aligned} \tag{20}$$

Firm 1 faces a symmetric problem and a symmetric set of first-order conditions. We therefore impose symmetry in order to derive the equilibrium. Under symmetry we know that the physicians would prescribe according to (10). Inserting this into (20) and solving for p, we find the equilibrium price to be (implicitly) given by

$$p^c = \frac{2v\,(1-\theta) + t\theta}{\tau\,(4-3\theta)}, \tag{21}$$

with the superscript (c) denoting the price competition regime. Thus, the symmetric equilibrium under price competition is defined by (12), (13) and (21).[24,25] Inserting (21) into (10), we obtain the following market shares for the competitive and the monopolistic segment,

$$\widehat{x} = \frac{1}{2} \quad \text{and} \quad \widetilde{x}^c = \frac{2v - \theta\,(v+t)}{t\,(4-3\theta)}, \tag{22}$$

respectively. The restriction securing an equilibrium with a competitive region and an elastic monopolistic region, i.e., $\widehat{x} < \widetilde{x} < 1$, is now given by

$$\frac{t\,(4-\theta)}{2\,(2-\theta)} < v < 2t, \quad \text{where } \frac{t\,(4-\theta)}{2\,(2-\theta)} \in \left[t, \frac{3}{2}t \right]. \tag{23}$$

Thus, the gross effectiveness (or quality) of the drug, v, must neither be too large nor too small relative to the mismatch cost, t. We assume (23) to hold in the following.

[23] The German market, too, used to exhibit relatively free pricing. However, this has changed after recent reforms, where reference pricing is now being practiced.

[24] Provided that $K_{\Phi\Phi}$ and $K_{\theta\theta}$ are positive and sufficiently large the system (12), (13) and (21) has a unique and stable equilibrium. Here, $\theta^c \leq 1$ implies $2K_\theta\,(1) \geq \frac{Nt}{\tau}$ or, equivalently, $\tau \geq \frac{Nt}{2K_\theta(1)}$.

[25] In their well-known contribution Dorfman and Steiner (1954) show that the advertising to sales ratio equals the ratio of the advertising and price elasticity. As a referee has pointed out to us, similar rules can be derived for our model that describe the relationship between expenditure on detailing and DTCA in relation to each other and in relation to sales revenue. The exact conditions can be provided upon request.

Only detailing has a direct effect on the equilibrium price. The price depends on DTCA only indirectly via the effect of DTCA on detailing. The same holds for the demand in the monopolistic segment as defined by $\widetilde{x}^c$. The reason is that DTCA does not affect the physicians' prescription choices, which in turn determine the price elasticity of demand. Differentiating (21) and (22) with respect to detailing, we obtain

$$\frac{\partial p^c}{\partial \theta} = \frac{2\left(2t - v\right)}{\tau\left(4 - 3\theta\right)^2} > 0 \quad \text{and} \quad \frac{\partial \widetilde{x}^c}{\partial \theta} = -\frac{2\left(2t - v\right)}{t\left(4 - 3\theta\right)^2} < 0. \tag{24}$$

Thus, a higher level of detailing increases the equilibrium price and thus decreases the demand in the monopolistic segment. As a consequence, the effect of more detailing on each firm's market share, as given by M, now becomes ambiguous. Inserting (22) into (5) and differentiating the resulting expression with respect to detailing, while observing the restriction in (23), we can show that:

$$\frac{\partial M}{\partial \theta} = \frac{8v + 8t\theta - 24v\theta + 21v\theta^2 - 9t\theta^2 + 3t\theta^3 - 6v\theta^3}{t\left(4 - 3\theta\right)^2} > 0.$$

Thus, the direct positive effect of detailing on market shares more than offsets the indirect negative price effect. We can summarise as follows:

Lemma 2 *(i) Detailing increases the equilibrium price. (ii) Detailing lowers demand in the monopolistic segment, but increases overall demand.*

The effect on price of detailing is interesting for the following two reasons. First, it runs counter to other theoretical findings using an informative advertising framework. For instance, Grossman and Shapiro (1984) show that informative advertising leads to lower prices. The argument is that advertising increases the fraction of fully informed buyers, i.e., the competitive segment, and this triggers price competition. Our model resembles the Grossman and Shapiro (1984) model. The basic difference between the two models is that we assume *elastic* demand in the monopolistic segment, while they assume *inelastic* demand in this segment.[26] Thus, in our model a firm faces two effects of lowering its price: (i) it steals some consumers from the rival in the competitive segment; and (ii) it increases the demand in the monopolistic segment. In Grossman and Shapiro (1984) only the first effect

[26] Formally, Grossman and Shapiro (1984) assume that the partially informed fractions, i.e., $\theta_0\left(1 - \theta_1\right)$ and $\theta_1\left(1 - \theta_0\right)$, purchase the product at any price p_0 and p_1, implying that $\widetilde{x}_0 = 1 - \widetilde{x}_1 = 1$.

is present. Interestingly, it turns out that this assumption qualitatively changes the effect of marketing upon prices.

Second, the effect of prices is consistent with empirical findings. Considering competition between branded drugs, Rizzo (1999) finds that advertising, or detailing more precisely, makes demand less elastic to prices, and thus leads to higher prices. This result is then interpreted as drug marketing being persuasive rather than informative. Our model demonstrates that even informative advertising might lead to higher prices, given that demand in the monopolistic segment is sufficiently elastic. Thus, the issue of persuasive versus informative drug marketing is unresolved.

