AN ABSTRACT OF THE DISSERTATION OF

Yasushi Kudo for the degree of Doctor of Philosophy in Economics presented on December 5, 2007.

Title: Essays on Strategic Behavior in Supermodular Settings: Lobbying, Advertising and Price

Abstract approved:

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This dissertation addresses issues of strategic behavior of firms in lobbying, brand and generic advertising, and advertising-price relationships in imperfectly competitive markets.

In the first study, we investigate conditions under which lobbying can improve social welfare and show that this type of lobbying will be undersupplied from society's perspective. We take a case for lobbying which reduces an excise tax to achieve this purpose.

In the second study, we examine the effect of generic advertising on a firm's brand advertising and profits. Some producers argue that generic advertising is harmful because it will reduce perceived product differentiation and thus will make differentiated products look similar to consumers. Using duopoly models of vertical and horizontal product differentiation, we argue that this argument is not necessarily correct. Also, we model the relationship between generic advertising and brand advertising in markets with *n* firms regardless of the type of product differentiation via supermodular game (Milgrom and Roberts (1990)).

In the third study, we scrutinize conditions under which there is a positive relationship between advertising and price. Theoretical work demonstrates that the welfare effect of advertising in imperfectly competitive markets depends upon the relationship between advertising and price. Applying the result of Milgrom and Roberts, we show that supermodularity is a condition under which advertising raise price.

However, we show with models of vertical and horizontal product differentiation that this is a sufficient but not necessary condition. To address this issue empirically, we estimate a reduced form price equation using firm level data in the U.S. brewing industry. Our empirical results show that advertising raises price and is oversupplied in the U.S. brewing.

Essays on Strategic Behavior in Supermodular Settings: Lobbying, Advertising and Price

by

Yasushi Kudo

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Presented December 5, 2007
Commencement June 2008

Doctor of Philosophy dissertation of Yasushi Kudo
Presented on December 5, 2007.

APPROVED:

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Yasushi Kudo, Author

ACKNOWLEDGEMENTS

The author wishes to express sincere appreciation for the advising, support, and encouragement of Victor Tremblay throughout my graduate studies. Also I would like thank to the members of my dissertation committee, Dr. Janet Lee, Dr. Rolf Färe, Dr. Andrew Stivers, and Dr. Carol Tremblay for providing valuable comments. My thanks also go to the Department of Economics for their financial assistance and the staff members, Barbara, Laura, Lisa, Eric, and Betu for their support.

Last, but not least, I want to thank my parents for their support for many years.

CONTRIBUTION OF AUTHORS

Dr. Carol Tremblay provided ideas and assistance in this dissertation. Kosin Isariyawongse helped with modeling in the second manuscript.

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Chapter 1

General Introduction

While the perfectly competitive model has been a key model to analyze many market situations, this model is of limited use when analyzing the strategic behavior of firms in imperfectly competitive markets. This project addresses issues of the strategic behavior of firms in lobbying, brand and generic advertising, and advertising-price relationships in imperfectly competitive markets.

In Chapter 2, we investigate conditions under which lobbying can improve social welfare and show that this type of lobbying will be undersupplied from society's perspective. We take a case for lobbying which reduces an excise tax to achieve this purpose.

In Chapter 3, we study the effect of generic advertising on a firm's brand advertising and profits. Some producers argue that generic advertising is harmful because it will reduce perceived product differentiation and thus will make differentiated products look similar to consumers. Using duopoly models of vertical and horizontal product differentiation, we argue that this argument is not necessarily correct. Also, we establish conditions under which firms play a supermodular game. In this setting, we can model the relationship between generic advertising and brand advertising in markets with *n* firms regardless of the type of product differentiation.

In Chapter 4, we scrutinize conditions under which there is a positive relationship between advertising and price. Theoretical work demonstrates that the welfare effect of advertising in imperfectly competitive markets depends upon the relationship between advertising and price. Advertising can affect price by influencing demand and cost conditions. For example, advertising expenditures may deter entry and lower price competition, because most of these expenditures are sunk. Alternatively, advertising could lower price when it increases firm demand and substantially lowers marginal cost due to the presence of scale economies.

Applying the result of Milgrom and Roberts (1990), we show that supermodularity is a condition under which advertising raises price. Also, using models with horizontal and vertical product differentiation, we show that this condition is sufficient but not necessary. Finally, to address this issue empirically, we estimate the advertising-price relationship in the U.S. brewing industry using firm level data.

These chapters address important strategic actions of firms. This study is important because insufficient price competition and excessive advertising and lobbying harms social welfare.

Chapter 2

Taxes and Socially Beneficial Lobbying

2.1 Introduction

Given recent scandals in Washington, there is increasing bipartisan support by state and federal lawmakers to limit the influence of political lobbyists. Many suggest that lobbying reduces social welfare and should, therefore, be substantially curtailed. Recent proposals would limit the size of gifts and increase the length of time before a lawmaker could become a lobbyist after leaving office. There have also been proposals that push for greater transparency by requiring full discloser of all perks received from lobbyists.[1]

Because of its many motives and consequences, analysis of lobbying is complex. State lobbying for pork and domestic industry lobbying for a share of tariff proceeds are examples of efforts that are generally regarded as welfare reducing. Bhagwati (1982) calls this form of lobbying a "directly-unproductive profit-seeking" (DUP) activity because it does not directly produce any output. However, Anam (1982) and Bhagwati

[1] For a more complete discussion of this lobbying reform debate, see Perry Bacon Jr., "Lobbying Reform Stumbles," *Time Magazine*, February 9, 2006, at www.time.com/time/nation, Brian Naylor, "The Politics of Lobbying Reform," *National Public Radio*, November 2, 2006, at www.npr.org/templates/story, and Jim Snyder and Jeffrey Young, "Like Congress, State Legislatures Wrestle with Lobbying Reforms," *The Hill*, May 17, 2006, at thehill.com/export/TheHill/Business.

and Srinivasan (1982) provide an international trade example where lobbying or rent seeking can be welfare improving.

The main purpose of this paper is to provide a non-trade example where lobbying improves social welfare. The case of an excise tax is used to illustrate this point. The government imposes an excise tax on a single industry. The tax is not used to mitigate the effect of an externality or other form of market failure but is instituted simply to pay for government services. In this case, market efficiency would increase if the excise tax were replaced by a more efficient and equitable property or income tax.[2] Firms within the industry may benefit from lobbying to lower the tax rate. This paper shows that under a reasonable set of conditions, lobbying by the industry to reduce the tax rate will be profitable and will improve market efficiency. It also demonstrates that the firms will generate too little lobbying from society's perspective.

2.2 The Theoretical Framework

To address the welfare effect of lobbying designed to reduce an excise tax, consider a general market with n firms that compete in price

[2] Partial equilibrium analysis is used here, which would be appropriate in markets where there are no close substitutes or complements. See Varian (1989) for a discussion of consequences of rent seeking or lobbying in a general equilibrium setting.

and advertising. Firms face a given excise tax *t*, which can be reduced with sufficient lobbying effort. Firms play a two stage game by simultaneously choosing lobbying in the first stage and prices in the second stage. This order of play is reasonable if lobbying affects price competition. Firms are symmetric, act independently to maximize their own profits, and have perfect and complete information. The market is uncovered, implying that total market demand increases with a reduction in the market price.

One way to model an excise tax is by distinguishing between consumer and producer prices. Let p^c be a consumer price, p^p be a producer price, *t* be an excise tax, which is a function of the total quantity of lobbying, $L = \sum_{i=1}^{n} L^i$, where the superscript *i* indexes an individual firm. Then, the consumer price can be written as

$$p^c = p^p + t\left(L\right). \tag{2.1}$$

Increased lobbying is assumed to influence government officials and lead to a lower *t*. Ignoring general equilibrium and equity issues, the social welfare function (*SW*) can be written as

$$SW = V\left(p^c\right) + \Pi\left(p^p, L\right), \tag{2.2}$$

where *V* is the money value of consumer surplus, and Π is producer surplus. With *n* firms, the effect of lobbying on social welfare becomes:

$$\frac{dSW}{dL} = \sum_{i=1}^{n}\left(\frac{\partial V}{\partial p^{c,i}}\frac{\partial p^{c,i}}{\partial L}\right) + \sum_{i=1}^{n}\left(\frac{\partial \Pi}{\partial p^{p,i}}\frac{\partial p^{p,i}}{\partial L}\right) + \frac{\partial \Pi}{\partial L}, \tag{2.3}$$

where $p^{c,i}$ and $p^{p,i}$ are firm i's consumer price and producer price, respectively. Lobbying will have a direct effect on p^c through t but will also affect p^c if it affects Nash pricing behavior. Assuming a concave social welfare function, the level of lobbying will be too low (high) from society's point of view if lobbying increases (decreases) social welfare.

To understand the effect of lobbying on social welfare, we must sign each of the terms on the right hand side of equation (2.3). Clearly, $\partial V/\partial p^{c,i} < 0$. In an imperfectly competitive market, an increase in Nash equilibrium prices will raise industry profits ($\partial \Pi/\partial p^{p,i} > 0$). If lobbying of an individual firm imposes a positive externality on other firms, the Nash equilibrium level of lobbying will be below the level which maximizes industry profits ($\partial \Pi/\partial L > 0$). To sign the remaining terms ($\partial p^{c,i}/\partial L$, $\partial p^{p,i}/\partial L$) requires a deeper investigation of the effect on lobbying on consumer and producer prices.

We first investigate the effect of lobbying on the consumer price. To simplify the analysis, consider a social planner who can change the price of lobbying (x). This allows us to investigate the effect of a change in the price of lobbying on the consumer price and lobbying effort. For profit maximizing firms, $dL/dx < 0$. That is, the firm's demand for lobbying has a negative slope. Thus, a subsidy to lobbying will increase L. From equation (2.1), the effect of x through a change L on the consumer price is

$$\frac{\partial p^{c,i}}{\partial x} = \frac{\partial p^{p,i}}{\partial L^i}\frac{dL^i}{dx} + \frac{\partial p^{p,i}}{\partial L^j}\frac{dL^j}{dx} + \frac{dt}{dL}\frac{\partial L}{\partial L^i}\frac{dL^i}{dx} + \frac{dt}{dL}\frac{\partial L}{\partial L^j}\frac{dL^j}{dx}. \qquad (2.4)$$

For notational convenience, let $dt/dL = t_L$; because $L = \sum_{i=1}^{n} L^i$, $\partial L / \partial L^i = 1$.

Given this, equation (2.4) can be written as

$$\frac{\partial p^{c,i}}{\partial x} = \frac{\partial p^{p,i}}{\partial L^i}\frac{dL^i}{dx} + \frac{\partial p^{p,i}}{\partial L^j}\frac{dL^j}{dx} + t_L\frac{dL^i}{dx} + t_L\frac{dL^j}{dx}. \qquad (2.5)$$

If firms are symmetric, equilibrium output prices and lobbying efforts will be the same for both firms; $\partial p^{p,i}/\partial L^i$ will equal $\partial p^{p,i}/\partial L^j$ and dL^i/dx will equal dL^j/dx. Under these conditions, equation (2.5) becomes

$$\frac{\partial p^{c,i}}{\partial x} = 2\frac{\partial p^{p,i}}{\partial L^i}\frac{dL^i}{dx} + 2t_L\frac{dL^i}{dx}. \qquad (2.6)$$

Because dL^i/dx is negative, an increase in x, leads to greater lobbying effort and, therefore, a lower consumer price when the following condition holds:

$$\frac{\partial p^{p,i}}{\partial L^i} < -t_L. \qquad (2.7)$$

That is, lobbying leads to a lower consumer price when the effect of lobbying has a greater effect on lowering taxes than on raising producer prices. Thus, to understand the effect of lobbying no the consumer price, we must know the effect on lobbying on the producer price.

2.3 Lobbying and Welfare in a Monopoly Market

To analyze the conditions under which the inequality in equation (2.7) holds, we begin with the simple monopoly case. To facilitate comparative static analysis, the firm is assumed to choose the producer price and lobbying simultaneously. For a profit maximizing monopolist, the solution will be the same whether strategic choices are made simultaneously or sequentially as long as demand and cost functions are separable over time.[3] The firm's profit function, defined below, is assumed to be twice continuously differentiable in price and lobbying and that the Hessian matrix of the second derivatives of the profit function with respect to price and lobbying is negative definite:

$$\begin{aligned}\pi\left(p^{p},L\right)&=p^{c}q\left(p^{c}\right)-tq\left(p^{c}\right)-xL\\&=p^{p}q\left(p^{c}\right)-xL,\end{aligned}\tag{2.8}$$

where $q(p^c)$ is the monopolist's demand. We use the notation π_k to denote the first derivative of the profit function with respect to variable k (the producer price or lobbying effort) and π_{kl} to denote the second derivative of

[3] For example, this would be violated in a durable goods market or when there is learning-by-doing in production.

the profit function with respect to variables *k* and *l*. We use the notation q_p to denote the first derivative of the demand function with respect to the consumer price and q_{pp} to denote its second derivative with respect to the consumer price.

Comparative static analysis is used to determine the effect of a change in the price of lobbying on the firm's optimal values of lobbying and the producer price. From the implicit function theorem (IFT) these effects are:

$$\begin{bmatrix} \frac{\partial p^p}{\partial x} \\ \frac{\partial L}{\partial x} \end{bmatrix} = -D_H^{-1} D_x, \tag{2.9}$$

where D_H^{-1} is the inverse of the monopolist's Hessian matrix and D_x is the vector of derivatives of the first order conditions with respect to *x*:

$$D_x = \begin{bmatrix} \pi_{px} \\ \pi_{Lx} \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \end{bmatrix}. \tag{2.10}$$

Applying the IFT produces the following comparative static results:

$$\begin{bmatrix} \frac{\partial p^p}{\partial x} \\ \frac{\partial L}{\partial x} \end{bmatrix} = -\frac{1}{det\left(D_H\right)} \begin{bmatrix} \pi_{pL} \\ -\pi_{pp} \end{bmatrix}. \tag{2.11}$$

For profit maximization the second order conditions ensure that π_{pp} and π_{LL}

are negative and the determinant of D_H is positive at the firm's optimum. This implies that $\partial L/\partial x < 0$; a profit maximizing firm's demand for lobbying has a negative slope. Lobbying will unambiguously lead to a higher producer price ($\partial p^p/\partial x < 0$) when price and lobbying are complements ($\pi_{pL} < 0$). Complementarity holds as long as the demand curve is not too convex, which is also a requirement for the second order conditions of profit maximization. Specifically, the complementary condition is:

$$\pi_{pL} = t_L \left(p^p q_{pp} + q_p \right) > 0 \,. \tag{2.12}$$

Because t_L is negative by assumption and q_p is negative for a downward sloping demand curve, equation (2.12) holds if q_{pp} is sufficiently small (i.e., demand is not too convex in price):[4]

$$q_{pp} < \frac{-q_p}{p^p} \,. \tag{2.13}$$

Note that this is a slightly stronger convexity constraint than that imposed by the second order condition of profit maximization:

$$q_{pp} < \frac{-2q_p}{p^p} \,. \tag{2.14}$$

When equation (2.13) holds, lobbying leads to a higher producer price.