Let us now examine the interaction between the firms' strategies. We know from (14) and (15) that detailing and DTCA are complementary strategies. This is true for any positive price, and thus also true for the equilibrium price under price competition. The issue now is to analyse the interaction between price and the two marketing strategies. By differentiating (12) and (13), we obtain the following:

$$\frac{d\theta^c}{dp} = \frac{N\left[(1-\theta)\left(\frac{v-2\tau p}{t}\right)+\frac{\theta}{2}\right]}{pN\left(\widetilde{x}-\frac{1}{2}\right)+K_{\theta\theta}}, \tag{25}$$

$$\frac{d\Phi^c}{dp} = \frac{(1-z)(1-\Phi)\theta\left[(1-\theta)\left(\frac{v-2\tau p}{t}\right)+\frac{\theta}{2}\right]}{pM(1-z)+K_{\Phi\Phi}}. \tag{26}$$

Evaluating (25) and (26) for the equilibrium price level, given by (21), we obtain the following result:

Proposition 3 *Detailing, DTCA and price are complementary strategies for the firms in the case of price competition.*

A proof is provided in the Appendix.

As discussed previously, a higher price has two opposing effects: First, it increases the revenues per drug sold. Second, it lowers demand (in the monopolistic segment). The proposition states that the first effect dominates, so that a higher price actually has a positive impact on both detailing and DTCA. As a consequence, the availability of price as a strategic variable *amplifies* the complementarity between the two marketing strategies. Compared with the price regulation case, a higher level of detailing not only increases

DTCA but also prices. Moreover, higher prices have a positive feedback on both detailing and DTCA. Thus, there is a complementarity between all strategic variables.

Under price regulation we showed that firms tend to overinvest in detailing and underinvest in DTCA from an industry perspective (cf. Lemma 1). This result carries over to the case of price competition, where it can be shown that (as expected) firms set a price that is below the one they would choose cooperatively.

Let us now examine whether or not firms benefit from the availability of DTCA under price competition. As for the price regulation case, the criteria for DTCA to be profitable for the firms is determined by the difference in equilibrium profits with and without DTCA, as defined by (19). Taking into account the equilibrium price, we obtain the following result:

Proposition 4 *(i) DTCA unambiguously increases firms' profits if the detailing costs are sufficiently convex, i.e. if*

$$\frac{K_{\theta\theta}}{K_\theta} > \frac{\widetilde{x} - \frac{1}{2} - \frac{\tau\theta}{2t}\frac{\partial p^c}{\partial \theta}}{\widetilde{x} - \theta\left(\widetilde{x} - 1/2\right)} \in (0,1)\,.$$

[27]

(ii) Under price competition DTCA is profitable for a wider range of parameters than in the case of price regulation.

A proof is provided in the Appendix.

Recall from Proposition 2 that firms benefit from DTCA if the detailing cost function is sufficiently convex. This result was derived for any price, including the equilibrium price under price competition. The above proposition demonstrates that price competition relaxes this condition.[28] As more detailing tends to allow the firms to charge a higher equilibrium price, the problem of over-investment into detailing is now less pronounced. The stiffening of detailing competition when DTCA is allowed is then "less costly" to the firms, and DTCA tends to be more profitable than under price regulation.

The comparative statics are further complicated under price competition as now the price, too, is affected by changes in the parameters. However, the effects of v and τ are still

[27] As for the price regulation case, this condition is not very strict. Firms benefit from DTCA for any detailing cost function with a higher degree of convexity than $1+\theta$. See footnote 18.

[28] Note that $\frac{\partial p^c}{\partial \theta} > 0$

straightforward. From (21), (8) and (9) we see that a higher v increases the equilibrium price, detailing and DTCA. Conversely, a higher co-payment τ increases the price elasticity of demand and therefore curbs the equilibrium price and marketing.

The complicated effects are thus associated with the parameters t and z. It can easily be shown that the comparative statics with respect to z are qualitatively the same as for the price regulation case except for the fact that prices are usually increasing in z.[29] The reason for this is the interaction with detailing. A higher z leads to more detailing, which in turn has a positive effect on prices.

Turning to the comparative statics with respect to t, recall that under price regulation a higher t implied less detailing and less DTCA. The reason is that a higher t reduces demand from the monopolistic segment. While the demand-reducing effect is still present under price competition, this effect is now counteracted by a positive impact on price of t. More differentiated drugs enable the firms to set higher prices, as is readily verified from (21). Thus, it is not clear whether a higher t leads to more or less marketing and, in turn, to higher or lower profits. Table 3 below illustrates the relationship.

Table 3: Comparative statics with respect to t

t	p^c	θ^c	Φ^c	$\widetilde{x}^c$	M^c	N^c	π^c
0.875	1.750	0.7935	0.2952	1.000	0.4787	0.7517	0.2713
0.900	1.775	0.7933	0.2951	0.959	0.4719	0.7516	0.2711
0.925	1.799	0.7933	0.2951	0.920	0.4654	0.7515	0.2711
0.950	1.824	0.7935	0.2952	0.882	0.4594	0.7516	0.2713
0.975	1.848	0.7940	0.2954	0.847	0.4538	0.7518	0.2716
1.000	1.873	0.7949	0.2958	0.814	0.4486	0.752 1	0.2722
1.250	2.179	0.8425	0.3165	0.528	0.4250	0.7664	0.3048

Assumptions: $v = 1.75, z = 0.5, \tau = 0.5$.

As expected, the equilibrium price unambiguously increases in t. Moreover, a higher price and a higher t both contribute to a lower demand in the monopolistic segment, as given by $\widetilde{x}$ in the table. However, the effects of t on the two marketing strategies are

[29] For some low τ, p^c is convex in z.

ambiguous. At low levels of t, both detailing and DTCA are decreasing due to a marginal increase in t. Contrary, at high levels, the marginal effect of t is positive. The reason is that the demand-reducing effect of t dominates the price-increasing effect for low levels of t, while the opposite is true for high levels of t. This also explains the effect on profits of changes in t .

5 Welfare and policy implications

In this section we analyse welfare and policy implications of DTCA. First, we characterise the social optimum (first-best) and compare this with the price regulation and price competition equilibria derived in the previous sections. Second, we analyse the desirability of DTCA using two different measures: (i) a standard (unweighted) welfare function; and (ii) consumer surplus net of medical expenditures. The second measure is equivalent to putting a zero weight on firms' profits. We believe this measure captures the objective of countries with insignificant R&D and production of pharmaceuticals.

Let us start by specifying the consumer surplus. The total number of patients is normalised to 1, of which a fraction $N \in [0,1]$, as given by (2), visits a physician. Patients' utility depend on the physicians' prescribing choice. The fraction of selective physicians, i.e., $\theta_0\theta_1$, trade off the two drugs, creating the following surplus for their patients:

$$\begin{aligned} C &= \theta_0\theta_1 \left[\int_0^{\widehat{x}} (v - \tau p_0 - ty)\, dy + \int_{\widehat{x}}^1 (v - \tau p_1 - t(1-y))\, dy \right], \qquad (27) \\ &= \theta_0\theta_1 \left[v - \tau p_0 \widehat{x} - \tau p_1 (1-\widehat{x}) - \frac{t}{2}\left(\widehat{x}^2 + (1-\widehat{x})^2 \right) \right]. \end{aligned}$$

Selective physicians contribute to consumer surplus by improving the *matching* of drugs to patients with different types of illnesses. Thus, C measures the social benefit of detailing due to improved matching.

The fraction of captive physicians, i.e., $\theta_i(1-\theta_j)$, trades off the drug they are aware of against an outside treatment (or no treatment), creating the following surplus for their patients:

$$\begin{aligned} D &= \theta_0(1-\theta_1) \int_0^{\widetilde{x}_0} (v - \tau p_0 - ty)\, dy + \theta_1(1-\theta_0) \int_{1-\widetilde{x}_1}^1 (v - \tau p_1 - t(1-y))\, dy, \qquad (28) \\ &= \theta_0(1-\theta_1) \left(\widetilde{x}_0 (v - \tau p_0) - \frac{t}{2}\widetilde{x}_0^2 \right) + \theta_1(1-\theta_0) \left(\widetilde{x}_1 (v - \tau p_1) - \frac{t}{2}\widetilde{x}_1^2 \right). \end{aligned}$$

Captive physicians make a prescription to every visiting patient who are better off with a drug treatment than an outside treatment. Thus, D measures the social benefit of detailing in terms of *reduced under-treatment* of patients with this particular illness. Finally, non-prescribing (uninformed) physicians recommend an outside treatment to their patients. Having normalised the benefit of the outside treatment to zero, total consumer surplus is, thus, given by:

$$CS = N \cdot [C + D]\,. \tag{29}$$

It is easily verified that gross consumer surplus (i.e., $CS + \tau p_0 Q_0 + \tau p_1 Q_1$) is unambiguously increasing in both detailing and DTCA. However, from the previous sections, we know that the copayment rate and prices affect the marketing levels, implying countervailing effects on net consumer surplus, i.e., CS. Section 5.2 below deals in detail with this issue, focusing on the benefit of allowing DTCA.

5.1 First best

Welfare is defined as the consumers' surplus and firms' profits (producers' surplus) net of third-party payments. Collecting terms, the welfare function can be written as:[30]

$$W = N \cdot \Omega - K(\theta_0, \Phi_0) - K(\theta_1, \Phi_1)\,, \tag{30}$$

where

$$\Omega \equiv \theta_0\theta_1\left(v - \frac{t}{2}\left(\widehat{x}^2 + (1-\widehat{x})^2\right)\right) + \theta_0(1-\theta_1)\widetilde{x}_0\left(v - \frac{t}{2}\widetilde{x}_0\right) + \theta_1(1-\theta_0)\widetilde{x}_1\left(v - \frac{t}{2}\widetilde{x}_1\right).$$

The social planner's problem is to maximise (30) with respect to $\widehat{x}$, $\widetilde{x}_i$, θ_i and Φ_i. The solution to this problem defines first-best and is given by the following set of first-order conditions:

$$\frac{\partial W}{\partial \widehat{x}} = N \cdot [\theta_0\theta_1 t(1 - 2\widehat{x})] = 0, \tag{31}$$

$$\frac{\partial W}{\partial \widetilde{x}_i} = N \cdot [\theta_i(1-\theta_j)(v - t\widetilde{x}_i)] = 0, \tag{32}$$

$$\frac{\partial W}{\partial \theta_i} = N \cdot \frac{\partial \Omega}{\partial \theta_i} - \frac{\partial K}{\partial \theta_i} = 0, \tag{33}$$

[30] In a first-best world the social planner has access to lump-sum transfers. Thus, in deriving first-best we ignore distortionary effects associated with the third-party payments. In a second-best world, however, this is likely to be an argument.

$$\frac{\partial W}{\partial \Phi_i} = (1-z)(1-\Phi_j)\cdot\Omega - \frac{\partial K}{\partial \Phi_i} = 0, \tag{34}$$

where

$$\frac{\partial \Omega}{\partial \theta_i} = \theta_j\left(v - \frac{t}{2}\left(\widehat{x}^2 + (1-\widehat{x})^2\right)\right) + (1-\theta_j)\,\widetilde{x}_i\left(v - \frac{t}{2}\widetilde{x}_i\right) - \theta_j\widetilde{x}_j\left(v - \frac{t}{2}\widetilde{x}_j\right).$$