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[4] Because $p^c = p^p - t$ and $q = q\left(p^c\right)$, $\frac{\partial q}{\partial p^p} = \frac{dq}{dp^c}\frac{\partial p^c}{\partial p^p} = \frac{dq}{dp^c}$.

The effect of lobbying on the consumer price is determined as follows. Given that there is just one firm and given equation (2.11), equation (2.5) can be written as:

$$\frac{\partial p^c}{\partial x} = \frac{-\pi_{pL} + t_L \pi_{pp}}{\det\left(D_H\right)}. \tag{2.15}$$

Given equation (2.12) and the fact that $\pi_{pp} = 2q_p + pq_{pp}$, this becomes:

$$\frac{\partial p^c}{\partial x} = \frac{t_L q_p}{\det\left(D_H\right)}. \tag{2.16}$$

As long as demand is downward sloping ($q_p < 0$), the tax rate is decreasing in lobbying ($t_L < 0$), and an equilibrium exists, lobbying (through a decrease in x) leads to a lower consumer price.

Under these general demand and cost conditions, shocks that increase lobbying (by lowering x) will cause the equilibrium producer price to rise and the consumer price to fall. From equation (2.3), one can see that lobbying will improve social welfare by decreasing the tax rate, which increases the producer price, decreases the consumer price, and raises consumer surplus. At the margin, producer surplus is unaffected, because profit maximization assures that $d\pi/dp^p = d\pi/dL = 0$. Because $dSW/dL > 0$, a profit maximizing monopolist will undersupply lobbying from society's perspective.

2.3.1 Graphical Explanation

To illustrate, consider a geometric treatment of the firm's problem when the demand function is linear. Recall that marginal cost is zero. In Figure 2.1, D represents market demand. With a positive tax rate and no lobbying, the producer demand falls by t, labeled D_t. We determine the welfare effect of lobbying by comparing the equilibrium with and without lobbying. With no lobbying, production equals q, the producer price is p^p, and the consumer price is p^c. Given a positive amount of lobbying, assumed to be profitable, the tax rate falls to t', for example, causing production to increase ($q \rightarrow q'$), the producer price to increase ($p^p \rightarrow p^{p'}$), and the consumer price decrease to ($p^c \rightarrow p^{c'}$).

In such a setting, a regulatory change that makes lobbying legal will lead to an unambiguous increases consumer plus producer surplus. Consumer surplus increases because lobbying leads to an increase in output and a decrease in the consumer price. For the firm to undertake lobbying, the effect of lobbying on profits must be non-negative. As a result, social surplus must rise.

A similar argument can be made for a marginal change in lobbying from its market equilibrium. Lobbying leads to an increase in consumer welfare, because production increases and the consumer price falls. Assuming profit maximization, a marginal increase in lobbying will have no effect on firm profits. Thus, social surplus rises.

2.4 Lobbying and Welfare in a Duopoly Market

We next consider a duopoly market with symmetric firms i and j. As assumed in section II, firms choose lobbying simultaneously in the first stage and choose prices simultaneously in the second stage. In the second stage, firms maximize profits with respect to the producer price, after observing the optimal levels of lobbying from the first stage, $L^* = L^{i*} + L^{j*}$. We assume that a unique and stable Nash equilibrium exists in each stage. The profit function is assumed to be continuous and twice continuously differentiable. The Hessian matrix of its second derivatives is negative definite, which implies that own-firm strategic effects on marginal profits are greater than cross-firm strategic effects [Bulow et al., (1985)]. Finally, we assume that $\pi_{pL} > 0$ for each firm. As in the monopoly case this imposes a limit on the convexity of firm demand.

Because the first order conditions in the second stage are identically equal to zero at the optimal values of lobbying and price, we are able to perform comparative static analysis of consumer and producer prices for an exogenous change in lobbying. Consider a social planner who changes the price of lobbying (*x*) by fiat or other means (e.g., a lobbying subsidy). Because prices are chosen after lobbying, any change in prices due to a change in *x* will result from a change in lobbying itself. Using the techniques described above, the following comparative static results emerge (proofs can be found in the appendix).

Proposition *Lobbying and Prices*: Given the assumptions above, producer prices rise and consumer prices fall when lobbying increases.

With this proposition, equation (2.3) implies that that lobbying will be undersupplied from society's perspective when firm demand is not too convex. Like the monopoly case, lobbying benefits consumers because quantity increases and the consumer price falls. Producer surplus also rises, because the Nash equilibrium level of lobbying will be less than that which maximizes joint profits. Thus, a marginal increase in lobbying will benefit the industry as a whole.

It is also true that firms will under-invest in lobbying from society's perspective. The lobbing of one firm generates benefits in the form of a lower tax rate to the firm and its rivals. Because benefits to rivals are ignored, firms will invest too little in lobbying from the industry's perspective. Thus, additional lobbying from the Nash equilibrium will benefit consumers and producers, demonstrating that the market will produce too little lobbying of this form.

2.4.1 Example

To illustrate, consider the following duopoly example, where firm *i*'s profit function is

$$\pi^i = \left[p^{c,i} - t(L) \right] q^i (p^{c,i}, p^{c,j}) - xL^i.$$

Let $t(L) = 1 - L^{1/2}$, where the tax rate falls at a decreasing rate with lobbying. Firm demand is assumed to take the following linear form:

$$q^i = 2 - p^{c,i} + bp^{c,j}.$$

Given that $p^{c,i} = p^{p,i} + t(L) = p^{p,i} + 1 - L^{1/2}$, the profit function becomes

$$\pi^i = p^{p,i} \left(1 + b + \left(1 - b\right) L^{1/2} - p^{p,i} + bp^{p,j}\right) - xL^i.$$

The parameter $b \in [0,1]$ defines the relevant market settings.

1. Monopoly Market: When b = 0, each firm is independent and $\pi^i_{ij} = 0$.

2. Uncovered Duopoly Market: When $b \in (0, 1)$, firms compete in an uncovered market. That is, total market demand $q^i + q^j$ increases in lobbying and decreases in prices. In this case, $0 < \pi^i_{ij} < -\pi^i_{ii}$.[5]

Assuming each firm chooses its optimal level of lobbying at the first stage and observes these levels before the second stage, Nash equilibrium producer and consumer prices and quantity as functions of lobbying are:

$$p^{p,i} = \frac{1+b}{2-b} + \frac{1-b}{2-b}\sqrt{L^i + L^j},$$

$$p^{c,i} = \frac{3}{2-b} - \frac{1}{2-b}\sqrt{L^i + L^j}, \text{ and}$$

$$q^i = \frac{1+b}{2-b} + \frac{1-b}{2-b}\sqrt{L^i + L^j}.$$

The effects of a change in a lobbying effort are summarized in Table 1. The derivatives with respect to own and rival's lobbying are:

$$\frac{\partial p^{p,i}}{\partial L^i} = \frac{\partial p^{p,i}}{\partial L^j} = \frac{1-b}{2(2-b)}\frac{1}{\sqrt{L^i + L^j}} > 0,$$

$$\frac{\partial p^{c,i}}{\partial L^i} = \frac{\partial p^{c,i}}{\partial L^j} = -\frac{1}{2(2-b)}\frac{1}{\sqrt{L^i + L^j}} < 0, \text{ and}$$

$$\frac{\partial q^i}{\partial L^i} = \frac{\partial q^i}{\partial L^j} = \frac{1-b}{2(2-b)}\frac{1}{\sqrt{L^i + L^j}} > 0.$$

For a monopoly or for an uncovered duopoly, an increase in lobbying will decrease the tax rate and increase the producer price. Because

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[5] If the market were covered (i.e., b = 1), a reduction in price or an increase in lobbying would have no effect on total market demand.

the decrease in the tax rate outweighs the increase in producer price, consumer price will fall.

This example illustrates that more lobbying can lead to higher producer prices and lower consumer prices, implying that lobbying is not socially excessive just because it is associated with higher producer prices. This example also demonstrates that lobbying has a positive externality (for example, $\partial q^i/\partial L^j > 0$), and thus this form of lobbying is undersupplied from society's perspective.

2.5 Conclusion

Lobbying for political favors has received considerable criticism of late. Lobbying that reduces efficiency and redistributes rents to those with more political power clearly reduces social welfare. Bhagwati (1982) calls this a directly-unproductive profit-seeking or DUP (pronounced "dupe") activity, because it is costly and produces no benefits to society as a whole.

Not all forms of lobbying are socially harmful, however. This paper proves that under a reasonable set of conditions firm lobbying to reduce an excise tax is welfare enhancing. It also demonstrates that this form of lobbying will be undersupplied from society's perspective. All that can be said about political lobbying is that some types are socially beneficial and others are harmful. This conclusion suggests that reform minded lawmakers who want to substantially restrict all forms of lobbying may actually reduce efficiency. Because it may be impractical to identify and restrict only lobbying efforts that harm society, perhaps a better policy would be one of transparency, where all perks and lobbyist identities are fully disclosed. This will allow voters to decide which politicians who receive perks from lobbying groups deserve to be elected.

2.6 Appendix

2.6.1 Notation

In the second stage of the lobbying and price setting game, firms *k, l* ∈ {1,2} maximize profit over the producer price:

$$\pi^k\left(p^{p,k}, p^{p,l}, t\left(L^*\right)\right) = p^{p,k} q^k\left(p^{c,k}, p^{c,l}\right) - xL^{k*}, \tag{2.17}$$

Optimal values of lobbying $L^* = L^{k*} + L^{l*}$ have been determined in the first stage.

Because we assume symmetry, we drop the superscript *k* and *l* where appropriate. In denoting the derivatives, for the profit π, the subscript *i* refers to the derivative with respect to own producer price, and *j* with respect to the other firm's producer price. π_i and π_{ii} refer to the first and second derivatives of the profit, respectively. For demand q, the subscript i refers to the derivative with respect to own consumer price, and j with respect to the other firm's consumer price. q_i and q_{ii} refer to the first and second derivatives of demand, respectively.[6]

We assume that a unique and stable equilibrium in pure strategies exists for this game. To that end we assume that the strategy spaces are nonempty, compact, convex subsets of a Euclidean space, and the profits are continuous and twice differentiable in these strategies and quasi-concave in their own strategies. We also assume that the matrix of second order conditions, denoted by D_H, is negative definite, so that $\pi_{ij} \in [0, \pi_{ii})$. That is, the firms' products can be anything from independent to perfect substitutes.

2.6.2 Proof of Proposition – Lobbying Increases Producer Prices

We want to find the change in producer price with respect to changes in lobbying. The first order conditions in producer price are:

$$\nabla_p = \begin{bmatrix} q + p^p q_i \\ q + p^p q_i \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}. \tag{2.18}$$

[6] Note that q_i is then both the derivative of demand with respect to the consumer price and with respect to producer price because the derivative of the consumer price with respect to the producer price is 1. That is, $\frac{\partial q^i}{\partial p^{p,i}} = \frac{\partial q^i}{\partial p^{c,i}} \frac{\partial p^{c,i}}{\partial p^{p,i}} = \frac{\partial q^i}{\partial p^{c,i}} \times 1 = \frac{\partial q^i}{\partial p^{c,i}} = q_i$.

From the Implicit Function Theorem for an interior equilibrium:

$$D_{pL} = -D_H^{-1} D_L, \tag{2.19}$$

where D_H is the matrix of derivatives of the first order conditions ∇_p with respect to the producer prices,

$$D_H = \begin{bmatrix} 2q_i + p^p q_{ii} & q_j + p^p q_{ij} \\ q_j + p^p q_{ij} & 2q_i + p^p q_{ii} \end{bmatrix},$$

D_L is the matrix of derivatives of the first order conditions ∇_p with respect to lobbying,

$$D_L = t_L \begin{bmatrix} q_i + q_j + p^p q_{ii} + p^p q_{ij} & q_i + q_j + p^p q_{ii} + p^p q_{ij} \\ q_i + q_j + p^p q_{ii} + p^p q_{ij} & q_i + q_j + p^p q_{ii} + p^p q_{ij} \end{bmatrix}, \tag{2.20}$$

where $t_L \equiv \partial t/\partial L^1 = \partial t/\partial L^2$ because of symmetry, and D_{pL} is the matrix of derivatives of producer prices with respect to lobbying effort:

$$D_{pL} = \begin{bmatrix} \dfrac{\partial p^{p,1}}{\partial L^1} & \dfrac{\partial p^{p,1}}{\partial L^2} \\ \dfrac{\partial p^{p,2}}{\partial L^1} & \dfrac{\partial p^{p,2}}{\partial L^2} \end{bmatrix}.$$

Note that elements in the matrix D_L are the same, $t_L\ (q_i + q_j + p^p q_{ii} + p^p q_{ij})$.