From (31) the socially optimal prescription choice by selective physicians implies $\widehat{x}^{fb} = 1/2$, which is the choice that minimises the mismatch costs. As this is also the equilibrium prescription choice, there is no social loss associated with the selective physicians. Moreover, from (32) we derive the first-best prescription choice by captive physicians:

$$\widetilde{x}_0^{fb} = \widetilde{x}_1^{fb} = \begin{cases} \frac{v}{t} & \text{if } v < t \\ 1 & \text{if } v \geq t \end{cases}.$$

Thus, we have two candidates for first-best. If the effectiveness of the drug is sufficiently small, i.e., if $v < t$, the patients with the highest mismatch costs ("longest distance") should not receive a prescription, as they would get negative utility from the treatment. On the other hand, if the effectiveness of the drug is sufficiently large, i.e., if $v \geq t$, it is socially optimal that every visiting patient receive a drug prescription. However, under price competition we know from (23) that v must be weakly larger than t for the equilibrium to be well-defined. Thus, in the following we assume $v \geq t$, implying that $\widetilde{x}_i^{fb} = 1$ is the relevant candidate. Given this assumption, we can from (33) and (34) derive first-best detailing and DTCA:

$$[z + (1-z)\,\Phi\,(2-\Phi)]\cdot\left[v\left(1-\theta^{fb}\right) - \frac{t}{4}\left(2-3\theta^{fb}\right)\right] - K_\theta\left(\theta^{fb}\right) = 0 \tag{35}$$

$$(1-z)\left(1-\Phi^{fb}\right)\cdot\theta\left[v\,(2-\theta) - \frac{t}{4}\,(4-3\theta)\right] - K_\Phi\left(\Phi^{fb}\right) = 0 \tag{36}$$

In general, detailing and DTCA can be both excessive and suboptimal when compared with the first-best.[31] The reason is that equilibrium detailing and DTCA are decreasing in the copayment rate (and increasing in price for the regulation case). Thus, for sufficiently low copayments (and/or sufficiently high regulated prices), excessive marketing occurs, and vice versa. A comparison of (35) and (36) with equilibrium detailing and DTCA provides, however, a more interesting result.

[31] A full characterisation of the comparison of first-best against equilibrium marketing has been carried out, and can be provided by the authors upon request.

Proposition 5 *First-best is in general not achievable via price and/or co-payment regulation. In particular, first-best detailing implies suboptimal DTCA, and first-best DTCA implies excessive detailing. In either case, under-treatment (under-diagnosing) occurs.*

A proof is provided in the Appendix.

Optimal price regulation and insurance policy are clearly outside the scope of this paper.[32] However, the proposition contains some policy implications relevant for this industry given the scale at which marketing activity takes place. In the price competition case, there is one instrument, τ, to induce socially optimal levels of three variables, θ, Φ and $\widetilde{x}$. Assume that τ (or p) is set so that firms' invest socially optimal in detailing, which is true for a relatively high copayment. In this case, DTCA will be suboptimal due to its strong public good character. Vice versa, if τ is set so that DTCA is socially optimal, which is true for a relatively low copayment rate, then detailing is excessive due to its business-stealing effect. In the price regulation case, there are two instruments, τ and p, that can induce socially optimal levels of the three variables, θ, Φ and $\widetilde{x}$. However, since these instruments have the same directional effect on both marketing strategies, it follows that in general first-best cannot be achieved.

5.2 The welfare effects of DTCA

To analyse the desirability of DTCA, we use two different welfare measures: (i) the (unweighted) sum of consumer surplus and profit net of third party transfers; and (ii) consumer surplus net of medical expenditures, consisting of copayments and third party payments. For simplicity, we assume that there is no social costs associated with the third party transfers.[33] Imposing symmetry, and collecting terms, we can write the social welfare function

[32] Price regulation is mainly concerned with the trade-off between R&D and cost containment, while insurance is concerned with moral hazard and adverse selection problems. As our purpose is a very different one, second-best policy is beyond the scope of this paper.

[33] In practice, third-party transfers are typically funded by taxation or social insurance which has distortionary effects on labour supply and possibly consumption. Since the effect of this social cost is rather straightforward, and since we want to focus on the existing parameters in our model, we do not pursue this issue.

as

$$\begin{aligned} W(p,\theta,\Phi) &= CS + 2\pi - 2(1-\tau)Q \\ &= N(\Phi)\cdot\left[\theta^2\left(v-\frac{t}{4}\right)+\theta(1-\theta)\left(\frac{v^2-(\tau p)^2}{t}\right)\right] - 2K(\theta,\Phi). \end{aligned} \quad (37)$$

We see that the first welfare measure simplifies to (gross) consumer surplus net of firms' marketing expenditures. Note that the copayment rate and the prices matter for welfare as they affect the number of patients ending up with a drug prescription. Thus, prices are not welfare neutral transfers between the agents in our model, but involve a traditional deadweight loss.

The criterion for (equilibrium) DTCA to be socially beneficial is that welfare is higher with DTCA than without DTCA evaluated in equilibrium. Formally, this can be written as:

$$\Delta W \equiv W\left(p^k,\theta^k,\Phi^k\right) - W\left(p^k|_{\Phi=0},\theta^k|_{\Phi=0},0\right) > 0, \quad \text{where } k = r,c. \quad (38)$$

In general, DTCA is desirable only if its positive effect on consumer surplus exceeds the increase in marketing expenditure.