The total rate of change in $p^{p,k}$ with respect to a change in lobbying is the sum of rates of change in $p^{p,k}$ with respect to changes in lobbying by each firm:

$$\frac{\partial p^{p,k}}{\partial L^k}+\frac{\partial p^{p,k}}{\partial L^l}. \tag{2.21}$$

The inverse of D_H is:

$$D_H^{-1}=\frac{1}{det(D_H)}\begin{bmatrix} 2q_i+p^p q_{ii} & -\left(q_j+p^p q_{ij}\right) \\ -\left(q_j+p^p q_{ij}\right) & 2q_i+p^p q_{ii} \end{bmatrix}. \tag{2.22}$$

From (2.19) - (2.21), we obtain:

$$D_{pL}=\frac{-t_L\cdot C}{det(D_H)}\begin{bmatrix} 2q_i+p^p q_{ii} & -\left(q_j+p^p q_{ij}\right) \\ -\left(q_j+p^p q_{ij}\right) & 2q_i+p^p q_{ii} \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix},$$

where $C = q_i + q_j + p^p q_{ii} + p^p q_{ij}$. Substituting $\pi_{ii} = 2q_i + p^p q_{ii}$ and $\pi_{ij} = q_i + p^p q_{ij}$, and multiplying, we obtain:

$$D_{pL}=\frac{-t_L\cdot C}{det(D_H)}\begin{bmatrix} \pi_{ii}-\pi_{ij} & \pi_{ii}-\pi_{ij} \\ \pi_{ii}-\pi_{ij} & \pi_{ii}-\pi_{ij} \end{bmatrix}. \tag{2.23}$$

Noting that $C = \pi_{ii} + \pi_{ij} - q_i$ and $det\left(D_H\right)=\pi_{ii}^2-\pi_{ij}^2=\left(\pi_{ii}+\pi_{ij}\right)\left(\pi_{ii}-\pi_{ij}\right)$, the effect of change in lobbying effort on producer price is then the sum of either row from D_{pL}:

$$\begin{aligned}\frac{\partial p^{p,k}}{\partial L^k}+\frac{\partial p^{p,k}}{\partial L^l}&=\frac{-2t_L}{det\left(D_p\right)}\left(\pi_{ii}-\pi_{ij}\right)\left(\pi_{ii}+\pi_{ij}-q_i\right)\\&=\frac{-2t_L}{\pi_{ii}+\pi_{ij}}\left(\pi_{ii}+\pi_{ij}-q_i\right).\end{aligned}$$

Thus,

$$\frac{\partial p^{p,k}}{\partial L^k} + \frac{\partial p^{p,k}}{\partial L^l} = \left(\frac{-2t_L}{\pi_{ii} + \pi_{ij}}\right)(q_i + q_j + p^p(q_{ii} + q_{ij})). \tag{2.24}$$

By assumption, the tax rate is decreasing in lobbying, $t_L < 0$. Also, from the assumptions of equilibrium, marginal profit is more sensitive to a change in own producer price than the other firm's producer price, so $\pi_{ii} + \pi_{ij} < 0$. Thus the first, bracketed term in (2.24) is negative. If the second term is negative then price is increasing in lobbying. This condition is analogous to the limit on convexity in the monopoly case, condition (2.13) in duopoly case:

$$q_{ii} + q_{ij} < \frac{-(q_i + q_j)}{p}. \tag{2.25}$$

If the market is uncovered, then either q_j is equal to zero because the demands are independent, or $q_i + q_j < 0$ because the total number of consumers lost from a price increase will be split between the competitor and the outside options. In the former case, the problem collapses to the monopoly situation and price will increase in lobbying as before as long as demand is not too convex, as specified in condition (2.13).

In the latter case, where a firm competes both with the other firm and some outside option, the producer prices will be increasing in lobbying when inequality (2.25) holds. Again, this is slightly stronger than the equilibrium requirement of negative definiteness of the Hessian matrix. To see this in the duopoly setting, recall that the determinant of D_H is positive: $\pi_{ii}^2 - \pi_{ij}^2 = \left(\pi_{ii} + \pi_{ij}\right)\left(\pi_{ii} - \pi_{ij}\right) > 0$. Given that $\pi_{ii} < 0$ and $\pi_{ij} > 0$, this condition is equivalent to:

$$\pi_{ii} + \pi_{ij} = 2q_i + q_j + p^p \left(q_{ii} + q_{ij}\right) < 0,$$

or,

$$q_{ii} + q_{ij} < \frac{-\left(2q_i + q_j\right)}{p^p}. \square$$

2.6.3 Proof of Proposition – Lobbying Decreases Consumer Prices

From 6.8 and 2.1 the total rate of change in consumer price is:

$$\begin{aligned}
\frac{\partial p^{c,k}}{\partial L^k} + \frac{\partial p^{c,k}}{\partial L^l} &= \left(\frac{\partial p^{p,k}}{\partial L^k} + \frac{\partial p^{p,k}}{\partial L^l}\right) + \left(\frac{dt}{dL^k} + \frac{dt}{dL^l}\right) \\
&= \frac{-2t_L}{\pi_{ii} + \pi_{ij}}(\pi_{ii} + \pi_{ij} - q_i) + 2t_L \\
&= 2t_L\left(\frac{q_i}{\pi_{ii} + \pi_{ij}}\right).
\end{aligned}$$

Just as in the monopoly case, if demand is downward sloping, the tax rate is falling in lobbying and an equilibrium exists, then consumer prices are always falling in lobbying. $\square$

Table 2.1: Changes in producer price, lobbying, and consumer price, from a change in the price of lobbying, *x*.

	Monopoly: $b = 0$	Uncovered: $b \in (0,1)$
$\frac{\partial p^{p,i}}{\partial L^i} = \frac{\partial p^{p,i}}{\partial L^j}$	> 0	> 0
$\frac{\partial p^{c,i}}{\partial L^i} = \frac{\partial p^{c,i}}{\partial L^j}$	< 0	< 0
$\frac{\partial q^i}{\partial L^i} = \frac{\partial q^i}{\partial L^j}$	> 0	> 0

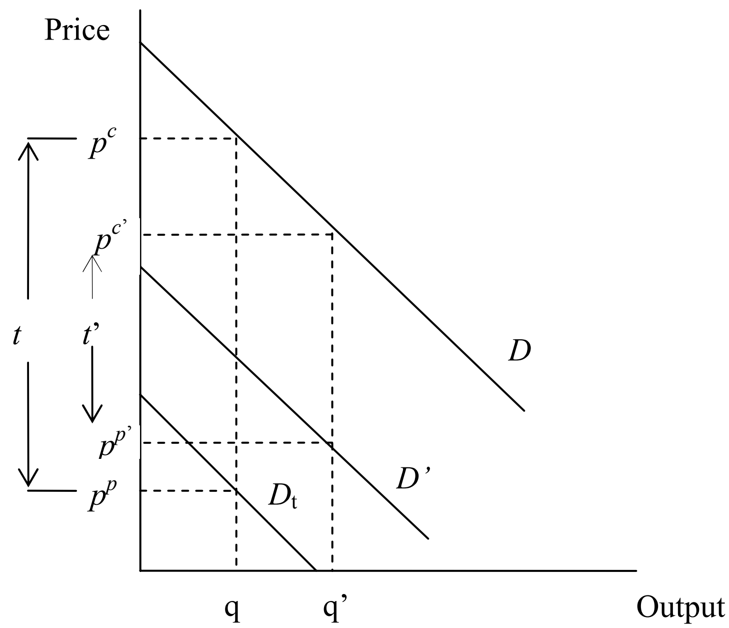

Figure 2.1: Monopoly demand. As lobbying increases from zero, tax rate falls from *t* to *t'*, producer price rises from p^p to $p^{p'}$, and consumer price falls from p^c to $p^{c'}$.

Chapter 3

Generic and Brand Advertising in Markets with Product Differentiation

3.1 Introduction

Although there is an extensive body of work on the economics of advertising, most of this research focuses on brand advertising in imperfectly competitive markets. Previous work has considered markets with differentiated products, whether real or subjective, and has clearly developed models to explain the mechanism by which advertising affects consumer choice. That is, advertising may change tastes through persuasive means or provide consumers with useful information that reduces the search cost of finding a brand with desirable characteristics. It may also serve as a complement to output by creating a desirable image or by raising the social status of the product. This body of work explains and predicts how brand advertising might affect firm behavior and the welfare of society.[7]

Research on the economics of generic commodity advertising and its relationship to brand advertising has just begun. Generic advertising is common in markets for agricultural commodities or processed foods, where

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[7] See Bagwell (2005) for an excellent review of the literature on brand advertising, and see Stivers and Tremblay (2005) for a review of the welfare effect of brand advertising.

producers frequently cooperate to supply a joint advertising campaign. Such campaigns are commonly financed through an institutional structure known as a commodity checkoff program that imposes a mandatory assessment on producers in the form of a sales or per-unit tax.[8] Marketing boards within the program develop and promote advertising campaigns designed to emphasize the universal characteristics of the product and increase market demand. When products are perfectly homogeneous, such mandatory programs avoid the free-rider problem and distribute program benefits equitably among producers.[9]

In markets with commodity checkoff programs, it is becoming more and more common for major producers to use brand advertising to differentiate their products. This raises questions about the relationship between generic and brand advertising. It also provides one reason for lawsuits by almond, peach, mushroom, plum, beef, and pork producers over mandatory generic advertising programs (Chakravarti and Janiszewski, 2004). In these markets, leading producers that have invested heavily in brand advertising oppose mandatory programs because they fear that generic advertising provides a disproportionate benefit to non-branded

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[8] Most assessments are based on a per-unit basis and constitute less than 1 percent of the dollar value of the good (Ward, 2006).

[9] For a more complete description of commodity checkoff programs and generic advertising, see Chakravarti and Janiszewski (2004), Chung et al. (2006), Crespi and McEowen (2006), Ward (2006), and Williams and Capps (2006).

producers. This can occur, for example, if generic advertising causes consumers to believe that branded and non-branded goods are of like quality. If true, such inequalities are a concern to marketing boards, as one of their goals is to assure that generic advertising produces an equitable distribution of benefits among producers (Ward, 2006).

These issues have motivated a series of recent theoretical papers on the economics of generic and brand advertising. Notable examples include the research by Crespi and Marette (2002), Hunnicutt and Israelsen (2003), Bass et al. (2005), and Crespi (2007).

Although the theoretical models developed in these papers make important contributions to our understanding of generic and brand advertising, they either analyze limiting cases or make substantive errors. Hunnicutt and Israelsen (2003) develop a useful model of generic and brand advertising in a monopolistically competitive industry. Their model clearly shows how the free-rider problem associated with firm advertising diminishes with product differentiation and demonstrates that the industry's optimal level of generic advertising diminishes when products become more differentiated.

The main limitation of the Hunnicutt and Israelsen model is that the type of product differentiation characterized by monopolistic competition is not always consistent with that found in agricultural and other food markets. It assumes that consumer preferences are symmetric and that one brand is an equally good substitute for any other brand.[10] Archibald and Rosenbluth (1975) argue that this type of differentiation is most likely to occur in markets where the characteristic space is very large. In agricultural and food markets, however, brands compete on a limited number of characteristics. These might include quality (e.g., premium versus generic brands of bananas, almonds, soft drinks, etc.) or a simple taste characteristic (e.g., sweet versus tart apples). In addition, because product demand does not derive directly from consumer utility functions, the model does not explain why consumers respond to advertising.[11]

The paper by Bass et al. (2005) uses optimal control methods to analyze the effects of generic and brand advertising in a duopoly market. Each firm sets its price, generic advertising level, and brand advertising level. Commodity checkoff programs are assumed not to exist. The main conclusions are that generic advertising suffers from the free-rider problem and that a firm's market share is determined primarily by brand advertising. Like Hunnicutt and Israelsen, the Bass et al. model does not explain why

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[10] For a discussion of the form of product differentiation in monopolistic competition, see Beath and Katsoulacos (1991).

[11] As Bagwell (2005, p. 3) indicates, "An economic theory of advertising can proceed only after this question is confronted." For example, does advertising lower consumer search costs or change consumer tastes.

consumers respond to advertising. It is also of limited use when analyzing issues important to agricultural markets because the model assumes that commodity checkoff programs do not exist and that the effects of generic and brand advertising are separable.

The papers by Crespi and Marette (2002) and by Crespi (2007) are related, so we discuss them together. Both start with models of consumer preferences, which explicitly show how generic and brand advertising affect utility (by changing tastes through persuasion) and formally characterize product differentiation as being vertical (i.e., there are real and subjective quality differences between brands). Firms play a three-stage game: (I) a marketing board sets the assessment rate,[12] (II) firm(s) choose brand advertising levels, and (III) firms choose prices. Backwards induction is used to identify the sub-game perfect Nash equilibrium. In the Crespi and Marette model, the goal of the marketing board is to choose an assessment rate (or the level of generic advertising) to maximize industry profits. The model assumes that a single high quality firm uses brand advertising; all other firms produce homogeneous goods of low quality and cannot use brand advertising.

[12] Because the level of generic advertising (G) is defined as the assessment rate (g) times total industry output, determining the optimal g also determines the optimal G at the Nash equilibrium level of output.

In the more recent model by Crespi, there are two firms, one with a high and the other with a low quality brand, and both can use brand advertising. To facilitate comparative static analysis in the recent Crespi model, firms are assumed to have no control over the assessment rate (g). The models in both papers demonstrate that generic advertising may influence subjective product differentiation and benefit the low quality firm more than the high quality firm(s). This is an important result that is consistent with concerns raised by many brand name producers of agricultural products about the adverse effects of generic advertising.

In spite of their contributions, however, the Crespi and Marette and the Crespi models suffer from several weaknesses. They both ignore the fact that generic advertising may be informative rather than persuasive. According to at least one expert (Ward, 2006, p. 55), "Generic advertising is all about information – information about a specific commodity and its underlying characteristics."[13] The Crespi and Marette model assumes that low quality producers cannot use brand advertising, a constraint that does not generally exist in real world markets and an assumption that may or may not be consistent with optimal behavior.

[13] Even the popular "Got Milk" ads, which are designed primarily to capture attention, provide some information. For example, in magazine ads Batman states that "milk's 9 essential nutrients" give him strength; Superman says that calcium in milk makes strong bones; the recording artist, Alondra, says that "Milk provides potassium, minerals, and vitamins needed for growth."

Although this constraint is relaxed in the more recent Crespi paper, the new model is limited in other ways. First, it is built from two assumptions that are inconsistent: that generic advertising attracts new customers to the market and that the number of consumers is fixed (i.e., the market is covered).[14] Second, his conclusion that the low quality firm will choose a positive level of brand advertising is incorrect. The firm's first-order condition with respect to brand advertising is always negative (equation 6), implying that the low quality firm will never use brand advertising. This is a standard result in models of brand advertising and vertical product differentiation (e.g., Tremblay and Martins-Filho, 2001; Tremblay and Polasky, 2002).

In the sections that follow, we avoid some of the weaknesses found in previous studies and derive new results concerning the relationship between generic and brand advertising. As in Crespi (2007), our purpose is to show how generic advertising affects the brand advertising behavior and profitability of firms in differentiated oligopoly markets. Unlike previous studies, we consider models with horizontal as well as vertical product differentiation. We also show how the notion of supermodularity aids in our understanding of the relationship between generic and brand advertising.

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[14] We show in the next section of the paper, that this inconsistency can be rectified by assuming that generic advertising has an informative component.

3.2 A Duopoly Model with Vertical Differentiation

We begin by developing a duopoly model with vertical product differentiation, as in Crespi (2007).[15] Brands produced by firms 1 and 2 differ in quality, indexed by k, and firm 1 is defined to be the high quality firm (i.e., $k_1 > k_2 > 0$). Real differences in quality are assumed to be exogenously determined, which can occur if firm 1 has more favorable weather conditions in agricultural production or some other idiosyncratic advantage that cannot be replicated by its competitor.

We use an indirect utility function, developed by Mussa and Rosen (1978), to describe consumer preferences. When prices are the same, all consumers prefer the high quality brand, but consumer strength of preference or willingness to pay for quality varies by person. This strength of preference is captured by the taste parameter ϕ. Tastes are distributed over the interval [0, 1], with N consumers dispersed uniformly over the taste interval. Thus, the indirect utility function for brand i (1 or 2) is $V_i = y + \phi k_i - P_i$, where y is consumer income and P_i is the price of brand i. Given prices and quality levels, preferences are illustrated in Figure 3.1. Notice that

[15] To aid comparison, we use the same notation except for the consumer taste parameter. In the Crespi model, θ is the vertical taste parameter. We choose to use ϕ as the vertical taste parameter and θ as the horizontal taste parameter.

consumers with relatively high values of quality (i.e., a high ϕ relative to that of the marginal consumer, ϕ_M) prefer brand 1 and consumers with relatively low values prefer brand 2.

Demand depends on consumer preferences, income, product quality, and market prices. To simplify the derivation of demand functions, we assume that consumers have unit demands and that the market is covered (i.e., each consumer buys one unit of either brand 1 or brand 2).[16] As is evident from Figure 3.1, demand for brand 1 is $D_1 = N(1 - \phi_M)$, and demand for brand 2 is $D_2 = N\,\phi_M$. Evaluating ϕ when $V_1 = V_2$ identifies ϕ_M, which equals $(P_1 - P_2)/(k_1 - k_2)$. Thus demand functions for brands 1 and 2 are

$$D_1(P_1, P_2, k_1, k_2) = N\left[1 - \left(P_1 - P_2\right)/k\right], \tag{3.1}$$

$$D_2(P_1, P_2, k_1, k_2) = N\left(P_1 - P_2\right)/k \tag{3.2}$$

where $k \equiv k_1 - k_2$ or the degree of vertical product differentiation.

Firms compete in prices and can use advertising to persuade consumers that the advertised brand is of higher quality. This can be accomplished by changing consumer tastes or by creating a premium image

[16] As Crespi (2007, footnotes 5 and 8) indicates, this makes the model more tractable and does not appreciably alter the main results. See Wauthy (1996) and Tremblay and Martins-Filho (2001) for discussion of models with uncovered markets, vertical differentiation, and brand advertising.

that becomes tied to the product. This form of advertising creates subjective product differentiation, as it only affects consumer perceptions of product quality or desirability. Pure image creating advertising can be seen in the market for premium cola, where Coke's marketing themes emphasize family values, while Pepsi's are designed to appeal to a younger, more rebellious generation. Similarly, in the early 1990s Anheuser-Busch created a blue-collar image for its Budweiser brand of beer, while Coors created a white-collar image for its flagship brand (Tremblay and Tremblay, 2005). Examples more relevant to subjective vertical differentiation include the Chiquita bananas and Bayer aspirin, brands that are heavily advertised to create a premium or high quality image.[17]

To distinguish this type of advertising from generic commodity advertising, it is called branded or brand advertising. In this model, a firm can use brand advertising (B_i) to increase consumer utility by enhancing the perceived quality of its brand. That is, $k_{\mathrm{i}} = k_{\mathrm{i}}(\kappa_{0i}, B_i)$, where κ_{0i} is the level of brand i's objective quality, $\kappa_{01} > \kappa_{02} > 0$. Brand advertising increases perceived quality, such that $\partial k_i/\partial B_i > 0$, and $\partial^2 k_i/\partial B_i^2 < 0$.

In the early stages of market evolution there is no real or subjective difference between brands (i.e., k is close to 0), making generic advertising

[17] For greater discussion of these and other examples where advertising creates subjective product differentiation, see Tremblay and Polasky (2002).

a worthwhile way of avoiding the free-rider problem associated with product advertising. Through a commodity checkoff program, firms are forced to fund generic advertising, financed by a per-unit assessment rate, *g*, imposed on each firm by a marketing board. Institutional inertia keeps the program in place, even as brand advertising begins to create subjective differentiation.[18]

In order to compare our results with those of Crespi (2007), we start by assuming that the market is covered and that generic advertising can increase the number of consumers. Then, we overcome this inconsistency by assuming that generic advertising has an informative as well as a persuasive component. Regarding information, assume that the market consists of two sets of people: (1) those who know of a product's existence and (2) those who do not know of a product's existence (e.g., an unusual fruit such as lychee). If consumers are defined as informed people, the market could be covered in that all consumers purchase one or another brand of lychee. The informative component of generic advertising then attracts new people to the market, increasing *N*; the persuasive component

[18] As brand advertising becomes more prominent and enhances perceived differentiation, Hunnicutt and Israelsen (2003) show that generic advertising will diminish when voluntary. Once in place, however, the evidence shows that the legal cost of rescinding a mandatory commodity checkoff program is high (Chung et al., 2006; Crespi and McEowen, 2006; Crespi 2007).

enhances subjective differentiation, increasing k_i. Thus, $N = N(g)$ and $k_i = k_i(\kappa_{0i}, B_i, g)$, such that $\partial N/\partial g > 0$, $\partial^2 N/\partial^2 g < 0$, $\partial k_i/\partial g > 0$, and $\partial^2 k_i/\partial g^2 < 0$.

At issue is the effect of generic advertising on each firm's brand advertising and profit levels under two scenarios. The first scenario has a symmetric effect on perceived quality, and the second raises the perceived quality of brand 2 relative to brand 1.[19]

Scenario 1: Generic advertising has a symmetric effect on brand quality. This implies that g attracts new consumers but has no effect on the quality gap or the degree of vertical differentiation (i.e., $\partial k_1/\partial g = \partial k_2/\partial g > 0$ or $\partial k/\partial g = 0$).

Scenario 2: Generic advertising enhances the quality of brand *2* relative to the quality of brand 1. In this case, generic advertising attracts new customers and lowers vertical differentiation (i.e., $\partial k_2/\partial g > \partial k_1/\partial g > 0$ or $\partial k/\partial g < 0$).

In order to focus on strategic issues, firm cost functions are very simple. Unit production costs are assumed to be the same for both firms and are normalized to 0.[20] Costs include only marketing expenditures, resulting in the following profit equation for firm $i = 1, 2$:

$$\pi_i = \left(P_i - g\right)Q_i - B_i\,, \tag{3.3}$$

where $Q_i \equiv D_i$. Firms are assumed to play a three-stage game. In the first

[19] A third scenario is also possible, one where g increases vertical differentiation (i.e., $\partial k/\partial g > 0$). As this is a non-issue with generic advertising, we ignore this case. If g were to increase product differentiation, whether differentiation is vertical or horizontal, both firms would benefit from and support commodity checkoff programs.

[20] Thus, price in this model can be though of as the markup of price over the marginal cost of production.

stage, the marketing board sets g.[21] In the second stage, firms compete in brand advertising. In the final stage, they compete in price. Firms are assumed to have perfect and complete information. That is, each firm knows the profits of each player and structure of the game (Gibbons, 1992).

We use backwards induction to obtain the sub-game perfect Nash equilibrium to the game, which produces a Nash equilibrium in each sub- or stage-game. At each stage, we assume that a unique equilibrium exists. Working backwards, the Nash equilibrium prices and profits in the final stage are

$$P_1^* = \frac{2}{3}(k_1 - k_2) + g, \tag{3.4}$$

$$P_2^* = \frac{1}{3}(k_1 - k_2) + g, \tag{3.5}$$

$$\pi_1^* = \frac{4}{9}(k_1 - k_2)N - B_1, \tag{3.6}$$

$$\pi_2^* = \frac{1}{9}(k_1 - k_2)N - B_2. \tag{3.7}$$

With perfect and complete information, firms are able to look forward and reason back to forecast Nash prices and profits in the final stage of the game. Given this information, the first-order conditions in the second stage are

[21] Because we are only interested in comparative static analysis and not in obtaining a closed form solution, the objective of the marketing board is ignored. This is consistent with Crespi (2007).

$$\frac{\partial \pi_1^*}{\partial B_1} = \frac{4}{9} \frac{\partial k_1\left(B_1^*, g\right)}{\partial B_1} N - 1 = 0\,, \tag{3.8}$$

$$\frac{\partial \pi_2^*}{\partial B_2} = -\frac{1}{9} \frac{\partial k_2\left(B_2^*, g\right)}{\partial B_2} N - 1 < 0\,. \tag{3.9}$$

Notice that firm 1 will use brand advertising as long as the marginal benefits are sufficiently high. Equation (3.9) will always be negative, however, implying that the optimal value of firm 2's brand advertising is 0. Thus, in Nash equilibrium firm 1 will choose a positive level of brand advertising and firm 2 will not advertise at all ($B_1^* > 0$ and $B_2^* = 0$). This result is consistent with the assumption made in the Crespi and Marette (2002) model, but firm 2's first-order condition is misinterpreted in Crespi (2007).

With vertical differentiation, it makes intuitive sense that only the high quality firm will use brand advertising, because advertising that increases product differentiation will dampen competition and raise prices [see equations (3.4) and (3.5)]. Because k is defined as k_1 - k_2, firm 1's advertising increases k by raising k_1, and firm 2's advertising lowers k by raising k_2. Because firm 2's brand advertising is costly and lowers vertical differentiation, it is optimal for firm 2 not to advertise.[22]

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[22] This result is driven by the assumptions of vertical product differentiation and a uniform

Our first issue of interest is the effect of generic advertising on Nash equilibrium levels of brand advertising. Because B_2^* equals zero, g has no effect on firm 2's brand advertising, and firm 1's first-order condition is not a function of B_2.[23] Applying the implicit-function theorem to equation (3.8), which is identically equal to zero at B_1^*, produces

$$\frac{\partial B_1^*}{\partial g} = -\frac{\dfrac{\partial^2 k_1}{\partial B_1 \partial g}}{\dfrac{\partial^2 k_1}{\partial B_1^2}} - \frac{\dfrac{\partial k_1}{\partial B_1}\dfrac{\partial N}{\partial g}}{\dfrac{\partial^2 k_1}{\partial B_1^2} N}. \tag{3.10}$$

Crespi correctly points out that the sign of $\partial B_1^*/\partial g$ is indeterminate, does not depend upon the scenario, and does depend critically upon the sign of $\partial^2 k_1/(\partial B_1 \partial g)$. If the only effect of generic advertising is to increase the size of the market, then $\partial^2 k_1/(\partial B_1 \partial g) = 0$ and generic advertising causes firm 1 to increases its expenditures on brand advertising. The result that an increase in the size of a market leads to an increase in endogenous sunk costs such as brand advertising is standard in the literature (Sutton, 1991). It also verifies

distribution of consumers. If, for example, the majority of consumers are clustered near k_1, then it may be worthwhile for firm 2 to use brand advertising to position its brand closer to k_1.

[23] Crespi performed comparative static analysis assuming that $B_2^* > 0$. If this were true, his analysis would still be in error, because it ignores the fact that the optimal values of brand advertising are embedded in the system of first-order conditions. The proper procedure is to implicitly differentiate both first-order conditions with respect to g and then use Cramer's rule to obtain comparative static results, which will depend upon the second-order conditions of profit maximization and the condition required for the Nash equilibrium to be stable (Bulow et al. 1985 and Baldani et al., 2005, Chapter 6). We use this technique in the next section of the paper.

Crespi's (p. 8) point that just because generic advertising leads to an increase in brand advertising does not necessarily imply that generic advertising lowers product differentiation. In addition, if generic advertising increases the marginal returns associated with brand advertising [i.e., $\partial^2 k_1/(\partial B_1 \partial g) > 0$], then an increase in generic advertising will also lead to an increase in firm 1's brand advertising. In this case, g and B_1 are said to be strategic complements (Bulow et al., 1985).

Next, we explore the effect of generic advertising on each firm's second-stage optimal profit functions (π_i^{**}). Differentiating equations (3.6) and (3.7) when brand advertising is set to its optimal level produces

$$\frac{\partial \pi_1^{**}\left(B_1^*, B_2^*, g\right)}{\partial g} = \frac{4}{9}\left[\left(k_1^* - k_2^*\right)\frac{\partial N}{\partial g} + \left(\frac{\partial k_1^*}{\partial g} - \frac{\partial k_2^*}{\partial g}\right)N\right], \tag{3.11}$$

$$\frac{\partial \pi_2^{**}\left(B_1^*, B_2^*, g\right)}{\partial g} = \frac{1}{9}\left[\left(k_1^* - k_2^*\right)\frac{\partial N}{\partial g} + \left(\frac{\partial k_1^*}{\partial g} - \frac{\partial k_2^*}{\partial g} + \frac{\partial k_1^*}{\partial B_1}\frac{\partial B_1^*}{\partial g}\right)N\right], \tag{3.12}$$

where $k^* = (k_1^* - k_2^*)$. This differs from the Crespi result, because $\partial B_2^*/\partial g$ is correctly set to zero as discussed above. The implications of these results can be seen more clearly by considering three cases. First, consider the case where generic advertising attracts new customers but has no effect on brand advertising ($\partial B_1^*/\partial g = 0$). This implies that

$$\frac{\partial \pi_1^{**}\left(B_1^*, B_2^*, g\right)}{\partial g} = \frac{4}{9}\left[\left(k_1^* - k_2^*\right)\frac{\partial N}{\partial g} + \left(\frac{\partial k_1^*}{\partial g} - \frac{\partial k_2^*}{\partial g}\right)N\right], \tag{3.13}$$

$$\frac{\partial \pi_2^{**}\left(B_1^*, B_2^*, g\right)}{\partial g} = \frac{1}{9}\left[\left(k_1^* - k_2^*\right)\frac{\partial N}{\partial g} + \left(\frac{\partial k_1^*}{\partial g} - \frac{\partial k_2^*}{\partial g}\right)N\right]. \tag{3.14}$$

Under scenario 1 where $\partial k^*/\partial g = 0$, generic advertising increases the profits of both firms by increasing market demand (i.e., $\partial N/\partial g > 0$). Under scenario 2 where $\partial k^*/\partial g < 0$, there is a tradeoff between the market demand effect (i.e., $\partial N/\partial g > 0$), which increases the profits of both firms, and the product differentiation effect (i.e., $\partial k^*/\partial g < 0$), which lowers the profits of both firms. The dominant effect will determine the influence of generic advertising on firm profits.