The second welfare measure is the consumer surplus net of medical expenditure. Imposing symmetry, and collecting terms, we can write this measure as follows:

$$\begin{aligned} \Psi(p,\theta,\Phi) &= CS - 2(1-\tau)Q \\ &= N(\Phi)\cdot\left[\theta^2\left(v-\frac{t}{4}-p\right)+\theta(1-\theta)(v-2p+\tau p)\left(\frac{v-\tau p}{t}\right)\right]. \end{aligned} \quad (39)$$

Note that this welfare measure is equivalent to putting a zero weight on firms' profits. As a consequence, marketing outlays are completely ignored, while total medical expenditure plays an important role. The criterion for DTCA to be desirable, using (39) as a measure, can formally be written as:

$$\Delta\Psi \equiv \Psi\left(p^k,\theta^k,\Phi^k\right) - \Psi\left(p^k|_{\Phi=0},\theta^k|_{\Phi=0},0\right) > 0, \quad \text{where } k = r,c. \quad (40)$$

According to this measure, DTCA should be allowed if the improvements in gross consumer surplus exceed the increase in medical expenditures following a liberalisation of DTCA.

An analytical approach to the comparison of welfare levels with and without DTCA proves to be intractable. We therefore resort to numerical analysis. As for the previous numerical analysis, we assume the following advertising cost function: $K(\theta,\Phi) = \frac{1}{2}\left(\theta^2+\Phi^2\right)$.

Consider first the case of price regulation. In terms of welfare and policy implications, the key parameters under price regulation are the regulated price p and the copayment rate τ.[34] In Table 4, we evaluate the welfare effect of DTCA, as given by (38), for different levels of p and τ.[35]

Table 4: The effect of DTCA on W under price regulation

τ/p	1.4	1.6	1.8	2.0	2.2	2.4
0.35	–	–	–	–	0.033	−0.003
0.45	–	–	0.091	0.066	0.036	−0.003
0.55	0.122	0.109	0.091	0.071	0.046	–
0.65	0.112	0.100	0.086	–	–	–
0.75	0.096	0.082	–	–	–	–
0.85	0.073	–	–	–	–	–

Assumptions: $v = 1.75$, $t = 1$, $z = 0.5$.

The table illustrates that DTCA is likely to be welfare improving, i.e., $\Delta W > 0$, for a wide range of combinations of prices and copayment rates. The exception is when the regulated price becomes very high.[36] In this case, equilibrium detailing, and possibly DTCA, are excessive, implying that the increase in consumer surplus due to DTCA is more than offset by the increase in aggregate marketing expenditures. The effect of the copayment is less clear. At high price levels, a higher copayment is likely to improve the net welfare benefit from DTCA, while at low price levels the opposite is true. The intuition is closely linked to whether marketing is suboptimal or excessive. At low price levels, DTCA, and possibly detailing, are suboptimal. A reduction of the copayment rate in this case, increases

[34] Numerous numerical exercises of the other parameters, i.e., v, t and z, have been carried out for both the price regulation and the price competition case. However, since the choice of whether or not to allow DTCA is likely to apply for all illnesses - and not for specific treatments depending on the levels of v, t and z - we have left these analysis out of the paper. The numerical results can, however, be provided upon request.

[35] The empty cells corresponds to combinations for p and τ where $\widetilde{x} \notin (1/2, 1]$.

[36] Notably, the pattern with respect to τ and p reported in Tables 4 and 5 emerges for a wide set of values of v, t and z.

the incentives for marketing, resulting in a net welfare improvement. At high price levels, the opposite is true.

Turning to the second welfare measure - consumer surplus net of medical expenditures - we provide in Table 5 a numerical evaluation of (40) for different values of p and τ.

Table 5: The effect of DTCA on Ψ under price regulation

τ/p	1.4	1.6	1.8	2.0	2.2	2.4
0.35	–	–	–	–	−0.208	−0.288
0.45	–	–	−0.091	−0.157	−0.243	−0.363
0.55	0.008	−0.034	−0.088	−0.159	−0.261	–
0.65	0.010	−0.028	−0.074	–	–	–
0.75	0.011	−0.018	–	–	–	–
0.85	0.011	–	–	–	–	–

Assumptions: $v = 1.75; t = 1; z = 0.5$

The table shows that DTCA is less likely to be beneficial using the second welfare measure. In fact, DTCA is beneficial only if the regulated price is very low. As for the previous case, a higher price level reduces the benefit of DTCA. A high price level directly increases medical expenditures. It also indirectly affects the medical expenditures by increasing detailing and thus the number of prescriptions. Thus, allowing DTCA in this case induces a large increase in medical expenditures and a moderate increase in gross consumer surplus, resulting in a negative $\Delta\Psi$.

The copayment effect is more complicated. Contrary to the previous case in Table 4, the benefit of DTCA is increasing in the copayment rate for low price levels, while the opposite is true for high price levels. To understand this note that the copayment rate just defines the cost sharing between the third-party payer and the consumer (patient). Thus, a higher copayment has no direct effect on medical expenditures. Indirectly, howenver, by its impact on $\widetilde{x}$, the copayment affects the number of prescriptions and in turn medical expenditure. At low prices and high copayments, firms' detailing activity is very low, and so is consumer surplus. Allowing DTCA in this case increases (gross) consumer surplus substantially, while the effect on medical expenditures is moderate, resulting in a higher $\Delta\Psi$.