In the second case, consider the comparative static results in equations (3.11) and (3.12) when $\partial B_1^*/\partial g > 0$. In this case, our predictions are different from those of Crespi. Under scenario 1, where $\partial k^*/\partial g = 0$, generic advertising benefits both firms. Under scenario 2 where $\partial k^*/\partial g < 0$, the results are indeterminate for both firms. This setting is most likely to produce an outcome where firm 1's profits fall and firm 2's profits rise. This could occur if generic advertising sufficiently lowers product differentiation (lowering profits of both firms) and sufficiently induces firm 1 to increase spending on brand advertising (raising profits of firm 2 relative those of firm 1).

In the third case where $\partial B_1^*/\partial g < 0$, our comparative static results are the same as those found in the Crespi model. Generic advertising benefits firm 1 under scenario 1. Otherwise the effect on firm profits is indeterminate.

Our amended version of the vertically differentiated model produces several important results. First, only the high quality firm uses brand advertising, a common feature in such markets as bananas, almonds, and aspirin where branded goods are heavily advertised and generic products are not advertised at all. Second, generic advertising is more likely to be beneficial to both firms when it attracts new customers, does not lower subjective product differentiation, and causes the high quality firm to use more brand advertising. Third, the low quality firm is likely to benefit and the high quality firm to be harmed by generic advertising when generic advertising sufficiently lowers subjective product differentiation and causes firm 1 to sufficiently increase spending on brand advertising.

3.3 A Duopoly Model with Horizontal Differentiation

Next, we develop a duopoly model that differs from the model above only in that differentiation is horizontal rather than vertical. To do this, we use a simple linear-city or address model (Hotelling, 1929, d'Aspremont et al., 1979). Brands 1 and 2 differ in a single horizontal characteristic, $\theta \in [\theta_1, \theta_2]$ and $0 \leq \theta_1 < \theta_2$. There are N consumers with preferences over θ who are uniformly distributed over the interval θ_1-θ_2. A consumer's ideal level of θ identifies the consumer's type or location. Unlike the case with vertical differentiation, consumers disagree over which value of θ is ideal or most preferred.

The market for breakfast cereal provides an example where there are real horizontal differences among brands. To illustrate, consider a market with just two brands, unsweetened corn flakes (brand 1, located at $\theta = 0$) and sweetened corn flakes (brand 2, located at $\theta = 1$). If $P_1 = P_2$, then consumers who prefer a sweeter cereal (with preference locations $½ < \theta \leq 1$) will prefer brand 2 and consumers who prefer a cereal that is less sweet (with preference locations $0 \leq \theta < ½$) will prefer brand 1.

The premium cola market provides an example of a market where horizontal differentiation is subjective or perceived. Following Tremblay and Polasky (2002), assume two brands, Coke (brand 1) and Pepsi (brand 2). Without advertising $\theta_1 = \theta_2 = ½$. Brand advertising can create subjective differentiation by producing distance between θ_1 and θ_2, at least in the eyes of the consumer. As discussed above, θ might index the degree of youth appeal. Aware of this characteristic, Coke has responded by using brand advertising to lower θ_1, and Pepsi has responded by using brand advertising to raise θ_2. Although advertising is expensive, benefits accrue to both firms because increased product differentiation dampens price competition.

This model may also apply to agricultural products where one brand is organic and the other is not. Although many consumers may prefer organic, others may prefer non-organic foods. The latter group may not believe that organic foods are superior and may be concerned that organic brands are linked to a liberal, environmental image.[24] Thus, the presence of organic and non-organic brands creates horizontal differentiation over an environmental characteristic. In such a market, generic advertising may exist to boost market demand, while individual firms use brand advertising to create a pro- or anti-organic/environmental image.

To parallel the vertical differentiation case, we use an indirect utility function to characterize consumer preferences when brands are horizontally differentiated. In the linear city model, the indirect utility function for a particular consumer considering brand i is $V_i = y - P_i - t\, d_i$, where $t > 0$ is the disutility associated with purchasing a brand that is not ideal and d_i is the distance from the consumer's ideal brand (i.e., the

[24] For a discussion of this issue, see the web page of The Food Standards Agency (www.food.gov.uk).

consumer's location or type) to the θ associated with brand i (θ_i). Figure 3.2 illustrates this case assuming brands 1 and 2 are located at θ_1 and θ_2. Notice, for example, that a consumer located at θ_M is a distance of d_1 from θ_1 and a distance of d_2 from θ_2.

As before, the market is covered and consumers have unit demands. The market demand for each brand depends on the location of the marginal consumer (θ_M), located where $V_1(\theta_M) = V_2(\theta_M)$. Assuming that a firm's horizontal location is arbitrary and that $0 \leq \theta_1 \leq ½ \leq \theta_2 \leq 1$, the marginal consumer is defined as

$$\theta_M = \left[t\left(\theta_1 + \theta_2\right) - P_1 + P_2\right] \big/ 2t. \tag{3.15}$$

With N consumers located within the preference interval, the demand functions are

$$D_1\left(P_1, P_2, \theta_1, \theta_2\right) = Nd_1 = N\left(\theta_M - \theta_1\right) = N\left[\frac{t\left(\theta_2 - \theta_1\right) - P_1 + P_2}{2t}\right], \tag{3.16}$$

$$D_2\left(P_1, P_2, \theta_1, \theta_2\right) = Nd_2 = N\left(\theta_2 - \theta_M\right) = N\left[\frac{t\left(\theta_2 - \theta_1\right) + P_1 - P_2}{2t}\right]. \tag{3.17}$$

In this model, θ_2 and θ_1 represent each brands perceived or subjective locations. Without brand advertising $\theta_2 = \theta_1 = ½$ (i.e., there is no product differentiation). We assume that brand advertising can increase subjective horizontal differentiation, $\partial\theta_1/\partial B_1 < 0$ and $\partial\theta_2/\partial B_2 > 0$.[25] Generic advertising increases N and may decrease or have no effect on subjective horizontal differentiation. Under scenario 1, generic advertising has no effect on horizontal differentiation ($\partial\theta_2/\partial g$ - $\partial\theta_1/\partial g = 0$); under scenario 2, generic advertising reduces horizontal differentiation ($\partial\theta_2/\partial g$ - $\partial\theta_1/\partial g < 0$). The remaining structure of the model is the same as with vertical differentiation. Given the degree of symmetry in the model, we can write the profit equation as

$$\begin{aligned}\pi_i &= \left(P_i - g\right)Q_i - B_i \\ &= \left(P_i - g\right)N\left[t\left(\theta_2 - \theta_1\right) - P_i + P_j\right]\big/2t - B_i, \quad \forall\, i, j = 1, 2, i \neq j,\end{aligned} \tag{3.18}$$

where $Q_i \equiv D_i$.

Recall that in the final stage of the game, firms compete in price. The Nash equilibrium for this sub-game is described below:

$$P_1^* = t\left(\theta_2 - \theta_1\right) + g\,, \tag{3.19}$$

$$P_2^* = t\left(\theta_2 - \theta_1\right) + g\,, \tag{3.20}$$

$$\pi_1^* = \frac{1}{2}Nt\left(\theta_2 - \theta_1\right)^2 - B_1, \tag{3.21}$$

$$\pi_2^* = \frac{1}{2}Nt\left(\theta_2 - \theta_1\right)^2 - B_2. \tag{3.22}$$

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[25] To ensure that second-order conditions hold, we assume that $\partial^2\theta_1/\partial B_1^2 > 0$ and $\partial^2\theta_2/\partial B_2^2 < 0$. This implies diminishing returns to brand advertising.

Notice that in the limit as θ_1 approaches θ_2, the degree of product differentiation diminishes and the Nash equilibrium approaches simple Bertrand, where price equals marginal cost and profits are zero.

In the second stage, firms compete in brand advertising. The first-order conditions for this stage game are

$$\frac{\partial \pi_1^*}{\partial B_1} = Nt\left(\theta_1 - \theta_2\right)\frac{\partial \theta_1}{\partial B_1} - 1 = 0, \tag{3.23}$$

$$\frac{\partial \pi_2^*}{\partial B_2} = Nt\left(\theta_2 - \theta_1\right)\frac{\partial \theta_2}{\partial B_2} - 1 = 0. \tag{3.24}$$

Unlike the case with vertical differentiation, both firms will use brand advertising in a horizontally differentiated market as long as the marginal benefits from advertising are sufficiently high.[26] Furthermore, if each firm has equally effective brand advertising (i.e., $\partial\theta_2/\partial B_2 = -\partial\theta_1/\partial B_1$), then the level of brand advertising will be the same for both firms. This is consistent with the outcome in the market for premium cola, where the amount of advertising spending by Coke and Pepsi is nearly the same (Tremblay and Polasky, 2002).

Analyzing the effect of generic advertising on the optimal level of brand advertising is more complex in this model. Given the nature of the

[26] Notice that the marginal benefits are positive for both firms. For firm 1, N and t are positive, while (θ_1 - θ_2) and $\partial\theta_1/\partial B_1$ are negative. For firm 2, N, t, (θ_2 - θ_1), and $\partial\theta_2/\partial B_2$ are positive.

game and the fact that both firms advertise when differentiation is horizontal, the first-order conditions are interdependent. In this case, comparative static results are obtained by implicitly differentiating both first-order conditions with respect to g and then using Cramer's rule. This produces the following comparative static results:

$$\frac{\partial B_1^*}{\partial g} = \frac{\begin{vmatrix} -\pi_{1g} & \pi_{12} \\ -\pi_{2g} & \pi_{22} \end{vmatrix}}{|\Pi|} = \frac{-\pi_{1g}\pi_{22} + \pi_{2g}\pi_{12}}{|\Pi|}, \tag{3.25}$$

$$\frac{\partial B_2^*}{\partial g} = \frac{\begin{vmatrix} \pi_{11} & -\pi_{1g} \\ \pi_{21} & -\pi_{2g} \end{vmatrix}}{|\Pi|} = \frac{-\pi_{11}\pi_{2g} + \pi_{1g}\pi_{21}}{|\Pi|}, \tag{3.26}$$

$$\text{where } \Pi = \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{pmatrix}.$$

For notational convenience, we define π_{ij} to equal the second derivative of firm i's profit function with respect to B_i and variable j.[27] For the Nash equilibrium to be stable, the determinant of matrix Π must be positive. Thus, the

$$\operatorname{sign} \partial B_1^* / \partial g = \operatorname{sign}\left(-\pi_{1g}\pi_{22} + \pi_{2g}\pi_{21}\right), \tag{3.27}$$

[27] That is,

$\pi_{11} = \partial^2 \pi_1 / \partial B_1^2 = Nt\left[\left(\partial\theta_1/\partial B_1\right)^2 + \left(\theta_1 - \theta_2\right)\partial^2\theta_1/\partial B_1^2\right]$,

$\pi_{12} \equiv \partial^2 \pi_1 / (\partial B_1 \partial B_2) = \pi_{21} \equiv \partial^2 \pi_2 / (\partial B_2 \partial B_1) = -Nt(\partial\theta_1/\partial B_1)(\partial\theta_2/\partial B_2)$,

$\pi_{22} \equiv \partial^2 \pi_2 / \partial B_2^2 = Nt\left[\left(\partial\theta_2/\partial B_2\right)^2 + \left(\theta_2 - \theta_1\right)\partial^2\theta_2/\partial B_2^2\right]$.

$$\text{sign}\,\partial B_2^* / \partial g = \text{sign}\left(-\pi_{11}\pi_{2g} + \pi_{21}\pi_{1g}\right). \tag{3.28}$$

For the second-order conditions of profit maximization to hold, π_{11} and π_{22} must be negative. Because $\partial\theta_1/\partial B_1 < 0$ and $\partial\theta_2/\partial B_2 > 0$ in this model, π_{12} and π_{21} are positive. This implies that B_1 and B_2 are strategic complements, such that an increase in B_i increases the marginal returns to B_j and causes B_j^* to increase.

Given these conditions, the signs $\partial B_1^*/\partial g$ and $\partial B_2^*/\partial g$ depend only on the sign of π_{ig}, which depends upon how generic advertising affects demand. Under scenario 1, generic advertising attracts new consumers (i.e., $\partial N/\partial g > 0$) but has no effect on horizontal differentiation (i.e., $\partial\theta_2/\partial g - \partial\theta_1/\partial g = 0$). In this case,

$$\pi_{ig} \equiv \frac{\partial^2 \pi_i}{\partial g \partial B_i} = t\left(\theta_i - \theta_j\right)\frac{\partial \theta_i}{\partial B_i}\frac{\partial N}{\partial g} > 0. \tag{3.29}$$

Thus, under scenario 1, generic advertising increases the brand advertising of both firms.[28] For both vertical and horizontal differentiation, this demonstrates that generic advertising can increase brand advertising without reducing product differentiation.

Comparative static analysis is more complex under scenario 2, where generic advertising reduces horizontal differentiation (i.e., $\partial\theta_2/\partial g$ -

[28] Notice that when $i = 1$, $\partial\theta_1/\partial B_1 < 0$ and $(\theta_1 - \theta_2) < 0$, so $\pi_{1g} > 0$; when $i = 2$, $\partial\theta_2/\partial B_2 > 0$ and $(\theta_2 - \theta_1) > 0$, so $\pi_{2g} > 0$.

$\partial\theta_1/\partial g < 0$). In this case,

$$\pi_{1g} \equiv \frac{\partial^2 \pi_1}{\partial g \partial B_1} = \frac{\partial N}{\partial g} t\left(\theta_1 - \theta_2\right)\frac{\partial \theta_1}{\partial B_1} + Nt\left(\frac{\partial \theta_1}{\partial g} - \frac{\partial \theta_2}{\partial g}\right)\frac{\partial \theta_1}{\partial B_1} + Nt\left(\theta_1 - \theta_2\right)\frac{\partial^2 \theta_1}{\partial g \partial B_1}, \tag{3.30}$$

$$\pi_{2g} \equiv \frac{\partial^2 \pi_2}{\partial g \partial B_2} = \frac{\partial N}{\partial g} t\left(\theta_2 - \theta_1\right)\frac{\partial \theta_2}{\partial B_2} + Nt\left(\frac{\partial \theta_2}{\partial g} - \frac{\partial \theta_1}{\partial g}\right)\frac{\partial \theta_2}{\partial B_2} + Nt\left(\theta_2 - \theta_1\right)\frac{\partial^2 \theta_2}{\partial g \partial B_2}. \tag{3.31}$$

As before, the first terms on the right had side of equations (3.30) and (3.31) are positive. The second terms are negative, however, and the signs of the third terms are unknown. Thus, generic advertising may raise or lower brand advertising in this case. If generic advertising and brand advertising are strategic complements, however, the third terms will be positive and sufficiently large so that both π_{ig} and $\partial B_i^*/\partial g$ are positive. This means that under scenario 2, generic advertising will lead to an increase in brand advertising when it sufficiently raises the marginal effectiveness of brand advertising.

Next, we analyze the effect of generic advertising on firm profits. Given that second-stage profits are similar for both firms, we can write the comparative static effect generally as

$$\frac{\partial \pi_i^{**}}{\partial g} = \frac{1}{2}t\left(\theta_2 - \theta_1\right)^2 \frac{\partial N}{\partial g} + Nt\left(\theta_2 - \theta_1\right)\left[\frac{\partial \theta_2}{\partial B_2}\frac{\partial B_2^*}{\partial g} - \frac{\partial \theta_1}{\partial B_1}\frac{\partial B_1^*}{\partial g} + \frac{\partial \theta_2}{\partial g} - \frac{\partial \theta_1}{\partial g}\right] - \frac{\partial B_i^*}{\partial g}. \tag{3.32}$$

Assuming the first-order conditions hold, this simplifies to

$$\frac{\partial \pi_i^{**}}{\partial g} = \frac{1}{2}t\left(\theta_j - \theta_i\right)^2 \frac{\partial N}{\partial g} + Nt\left(\theta_j - \theta_i\right)\left[\frac{\partial \theta_j}{\partial B_j}\frac{\partial B_j^*}{\partial g} + \frac{\partial \theta_j}{\partial g} - \frac{\partial \theta_i}{\partial g}\right]. \tag{3.33}$$

Under scenario 1, the profits of both firms will increase with generic advertising. With complete symmetry, where the brand advertising of each firm is equally effective at creating subjective differentiation and the effect of generic advertising on the amount of brand advertising is the same for both firms, the effect of g on profits will be the same for both firms. Under scenario 2, the effect is indeterminate, because $\partial B_j^*/\partial g$ may be positive or negative and because $(\theta_j - \theta_i)\cdot(\partial\theta_j/\partial g - \partial\theta_i/\partial g) < 0$.

Given the degree of symmetry inherent in this model, generic advertising is more likely to have a symmetric effect on the brand advertising and profits of each firm when differentiation is horizontal rather than vertical. An asymmetric result can occur with horizontal differentiation, however, if generic advertising induces one firm to use more brand advertising than the other firm. In this case, the heavy advertiser will have relatively lower profits, because both firms benefit equally from advertising that increases horizontal differentiation but only one firm pays for it. It could also occur if generic advertising attracts relatively more consumers who favor brand 2 (i.e., it skews the distribution toward θ_2), generating greater gains for firm 2 relative to firm 1. This outcome would be of obvious concern to firm 1 and may motivate legal actions to eliminate mandatory checkoff programs.

3.4 Generic and Brand Advertising in a Supermodular Setting

An alternative way to analyze the relationship between generic and brand advertising in an oligopoly setting is to assume that firms play a supermodular game. As the analysis above indicates, the effect that generic advertising has on brand advertising depends critically on whether or not one agent's advertising raises the marginal returns of another agent's advertising. When the effect is positive, this causes the best reply of each firm to increase in generic advertising and in each of its rival's brand advertising, a defining characteristic of a supermodular game. In a supermodular setting, comparative static results emerge from a relatively general model, even when the assumptions of the implicit function theorem do not hold (Milgrom and Roberts, 1990); Milgrom and Shannon, 1994; Shannon 1995; and Vives, 1999).

To illustrate, consider the case of a smooth supermodular game where best reply functions are differentiable.[29] Firms compete in a two-stage game. In the first stage, a marketing board sets generic advertising (g). In the second stage, two or more firms in a market compete by simultaneously choosing price (P) and brand advertising (B). For the game to be supermodular, the following assumptions must hold for each firm $i = 1, 2, 3, \ldots$ and each of its rivals, indexed by j (Milgrom and Roberts, 1990, p. 1264).

(A1) *Bounded Strategies*: P_i and B_i each lie within a closed interval where $\{P_i \mid 0 < P_{iL} \leq P_i \leq P_{iH} < \infty\}$ and $\{B_i \mid 0 < B_{iL} \leq B_i \leq B_{iH} < \infty\}$.
(A2) *Differentiability of the Profit Function*: Firm i's profit (π_i) equation is twice continuously differentiable with respect to P_i and B_i in $\{(P_i, B_i)$: $P_{iL} < Pi < P_{iH}$, $B_{iL} < B_i < B_{iH})$.
(A3) *Complementary Strategies*: $\partial^2\pi_i / \partial P_i\, \partial B_i \geq 0$.
(A4) *Strategic Complementarity Strategies*: $\partial^2\pi_i / \partial P_i\, \partial P_j \geq 0$, $\partial^2\pi_i / \partial P_i\, \partial B_j \geq 0$, $\partial^2\pi_i / \partial B_i\, \partial P_j \geq 0$, and $\partial^2\pi_i / \partial B_i\, \partial B_j \geq 0$.
(A5) *Complementary Exogenous Variable*: $\partial^2\pi_i / \partial P_i\, \partial g \geq 0$ and $\partial^2\pi_i / \partial B_i\, \partial g \geq 0$.

The key assumptions are A3-A5. When strictly positive, A3 implies that P_i and B_i are complements in the demand function, which assures that there are increasing differences or increasing marginal returns between the pair of firm i's strategies (P_i and B_i). This means that an increase in P_i (B_i) causes B_i (P_i) to increase. When the restrictions in A4 are strictly positive, the best

[29] Alternatively, one could assume that best-replies are complete lattices instead of smooth functions without affecting the main conclusions, as discussed in Milgrom and Roberts (1990), Milgrom and Shannon (1994), and Vives (1999).

reply functions have a positive slope with respect to a firm's own and its rival's strategies. In other words, the pairs of strategies P_i-P_j, P_i-B_j, B_i-P_j, and B_i-B_j are strategic complements. When the restrictions in A5 are strictly positive, there are increasing marginal returns between the exogenous variable g and each strategic variable of firm i, P_i and B_i.

When these assumptions hold, Milgrom and Roberts prove that the game will have at least one Nash equilibrium. Assuming a unique solution and that strict inequalities hold for A3-A5, they also prove that an increase in the exogenous variable g will cause Nash equilibrium prices (P^*) and brand advertising (B^*) to increase for each firm (Milgrom and Roberts, 1990, Theorem 6). This result holds for all markets with more than one firm and for a discrete as well as a continuous change in g.

The Milgrom-Roberts theorem is driven by the fact that the market exhibits super-complementarity. That is, assumptions A3-A5 imply that the exogenous variable and all strategic variables in the model are complements. Because of increasing marginal returns, an increase in generic advertising causes P_i^* (and B_i^*) to increase. The increase in P_i^* (B_i^*) in turn causes B_i^* (P_i^*) to rise because the firm's own choice variables are complements (A3). It also causes P_j^* and B_j^* to increase for all j because rival choice variables are strategic complements (A4). Finally, this causes a chain of feedback effects: the resulting increases in P_j^* and B_j^* cause further increases in P_i^* and B_i^*, etc. Because all of these direct and indirect effects work in the same direction, an increase in g will cause the Nash level of brand advertising to unambiguously increase for each firm.

The recent claim that generic advertising has forced some producers to respond by increasing their brand advertising raises questions concerning the motivation for this response. According to Supreme Court testimony in a case involving tree fruit, one high quality producer claims to have increased brand advertising in order to undo the negative impact of generic advertising on product differentiation (Glickman v. Wileman Brothers & Elliot, 1997; Crespi, 2007). As Crespi (2007, p. 8) points out, however, this need not be the only reason why brand advertising increases in response to generic spending. Another possibility is that brand advertisers spend more to take advantage of gains in the marginal effectiveness of brand advertising produced by generic advertising.[30]

3.5 Conclusion

This paper extends previous work and produces several new

[30] Unfortunately, the Milgrom and Roberts result is not powerful enough to rule out the possibility that generic advertising increases brand advertising when the game in not supermodular. Thus, other explanations are still possible.

insights concerning the relationships between generic advertising and a firm's brand advertising and profitability. In a duopoly model with vertical product differentiation, we revise previous work to show that only the high quality firm will use brand advertising. In this case, generic advertising is likely to benefit the low quality firm more than the high quality firm when generic advertising lowers product differentiation and induces the high quality firm to spend more on brand advertising.

In a duopoly model with horizontal differentiation, we show that both firms advertise to promote their brands and that a symmetric outcome is more likely. When this occurs, profits and expenditures on brand advertising will be the same, and each firm will respond in the same way to an increase in generic advertising. This suggests that producers will be more likely to be either uniformly in favor or uniformly opposed to commodity checkoff programs when differentiation is horizontal. Asymmetries can arise in the horizontally differentiated model, however, if generic advertising induces one firm to spend more on brand advertising than the other firm. In this case, the heavy advertiser will have lower profits. Differences in profits can also occur if generic advertising increases the demand for one brand relative to that of the other brand.

Finally, we show that the relationship between generic advertising and brand advertising is clear when the structure of the model is supermodular. That is, generic advertising will induce firms to spend more on brand advertising when firms play a supermodular game. This requires that generic and brand advertising are strategic complements, which occurs when generic advertising increases the marginal returns of brand advertising. Regardless of the type of differentiation, the results confirm Crespi's conjecture that generic advertising may induce firms to spend more on brand advertising even when generic advertising does not reduce perceived product differentiation.

Future research might move in two directions. First, our theoretical analysis identifies conditions under which generic advertising will have symmetric and asymmetric effects on brand advertising and firm profits. Future research might focus on empirically estimating these relationships for different horizontally and vertically differentiated industries to determine if model predictions are consistent with the data, as in Crespi and Marette (2002). One could also test whether firms behave as if generic and brand advertising are strategic complements or substitutes, as in Seldon et al. (1993). Second, to date brand advertising has been assumed to be purely persuasive. In future research we plan to analyze the relationship between generic and brand advertising when brand advertising is purely informative, as in the brand advertising model developed by Stivers and Tremblay (2005).

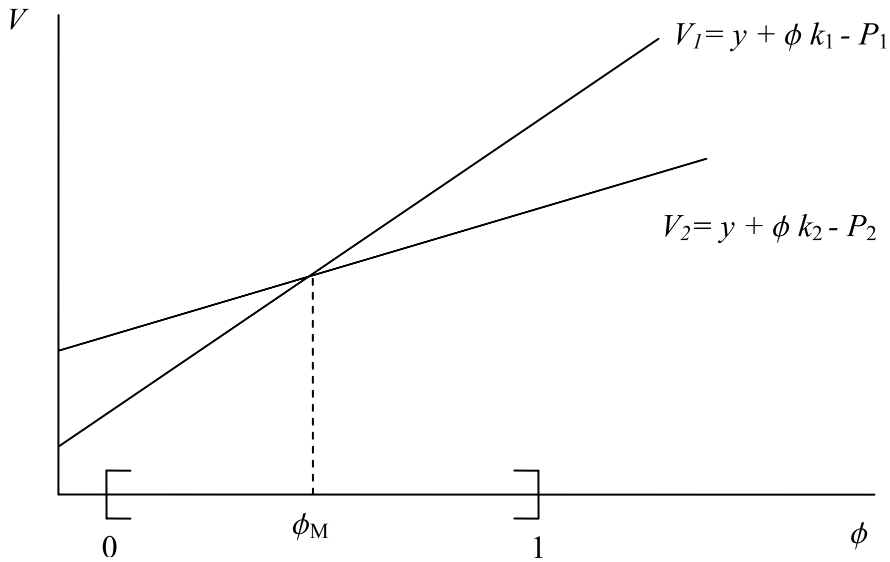

Figure 3.1: Indirect Utility Functions for Vertically Differentiated Brands

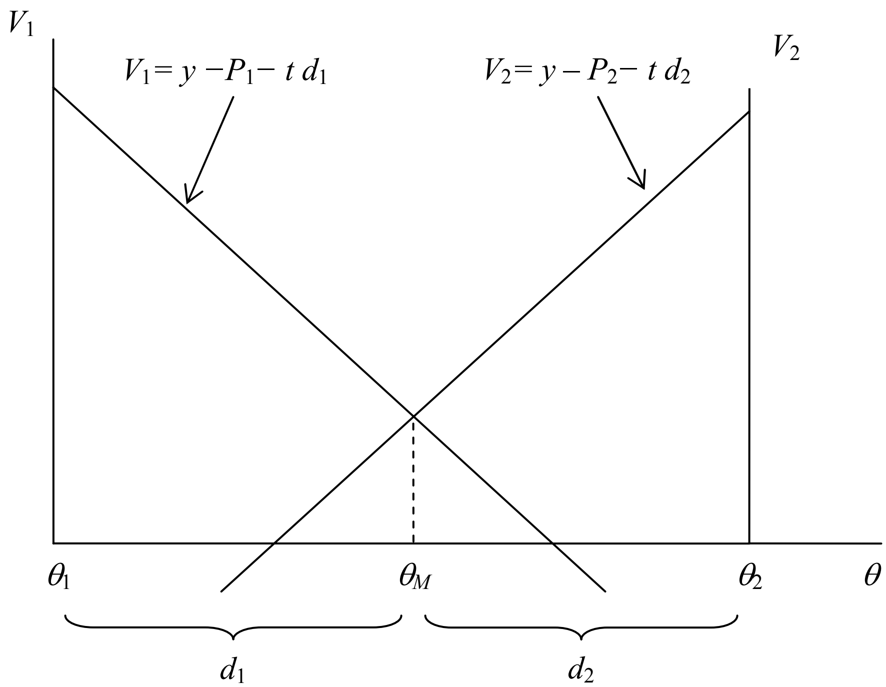

Figure 3.2: Indirect Utility Functions for Horizontally Differentiated Brands

Chapter 4

The Advertising-Price Relationship: Theory and Evidence

4.1 Introduction

Theoretical work demonstrates that the welfare effect of advertising in imperfectly competitive markets depends critically upon the advertising-price relationship. In their seminal study, Dixit and Norman (1978) show that advertising will raise market power and lower (raise) social welfare when it raises (lowers) prices in imperfectly competitive markets. Becker and Murphy (1993) and Stivers and Tremblay (2005) demonstrate that this simple test is invalid, however, when advertising produces sufficient positive externalities and/or sufficiently lowers consumer search costs. In this case, advertising that raises price need not be socially excessive, but advertising that lowers price will be undersupplied from society's perspective. Regardless of the circumstances, however, a first step in estimating the welfare effect of advertising is to determine whether advertising raises prices and market power.