We believe the observed patterns in Table 4 and 5 can explain the empirical fact that most countries with insignificant R&D and production of pharmaceuticals practice strict regulation on drug marketing, especially on DTCA. The reason is that these countries are likely to be concerned about consumers' surplus and medical expenditures, and not about (foreign) firms' profits.

Turning to the case of price competition, the key parameter in terms of welfare and policy implications is the copayment rate τ. In Table 6 we have evaluated (38) and (40) for different levels of τ.[37]

Table 6: Welfare effects of DTCA under price competition

τ	0.4	0.5	0.6	0.7	0.8	0.9
ΔW	-0.049	0.074	0.106	0.108	0.099	0.087
$\Delta\Psi$	-0.449	-0.130	-0.022	0.023	0.041	0.046

Assumptions: $v = 1.75; t = 1; z = 0.5$

The table shows that the effect of DTCA on the two welfare measures are somewhat different under price competition than under price regulation. DTCA is likely to be beneficial to welfare only if the copayment rate is sufficiently high. Regarding consumer surplus net of medical expenditures, we find that $\Delta\Psi$ unambigiously increases in the copayment rate, implying that the net benefit of DTCA tends to be greater for high levels of co-insurance. The reason is that a low copayment rate induces high prices and substantial marketing. More intensive marketing increase gross consumer surplus by improving the matching (detailing) and by reducing the level of under-treatment (DTCA and detailing). However, a lower copayment rate also leads to higher medical expenditures, directly by increasing the prices, and indirectly by increasing marketing and in turn demand. In fact, when the copayment rate becomes sufficiently small, the medical expenditure effect starts to dominating the improvements to consumers' surplus. Allowing DTCA in this situation is detrimental to welfare.

The effect of DTCA on consumer surplus net of marketing expenditures, ΔW, is different. At high copayment levels, DTCA tends to be welfare improving, while at low copayment

[37] The pattern reported in Table 6 holds for a wide set of parameter values of v, t and z.

levels the opposite is true. The explanation is, as for the price regulation case, linked to marketing being excessive or suboptimal. At low copayment rates, prices are high and marketing, especially detailing, is potentially excessive. A further reduction of the copayment rate is in this case likely to lead to substantial increases in aggregate marketing expenditures, whilst the increase in consumers' surplus is modest. At high copayment rates, the intuition is the opposite. In this case prices are low and marketing, especially DTCA, is potentially suboptimal. An increase in the copayment rate in this case is likely to improve welfare, as the increase in total marketing expenditures is modest, whilst the improvements to the patients are substantial.

We conclude this section with a comparison of the welfare effects of DTCA in the case of price regulation as opposed to price competition. In order to establish a benchmark, we assume that the regulated price is fixed at the level of the duopoly price in the absence of DTCA, i.e., $p = p^c|_{\Phi=0}$. The net effect of DTCA on the two welfare measures, W and Ψ, can then be calculated for different levels of the co-payment τ, as given in Table 7.

Table 7: Welfare effects of DTCA: competition vs. regulation

τ	0.4	0.5	0.6	0.7	0.8	0.9
ΔW	0.016	0.009	0.112	0.111	0.101	0.088
$\Delta\Psi$	0.204	0.169	0.104	0.071	0.057	0.005

Assumptions: $v = 1.75; t = 1; z = 0.5$

Comparing Table 7 with Table 6, it is evident that the net benefit of DTCA on either welfare measure is always greater under price regulation than under price competition. The reason is, of course, that price regulation eliminates the welfare loss arising from an increase in the market price under DTCA. While the co-payment has a similar impact on the net benefit of DTCA in the case of the utilitarian welfare, W, a strikingly different pattern emerges when we use consumer surplus net of medical expenditures, Ψ, as our welfare measure. Here, under price regulation, the net benefit of DTCA decreases rather than increases with the co-payment. Since prices do not increase, the net welfare loss due to greater moral hazard under DTCA is eliminated. However, then a greater co-payment tends to imply a lower share of patients to whom the drug is prescribed. This in turn reduces the social returns to DTCA.

6 Concluding remarks

In this paper we have studied the effects of DTCA in the prescription drug market. Especially, we have been concerned with the effect of DTCA on firms' profits and social welfare. Building on the informative advertising models developed by Butters (1977), Grossman and Shapiro (1984), among others, we have focused on the interaction between consumer-oriented (DTCA) and physician-oriented (detailing) marketing. We have studied both the case with and the case without price regulation, and have taken account of variations in copayments.

Regarding the profitability of DTCA, we report the following three findings: First, DTCA, detailing and price (if not regulated) are complementary strategies for the firms. Thus, allowing DTCA is prone to increase the spending on detailing and rise prices. Second, firms tend to overinvest in detailing and underinvest in DTCA from an industry perspective. This is due to the market-expanding nature of DTCA and the business-stealing nature of detailing. Third, we show that firms benefit from DTCA if the detailing technology is sufficiently costly. Otherwise, firms compete excessively in terms of detailing, implying that the use of DTCA will induce even more excessive detailing. In this case firms prefer a ban on DTCA.

Turning to welfare, we establish the following results: First, we show that both DTCA and detailing can be excessive or suboptimal depending on the copayment. Generally, first-best cannot be achieved, and the regulator must trade off suboptimal levels of DTCA against excessive levels of detailing. Second, we find that the impact of DTCA on welfare is generally ambiguous, and, in particular, depends on the copayment rate and the price (if regulated). Under generous insurance and/or lenient price regulation, DTCA is detrimental to welfare. Moreover, if the regulator is not concerned about firms' profits, but just about consumer surplus net of medical expenditures, then DTCA is more likely to be banned.