Advertising can affect price by influencing a number of demand and cost factors. Because most advertising costs are sunk, for example**,** advertising expenditures may deter entry and lower price competition (Sutton, 1991). Alternatively, advertising could lower price when it increases firm demand and substantially lowers marginal cost due to the presence of scale economies.

Most theoretical research on the advertising-price relationship has focused on the demand effect of advertising in imperfectly competitive markets. In his extensive survey, Bagwell (2005) summarizes three important ways that advertising may influence demand. First, advertising may change consumer tastes through persuasive means by creating spurious or subjective product differentiation. This form of advertising strengthens consumer brand loyalty, which generally results in more inelastic demand functions and less competitive pricing. Second, advertising may provide consumers with useful information about prices and product characteristics. With better informed consumers, demand becomes more price elastic and market prices generally become more competitive.[31] When advertising can be both informative and persuasive, Banerjee and Bandyopadhyay (2003) show that prices will be higher or lower depending on the relative mix of persuasive versus informative ads. Finally, advertising may be viewed as simply a complement to output (Becker and Murphy, 1993). In this case, advertising does not change consumer preferences. It may provide information but its primary influence comes from the creation of a

[31] The one exception is the model by Stivers and Tremblay (2005), which shows that purely informative advertising can lower the full price paid by consumers (i.e., the market price plus unit search costs) and raise market prices.

particular image that becomes tied to the product. Consumers who value these images will be willing to pay a higher price for advertised brands.

Given the variety of theoretical possibilities, it is not surprising that the results of empirical studies of the advertising-price relationship are mixed and appear to vary across industries.[32] Several studies confirm that a ban on advertising increases market prices, which suggests that advertising is primarily informative in nature and/or allows firms to benefit from scale economies.[33] Consistent with the persuasive viewpoint, however, is the evidence that heavily-advertised brands are more expensive than like brands that receive little advertising.[34] This conclusion is problematic, however, because heavily-advertised brands may be higher priced because of subtle quality differences. If firms use advertising as a signal to inform consumers of high-quality experience goods, then the higher price for heavily-advertised goods reflects a difference in quality and is not due to persuasion. Consistent with the viewpoint that advertising is a complement to output, recent evidence by a team of psychiatrists indicates that

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[32] The literature is too extensive for a complete review, but the interested reader can see Bagwell (2005) for a survey of almost 500 theoretical and empirical articles on the economics of advertising.

[33] In his seminal study, Benham (1972) found that advertising restrictions led to higher prices for eyeglasses. This result is confirmed in subsequent studies, such as Cady (1976) for prescription drugs, Maurizi and Kelly (1978) for retail gasoline, Kwoka (1984) for optometry services, and Milyo and Waldfogel (1999) for alcoholic beverages. For a review of this evidence, see Carlton and Perloff (2005) as well as Bagwell (2005).

[34] See, for example, Wills and Mueller (1989), Connor and Peterson (1992), Rizzo and Zeckhauser (1992), and Tremblay and Tremblay (1995).

consumers do gain utility from the images created by advertising (McClure *et al*., 2004). This study found that test subjects who drank Coca-Cola experienced greater pleasure, measured by functional magnetic resonance imaging (fMRI), when they were informed that they were drinking the Coke brand than when they were uninformed.[35] Thus, the brand name provides utility in-and-of itself.[36]

One goal of this research is to analyze the theoretical relationship between advertising and prices in imperfectly competitive markets when there is persuasive, informative or image creating advertising. In section 2, we show how recent theoretical work on supermodular games identifies a set of sufficient conditions that guarantee a positive relationship between advertising and price. We use two simple duopoly models, one with horizontal and the other with vertical product differentiation, to show that supermodularity is sufficient but not necessary for there to be a positive relationship between price and advertising. In both models, advertising raises price when it is persuasive, yet only the model with horizontal differentiation is supermodular. Thus, in section 3 we turn to empirical

[35] It appears that consumer preferences for soft drinks are processed in two separate regions of the prefrontal cortex; the ventromedial region judges purely sensory information, and the dorsolateral region judges cultural and image influences created by advertising (McClure et al., 2004: 385).

[36] Of course, advocates of the persuasive view might argue that this enhanced pleasure results from the deceptive nature of advertising rather than the creation of a desirable image.

analysis to shed additional light on the issue. We develop an empirical model to estimate the advertising-price relationship in the U.S. brewing industry using firm level data. We also estimate changes in the Lerner Index due to advertising. We find that beer advertising are associated with higher prices and market power. In section 4, we suggest that advertising in these industries has been primarily persuasive and image enhancing, and conclude that beer advertising has reduced social welfare.

4.2 The Theoretical Relationship between Advertising and Price

Advances in economic theory shed some light on the relationship between advertising and price in imperfectly competitive markets. When firms compete in a strictly supermodular game, for example, the structure of the game is sufficient to assure a positive relationship between advertising and price (Milgrom and Roberts, 1990).[37] To illustrate this concept, consider a smooth supermodular game where n firms compete in a market by maximizing profit (π) with respect to price (p) and advertising (A).[38] Firm i's strategies are identified as p_i and A_i, and a particular rival's strategies as p_j and A_j. Each firm is assumed to have complete information

[37] See Vives (1999) for a more detailed discussion of supermodular games.

[38] One could assume more generally that strategies are complete lattices instead of smooth functions without affecting the main conclusions of the paper. For further discussion, see Milgrom and Roberts (1990) and Vives (1999).

and to choose price and advertising simultaneously to maximize its own profit.

Two important assumptions are critical to supermodularity.[39] First, a firm's own strategic variables must be complementary: $\partial^2\pi_i/\partial p_i\partial A_i > 0 \ \forall \ i = 1, 2, 3, \ldots, n$. This implies, for example, that an increase in A_i raises the marginal returns of price ($\partial\pi_i/\partial p_i$) and induces the firm to increase A_i, a condition that will hold when advertising and price are complements in the firm's demand function and an increase in advertising does not lead to lower marginal costs (through scale effects).[40] Thus, A_i and p_i move together, ceteris paribus. Second, firm and rival prices and advertising levels are strategic complements (Bulow *et al.*, 1985): $\partial^2\pi_i/\partial p_i\partial p_j > 0$, $\partial^2\pi_i/\partial p_i\partial A_j > 0$, $\partial^2\pi_i/\partial A_i\partial p_j > 0$, and $\partial^2\pi_i/\partial A_i\partial A_j > 0$. This means that an increase in each of firm *i*'s strategic variables raises the marginal returns of each of firm *j*'s strategic variables.

One can think of this as a game of super-complementarity where all strategic variables move together. For example, an exogenous shock, such as a reduction in the price of advertising that increases firm *i*'s advertising,

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[39] The other assumptions are that the profit function is twice continuously differentiable and all strategic variables are bounded between positive and negative infinity. Regarding price, it is reasonable to assume that the equilibrium price is bounded by zero and the monopoly price. Regarding advertising, it is reasonable to assume that advertising is bounded by 0 and total revenue.

[40] This will occur when advertising and price are separable in the firm's demand function and when advertising increases firm demand. This definition follows from Bulow et al. (1985).

will cause the firm to raise its price (because A_i and p_i are complements) and induce firm j to raise its price and advertising spending (given the strategic complementary assumption). Feedback effects reinforce these changes, as the increases in A_j and p_j cause firm i to further raise its price and advertising, etc. Thus, the supermodularity structure guarantees a positive relationship between advertising and price.[41] In the next section, we examine this idea with two models of duopoly, one with horizontal and the other with vertical product differentiation. In the simple Hotelling model of horizontal differentiation, supermodularity is both necessary and sufficient for advertising to raise price. In contrast, we find that a duopoly model with vertical product differentiation is not always supermodular even though advertising raises price. This underscores the point that supermodularity is sufficient but not necessary for there to be a positive relationship between advertising and price.

4.2.1 Duopoly with Horizontal Product Differentiation

Consider a duopoly market where products are substitutes and differentiated along a single horizontal characteristic, θ, as in Hotelling (1929) and d'Aspremont *et al*. (1979). For simplicity, assume that $0 \leq \theta \leq$

[41] Spence (1977: 543) is a precursor to this line of research, as he showed that advertising will increase price in a monopoly setting when $\partial^2\pi_i / \partial p_i \partial A_i > 0$.

θ_H. Examples of horizontal characteristics include the location of a bank or the color of a particular model of car. Each firm (1 and 2) produces a single product or brand, and a brand's characteristic is predetermined, such that firm 1's product is located at 0 and firm 2's product is located at θ_H.[42]

Consumers have different preferences over the horizontal characteristic, and each consumer's type is identified by his or her ideal characteristic location (e.g., a car color that is either black, white, or a particular shade of gray). For simplicity, assume that preferences are uniformly distributed over the interval $[0, \theta_H]$. With only two brands, a white and a black car, consumers with preferences closer to 0 prefer brand 1 (a white car) and consumers with preferences closer to θ_H prefer brand 2 (a black car) when output prices are the same. The indirect utility function for a θ-type consumer is $U_1(\theta) = s - t_1\theta - b\, p_1$ when brand 1 is purchased and $U_2(\theta) = s - t_2\, (\theta_H - \theta) - b\, p_2$ when product 2 is purchased. Parameter s identifies a consumer's willingness to pay for an ideal product and is assumed to be large enough to assure that each consumer purchases either brand 1 or brand 2 (i.e., the market is covered). The t parameters capture the unit cost or disutility associated with purchasing a product that is less than

[42] Because our focus is on advertising, we ignore firm decisions regarding product characteristics. When two firms compete in a dynamic game of location choice and price competition, however, d'Aspremont et al. (1979) show that firms will locate at the two extremes of the characteristic space. See Tremblay and Polasky (2002) and Soberman and Parker (2004) for a discussion of how advertising may affect consumer perceptions of product location.

ideal. For example, the consumer at preference location $\theta = 0$ would receive no disutility from purchasing brand 1 (located at 0), because brand 1 is ideally located for this consumer. That same consumer would receive a total disutility of $t_2\theta_H$ when brand 2 is purchased, however. Notice that there is no product differentiation when $t_1 = t_2 = 0$ (i.e., utility does not depend on θ) and that product differentiation increases as these parameters increase.[43] Parameter b represents the disutility associated with a unit increase in the price. One could imagine, for example, that b is lower when consumers have greater brand loyalty or a low willingness to substitute one brand for another.

Firm demand depends on the location of the marginal consumer, θ_m, defined as the consumer who is indifferent between purchasing brands 1 and 2.[44] For this consumer, $U_1(\theta_m) = U_2(\theta_m)$, implying that: $\theta_m = (t_2\theta_H - b\,p_1 + b\,p_2)/(t_1 + t_2)$. Assuming each consumer purchases a single unit (i.e., unit demands), firm demand functions are:

$$D_1 = \theta_m = \frac{t_2\theta_H - bp_1 + bp_2}{t_1 + t_2}, \tag{4.1}$$

[43] As one referee pointed out, we could also set $t_1 = t_2 = t$ and let advertising influence a consumer's willingness to pay (i.e., $s_1 \neq s_2$). The comparative statics are unchanged by this modification. Allowing t rather than s to vary focuses attention on the impact of advertising on perceived product differentiation.

[44] The marginal consumer will have a positive utility when s_i is sufficiently large. To assure a duopoly market, θ_m must lie between 0 and θ_H, a condition that holds at the Nash equilibrium.

$$D_2 = \theta_H - \theta_m = \frac{t_1\theta_H + bp_1 - bp_2}{t_1 + t_2}, \tag{4.2}$$

where D_i represents quantity demanded for brand i. Ignoring advertising for the moment, firm i's profit equation is $\pi_i(p_1, p_2) = p_i\ D_i(p_1, p_2) - c_i(D_i)$, where c_i is total cost. In this stage of the game, assume that firms have complete information and compete by simultaneously choosing prices. Thus, Nash equilibrium prices are:

$$p_1^* = mc + \frac{(t_1 + 2t_2)\theta_H}{3b}, \tag{4.3}$$

$$p_2^* = mc + \frac{(2t_1 + t_2)\theta_H}{3b} \tag{4.4}$$

where mc is marginal cost.