The model is closely linked to empirical findings and stylised facts of marketing in the prescription drug market. In this sense it contributes to explaining and interpreting the empirical findings. It also contributes to the theoretical literature, not only by filling the gap with respect to DTCA, but also by extending the basic model of advertising to involve two marketing strategies.

Let us, however, highlight some issues. It has been argued that DTCA may prompt unnecessary visits, and that such visits cause physicians to waste valuable time, and may result in unnecessary medication. In our model, some patients are actually better off with an outside (or no) treatment. By attaching a cost to physician visits, we could in principle capture the first part of the argument. However, a visit cost would only reduce the scope for DTCA, and not change any of the results qualitatively. The second part of the argument - that patients "pressure" the physician to prescribe unnecessary medication - is, however, not justified by empirical studies. As mentioned above, Iizuka and Jin (2005) find that DTCA prompts physician visits, but has no influence on the physicians' prescription choice. We feel thus comfortable by not addressing this latter part of the argument.

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A Appendix: Proofs of Lemmas and Propositions

Proof of Proposition 2: Condition (19) can be written explicitly as

$$\begin{aligned}\Delta\pi(\Phi) &= \pi[\theta^r, \Phi^r] - \pi[\theta^r|_{\Phi=0}, 0] > 0, \\ &= p\{N(\Phi) M[\theta^r] - zM[\theta^r|_{\Phi=0}]\} - \{K[\theta^r, \Phi^r] - K[\theta^r|_{\Phi=0}, 0]\} > 0.\end{aligned}$$

Inserting into this from the equilibrium condition for detailing, $pN\left(\Phi^r\right)M\left(\theta^r\right)=\theta^r K_\theta\left(\theta^r\right)$ .as by (12), we obtain the following expression:

$$\Delta\pi=\theta^r\left(\Phi\right)\cdot K_\theta\left(\theta^r\left(\Phi\right)\right)-\theta^r\left(0\right)\cdot K_\theta\left(\theta^r\left(0\right)\right)-K\left(\theta^r\left(\Phi\right),\Phi\right)+K\left(\theta^r\left(0\right),0\right), \tag{41}$$

which now is a function of DTCA only. Differentiating this with respect to Φ, we get:

$$\frac{d\Delta\pi}{d\Phi}=\frac{d\pi}{d\Phi}=\theta^r K_{\theta\theta}\frac{d\theta^r}{d\Phi}-K_\Phi. \tag{42}$$

Then insert (14) and rearranging the expression, we obtain:

$$\frac{d\Delta\pi}{d\Phi}=K_{\theta\theta}\frac{2p\left(1-z\right)\left(1-\Phi\right)M}{pN\left(\widetilde{x}-\frac{1}{2}\right)+K_{\theta\theta}}-K_\Phi, \tag{43}$$

which can be positive and negative depending on the relative size of the two terms. Evaluating (43) for the equilibrium DTCA level, given by (13), and rearranging the expression, we obtain the following:

$$\left.\frac{d\Delta\pi}{d\Phi}\right|_{\Phi=\Phi^r}=K_\Phi\left[\frac{K_{\theta\theta}-pN\left(\widetilde{x}-\frac{1}{2}\right)}{K_{\theta\theta}+pN\left(\widetilde{x}-\frac{1}{2}\right)}\right]. \tag{44}$$

Obviously, this is positive if and only if $K_{\theta\theta}>pN\left(\widetilde{x}-1/2\right)$. Using the detailing condition in (12) once more, we can rewrite the condition as follows:

$$\frac{K_{\theta\theta}}{K_\theta}>\frac{\widetilde{x}-1/2}{\widetilde{x}-\theta\left(\widetilde{x}-1/2\right)}, \tag{45}$$

where it is readily verified that[38] $\frac{\widetilde{x}-1/2}{\widetilde{x}-\theta(\widetilde{x}-1/2)}\in\left(0,1\right)$.■

Proof of Proposition 3: The sign of (25) and (26) are both determined by the sign of

$$\theta\left(1-\theta\right)\left(\frac{v-2\tau p^c}{t}\right)+\frac{\theta^2}{2}=\theta^2\frac{2v\left(1-\theta\right)+t\theta}{2t\left(4-3\theta\right)}>0,$$

where the equality follows after inserting the equilibrium price, as given by (21). Thus, $\frac{d\theta^c}{dp}>0$ and $\frac{d\Phi^c}{dp}>0$.Finally, the interaction between detailing and DTCA (14) and (15), and the interaction between price and detailing is given by (24). This completes the proof. ■

[38] The concavity of $\frac{d\pi}{d\Phi}$ can be established under some mild conditions.

Proof of Proposition 4: Following the first part of the proof of Proposition 2, we can write

$$\Delta\pi\left(\theta^{c}\left(\Phi\right),\Phi\right)=\theta^{c}\left(\Phi\right)\cdot K_{\theta}\left(\theta^{c}\left(\Phi\right)\right)-\theta^{c}\left(0\right)\cdot K_{\theta}\left(\theta^{c}\left(0\right)\right)-K\left(\theta^{c}\left(\Phi\right),\Phi\right)+K\left(\theta^{c}\left(0\right),0\right), \quad (46)$$

and

$$\frac{d\Delta\pi}{d\Phi}=\frac{d\pi}{d\Phi}=\theta^{c}\left(\Phi\right)K_{\theta\theta}\frac{d\theta^{c}}{d\Phi}-K_{\Phi}. \quad (47)$$

Using the best-response functions $\theta^{c}\left(\Phi\right)$ and $p^{c}=p^{c}\left(\Phi\right)$ that follow from the system of first-order-conditions (12) and (21), and applying Cramer's rule we can calculate

$$\frac{d\theta^{c}}{d\Phi}=\frac{2\left(1-z\right)\left(1-\Phi\right)\left(4-3\theta^{c}\right)\tau p^{c}M}{\theta^{c}\left|J'\right|}, \quad (48)$$

where

$$\left|J'\right|:=\tau\left(4-3\theta^{c}\right)\left\{K_{\theta\theta}+p^{c}N\left[\widetilde{x}-\frac{1}{2}-\frac{\theta^{c}\left(2t-v\right)}{t\left(4-3\theta^{c}\right)^{2}}\right]\right\}>0 \quad (49)$$

is the Jacobian determinant of the system (12) and (21), and where $\widetilde{x}=\frac{v-\tau p^{c}}{t}\geq\frac{1}{2}$.[39] Inserting into (47) from (48) and rearranging, we obtain:

$$\frac{d\Delta\pi}{d\Phi}=2K_{\theta\theta}\left(1-z\right)\left(1-\Phi\right)\left(4-3\theta^{c}\right)\tau p^{c}M\left(\left|J'\right|\right)^{-1}-K_{\Phi}. \quad (50)$$

Evaluating (43) for the equilibrium DTCA level, as given by (13), and rearranging the expression, we obtain

$$\left.\frac{d\Delta\pi}{d\Phi}\right|_{\Phi=\Phi^{c}}=\frac{K_{\Phi}\tau\left(4-3\theta^{c}\right)}{\left|J'\right|}\left\{K_{\theta\theta}-p^{c}N\left[\widetilde{x}-\frac{1}{2}-\frac{\theta^{c}\left(2t-v\right)}{t\left(4-3\theta^{c}\right)^{2}}\right]\right\}. \quad (51)$$

The RHS is positive if and only if the term in brackets is positive. Using the first-order condition in (12), we can rewrite the condition as follows

$$\frac{K_{\theta\theta}}{K_{\theta}}>\frac{\widetilde{x}-\frac{1}{2}-\frac{\theta^{c}(2t-v)}{t(4-3\theta^{c})^{2}}}{\widetilde{x}-\theta\left(\widetilde{x}-\frac{1}{2}\right)}=\frac{\widetilde{x}-\frac{1}{2}-\frac{\tau\theta^{c}}{2t}\frac{\partial p^{c}}{\partial\theta}}{\widetilde{x}-\theta\left(\widetilde{x}-\frac{1}{2}\right)}, \quad (52)$$

where the equality follows under observation of $\frac{\partial p^{c}}{\partial\theta^{c}}=\frac{2(2t-v)}{\tau(4-3\theta^{c})^{2}}>0$. It is readily verified that $\frac{\widetilde{x}-\frac{1}{2}-\frac{\tau\theta^{c}}{2t}\frac{\partial p^{c}}{\partial\theta}}{\widetilde{x}-\theta\left(\widetilde{x}-\frac{1}{2}\right)}<1$ for all v and t and $\frac{\widetilde{x}-\frac{1}{2}-\frac{\tau\theta^{c}}{2t}\frac{\partial p^{c}}{\partial\theta}}{\widetilde{x}-\theta\left(\widetilde{x}-\frac{1}{2}\right)}<0\Leftrightarrow v\leq\frac{t\left(8-6\theta^{c}+3\theta^{c2}\right)}{\left(8-8\theta^{c}+3\theta^{c2}\right)}$. This completes the proof of part (i). Part (ii) follows directly from a comparison of the RHS in (45) and (52). ■

[39] It can be verified that $\left|J'\right|>0$ for any convex function $K\left(\theta\right)$.

Proof of Proposition 5: Comparing (35) and (36) with the market outcomes in (12) and (13), we find that equilibrium detailing is equal to first-best if and only if the following is true:

$$v\left(1-\theta^{fb}\right)-\frac{t}{4}\left(2-3\theta^{fb}\right)=p^{k}\left[\left(1-\theta^{fb}\right)\left(\frac{v-\tau p^{k}}{t}\right)+\frac{\theta^{fb}}{2}\right], \tag{53}$$

where the superscript denotes the price regulation or the price competition case, i.e., $k=r,c$. Moreover, equilibrium DTCA is equal to first-best DTCA if the following is true:

$$v\left(2-\theta^{fb}\right)-\frac{t}{4}\left(4-3\theta^{fb}\right)=p^{k}\left[\left(1-\theta^{fb}\right)\left(\frac{v-\tau p^{k}}{t}\right)+\frac{\theta^{fb}}{2}\right]. \tag{54}$$

Observe first that the right-hand sides (RHS) of (53) and (54) are identical, while the left-hand sides (LHS) differ. Since p and τ are only present on the RHS, then the first part of the proposition follows.

The second part is established by comparing the LHS of (53) and (54):

$$v\left(1-\theta^{fb}\right)-\frac{t}{4}\left(2-3\theta^{fb}\right)<v\left(2-\theta^{fb}\right)-\frac{t}{4}\left(4-3\theta^{fb}\right) \quad \Leftrightarrow \quad \frac{t}{2}<v,$$

which is true by assumption. Thus, for a τ that implements $\theta^{k}=\theta^{fb}$, then $\Phi^{k}<\Phi^{fb}$ must be true. Vice versa, for a τ that implements $\Phi^{k}=\Phi^{fb}$, then $\theta^{k}>\theta^{fb}$ must be true. Finally, we know that $\widetilde{x}^{fb}=1$, while in equilibrium $\widetilde{x}^{k}<1$. This completes the proof. ■

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