With this result, we can now investigate how advertising influences Nash prices by influencing the primitives of the model. The simplest way to do this is to assume that firms play a multistage game of perfect and complete information by choosing advertising simultaneously in the first stage and price in the second stage.[45] Firms would use backwards induction to obtain the optimal level of advertising in a subgame perfect equilibrium by looking forward and basing their advertising decisions on the Nash

[45] Alternatively, if price and advertising are chosen simultaneously, then all first order conditions with respect to price and advertising would need to be solved simultaneously to obtain Nash equilibrium prices. In any case, the main conclusions of this section hold whether the model is static or dynamic.

equilibrium prices correctly anticipated in the last stage of the game. Advertising that changes the parameters of the model will have predictable effects on equilibrium prices as indicated in equations (4.3) and (4.4).

Assuming it is profitable to do so, the theory of advertising suggests that advertising may influence Nash prices in three ways. It may change tastes by increasing brand loyalty (lowering b), create a product image that increases perceived product differentiation (increasing t_1 and t_2), or it may inform people of a product's existence (increasing θ_H). In this model, all conditions of supermodularity are met when: (1) advertising increases brand loyalty (lowering b), (2) advertising increases perceived product differentiation (increasing t_1 and t_2), or (3) advertising attracts new people to the market (increasing θ_H). Thus, these forms of advertising will increase Nash equilibrium prices.

Graphically, a game is supermodular when changes such as these cause each firm's best reply functions to shift away from the origin. This can be seen in Figure 4.1, which plots the best reply functions with respect to price for each firm (BR_1 and BR_2) and identifies the Nash equilibrium prices (p_1^*, p_2^*) where the best reply functions intersect. As the figure indicates, advertising will move the intercepts of the best reply functions away from the origin and raise Nash equilibrium prices when advertising lowers b, raises t_i, and raises θ_H.[46] When advertising has the opposite effect (e.g., it lowers brand loyalty or reduces perceived differentiation), the structure of the model is not supermodular and advertising lowers Nash prices. In the simple Hotelling model, supermodularity is necessary and sufficient for advertising to raise prices, an outcome that is not true in the next example.

4.2.2 Duopoly with Vertical Product Differentiation

We now assume that the two brands are differentiated over a vertical characteristic. A good example of such a characteristic is product quality, indexed by z. As in the previous example, we assume that a product's characteristic is predetermined and that brand 1 is of higher quality, $z_1 > z_2 > 0$.[47] Consumer preferences for quality are identified by the taste parameter ϕ, which varies by consumer and is uniformly distributed over the interval $[\phi_L, \phi_H]$, where $0 < \phi_L < \phi_H$. Consumers with a higher ϕ have a stronger preference or willingness to pay for high quality goods.[48] Unlike the case with horizontal differentiation, consumers agree over the

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[46] Note that if marginal costs rise with output, advertising that increases production could also lead to higher prices. Alternatively, advertising that raises output could lead to lower prices if substantial scale economies exist, ceteris paribus. For the remainder of the paper, we ignore scale effects.

[47] See Wauthy (1996) and Tremblay and Martins (2001) for a discussion of duopoly models with vertical differentiation when product quality is endogenous.

[48] For example, a wealthier consumer will have a greater ability to pay and, therefore, may have a greater willingness to pay for high quality goods.

preference ordering of the vertical characteristic. That is, all consumers prefer brand 1 over brand 2 when $p_1 = p_2$. We use a Mussa and Rosen (1978) indirect utility function to model the preferences of a ϕ-type consumer: $U_i(\phi) = s + z_i \phi - bp_i$ when product i (1 or 2) is purchased. In our application, we assume that s is large enough to assure a covered market. As in the model with horizontal differentiation, b represents the disutility associated with a unit increase in the price.

Firm demand depends on the location of the marginal consumer, ϕ_m, the individual who is indifferent between purchasing products 1 and 2. For this consumer, $U_1(\phi_m) = U_2(\phi_m)$ when $\phi_m = (bp_1 - bp_2)/z$, where $z \equiv z_1 - z_2$ defines the degree of vertical product differentiation. Assuming that consumers have unit demands, firm demand functions are:

$$D_1 = \phi_H - \phi_m = \phi_H - \frac{bp_1 - bp_2}{z}, \tag{4.5}$$

$$D_2 = \phi_m - \phi_L = \frac{bp_1 - bp_2}{z} - \phi_L. \tag{4.6}$$

If costs are linear as in the previous model, then the Nash equilibrium prices in the model with vertical differentiation are:

$$p_1^* = mc + \frac{z\left(2\phi_H - \phi_L\right)}{3b}, \tag{4.7}$$

$$p_2^* = mc + \frac{z\left(\phi_H - 2\phi_L\right)}{3b}. \tag{4.8}$$

Now, if it is profitable to advertise, the model of vertical differentiation is supermodular when advertising increases the size of the market (increases ϕ_H - ϕ_L) but *not* when it raises brand loyalty (increases b) or raises the degree of product differentiation (increases z). Yet, Nash prices rise when advertising increases ϕ_H - ϕ_L, b, or z. It is quite clear from Figure 4.2, which plots the best reply functions for each firm, that prices rise when advertising increases ϕ_H - $\phi_{L.}$ It is less clear from the figure whether advertising that increases z and b increases or decreases Nash prices. For example, an increase in z raises the BR_1 intercept but lowers the BR_2 intercept. The net effect is for Nash prices to rise, however, because BR_1 shifts up by more than BR_2 shifts left. This demonstrates the limitation of supermodularity: advertising can raise prices in markets that are not supermodular.

To summarize, supermodularity defines a set of market and advertising conditions that assure a positive relationship between advertising and price in an imperfectly competitive market. An exogenous shock that increases advertising will unambiguously raise equilibrium prices when two important conditions are met: (1) A firm's own advertising and price are complements, which occurs when advertising and price are complements in the firm's demand function and when an increase in advertising does not lead to lower marginal costs, and (2) advertising and price are strategic complements among competitors.

The strategic complementarity condition is the most difficult to interpret. It will hold when one firm's advertising increases each competitor's marginal returns to increasing price and advertising spending. This requires that advertising is constructive (i.e., a firm's advertising increases its own and its rivals' demand). As the model with vertical differentiation illustrates, however, supermodularity need not hold when advertising is purely persuasive or image creating (i.e., it increases brand loyalty or perceived differentiation), conditions normally associated with higher prices. This demonstrates that supermodularity provides sufficient but not necessary conditions for a positive relationship between advertising and price. In any case, models with both horizontal and vertical differentiation indicate that advertising will lower (raise) equilibrium prices when it reduces (raises) brand loyalty, perceived differentiation, and the marginal cost.

This explains why the advertising-price relationship is so complex and ultimately an empirical question. Given the difficulty of testing for supermodularity[49] and the fact that it provides only sufficient conditions, we proceed by developing an empirical model to directly estimate the

[49] Seldon et al. (1993) provide such a test for just one strategic variable, a firm's own and its rivals' advertising.

advertising-price relationship using data from the U.S. brewing industry. We then use the estimated model to predict the effects of advertising on the Lerner Index.

4.3 Empirical Tests of the Advertising-Price Relationship

In this section, we derive an empirical model to estimate the advertising-price relationship. We use firm level data from the U.S. brewing industry. This is a worthwhile industry to study, because it is imperfectly competitive and because advertising has played an important role in its development.[50]

One might expect advertising to increase prices in this industry because beer ads have persuasive and image enhancing elements. In their comprehensive consumer survey of over 1,800 consumers, for example, Bauer and Greyser (1968) find that consumers felt that only 4 percent of beer ads were informative. This market needs not be supermodular, however, as advertising that is persuasive and image-enhancing need not be consistent with supermodularity. In addition, most of the empirical evidence indicates that advertising has not increased market demand for beer during the sample period (Tremblay and Tremblay (2005)). Thus, the ultimate

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[50] For recent studies that discuss how advertising helped shape these industries, see Tremblay and Tremblay (2005; 2007).

answer is still uncertain.

We use demand and supply side equations to identify the important determinants of a firm's equilibrium price in an imperfectly competitive setting. Firm *i*'s inverse demand function is given by $p_i(q_i, A_i, q_{-i}, A_{-i}, \underline{x})$, where q_i is firm *i*'s output, q_{-i} is aggregate rival output, A_{-i} is aggregate rival advertising, and $\underline{x}$ is a vector of other relevant demand determinants. Following Bresnahan (1989) and Kadiyali *et al*. (2001), a firm's supply relation, which nests a range of possible equilibria, would take the following form: $p_i = mc_i + \lambda\ q_i$, where *mc* is marginal cost and λ is an unknown conduct parameter. Firm behavior is competitive when λ equals 0, and less competitive when λ > 0. Solving these two equations for the equilibrium price produces the following equation:

$$p_i = f\left(mc_i, A_i, q_{-i}, A_{-i}, \underline{x}; \lambda\right). \tag{4.9}$$

The right-hand side of (4.9) contains one non-exogenous variable, advertising. If advertising is pre-determined when price decisions are being made, we can estimate equation (4.9) using OLS. If advertising is determined simultaneously with price, then an instrumental variable (IV) approach is warranted. Thus, we estimate the models using OLS and IV estimators. In the empirical applications that follow, we assume that equation (4.9) can be accurately approximated by a linear specification.

4.3.1 The Advertising-Price Relationship in the Brewing Industry

We use data from the brewing industry. The sample consists of 467 observations of annual data from 36 macro brewers from 1950 through 2003.[51] Advertising is defined as the quantity of advertising messages per (31-gallon) barrel, measured as advertising expenditures per barrel divided by a price index of advertising. In addition to marginal cost, advertising, and the strategic variables of rivals, previous studies show that an important determinant of beer demand is the fraction of the population from 18 to 44 years old (Tremblay and Tremblay, 2005). We control for this with a demographics variable (*DEM*). Because national brands command a price premium over regional brands, a premium that may be due to differences in quality, a national dummy variable (D_N) is included in the model. This variable takes on the value of 1 when a firm markets its beer nationally and 0 otherwise. One concern with our sample is that the degree of competition may have changed over time. This is especially true in brewing, as the number of independent macro brewers declined from 350 to 21 from 1950

[51] We ignore the domestic specialty brewers, sometimes called micro or craft brewers, because price and marketing data are unavailable for these small firms. In any case, the craft sector is very small, accounting for less than 3.2 percent of domestic sales during our sample period, and craft style beer does not compete directly with the brands produced by the macro brewers, such as Budweiser, Miller Lite, and Coors Light.

to 2003. In spite of this rise in industry concentration, however, previous studies show that the beer market has remained competitive. For example, Tremblay and Tremblay (2005) find that firms with less successful marketing campaigns experienced a decline in demand and an increase in excess capacity. In response, many slashed prices in order to reduce excess capacity. To control for factors that may influence price competition, we include the Herfindahl-Hirschman index of industry concentration (*HHI*) and the firm's capacity utilization rate (*CUR*), defined as the firm's annual production divided its brewing capacity. The data and sources are more completely described in the Appendix.

The empirical results for the model described above are presented in the first two columns of Table 4.1. Because advertising may be predetermined or endogenous, we estimate the regression model using ordinary least squares (OLS) and the method of instrumental variables (IV). Following Greene (2003: 79-80), instruments for a firm's advertising include the exogenous price of advertising and all exogenous variables in the model from the current and the preceding period. The t-ratios listed in Table 4.1 are derived from estimates of the heteroskedasticity and autocorrelation consistent (HAC) covariance matrix (Davidson and

MacKinnon, 2004, p. 362).[52] Comparing estimates in columns (1) and (2), all of the parameters that are significantly different from zero have the same sign. Consistent with simple static models of price competition such as Bertrand, the marginal cost parameter estimate is close to one, not significantly different from one but significantly different from zero. An increase in the primary drinking age population (*DEM*) leads to a significant increase in price. Price falls significantly with rival output (q_{-i}). As expected, a lower capacity utilization rate (*CUR*) leads to significantly tougher price competition. Price competition appears to increase with industry concentration (*HHI*), a result that contradicts simple static models of oligopoly such as a Cournot model with *n* firms. In any case, the evidence is consistent with Tremblay and Tremblay (2005), who find that price competition has been tough in brewing. The national dummy variable (D_N) is small and insignificantly different from zero. This suggests that the model adequately captures quality differences between national and regional brands.

Finally, the results provide strong evidence that advertising is associated with higher beer prices. A firm's own advertising has a positive

[52] Breusch-Godfrey tests reveal fifth-order autocorrelation in the errors in the OLS and IV models. Due to the difficulty in accurately determining the appropriate weighting matrix for generalized least squares estimation, particularly for a fifth-order process, and due to the possibility of heteroskedasticity given the cross-section aspect of the data, we use the HAC estimator.

and significant effect on its own price. Rival advertising is insignificant. The net effect of a firm's own and its rivals' advertising is always positive, however, indicating that advertising raises prices in the U.S. brewing industry.

To control for possible dynamic effects missing in the model, we consider an alternative specification which appends a squared time trend variable (T^2) to the original model. The estimated OLS and IV parameters of this specification appear in columns (3) and (4) of Table 4.1, along with t-ratios derived from estimates of the HAC covariance matrix.[53] The parameter estimate on T^2 is marginally significant (at 10 percent) using OLS but insignificant using IV. Regardless of model specification or the estimation technique, own advertising has a positive and highly significant effect on price in the U.S. brewing industry.[54]

We conduct Hausman specification tests and find that the null hypothesis that OLS is consistent is rejected for the models with and without T^2. This indicates that the IV estimator is appropriate for these

[53] We find third-order autocorrelation for both the OLS and IV models that include T^2.

[54] We also investigate two additional specifications. Although previous research shows that consumer income has little or no effect on beer demand, we added per-capita disposable income to the model. Second, because the parameter on *HHI* is negative and because Tremblay and Tremblay (2005) speculate that concentration may have reached a critical level by 1996, we replaced *HHI* with a dummy variable that equals 1 for the 1996-2003 period and 0 otherwise. For both of these alternative specifications, OLS and instrumental variable estimation results confirm that firm advertising leads to significantly higher prices in brewing.

models. We also check for weak instruments by using the value of the F-statistic for the joint significance of the excluded variables in the first stage (the lagged exogenous variables and the price of advertising). The test-statistic in both models exceeds 10, indicating that weak instruments are not a cause for concern (Staiger and Stock, 1997). These tests support the IV findings that advertising significantly increases brewing industry prices.

To put these results into perspective, we next analyze how advertising has affected the Lerner index of market power. We compare its actual value, evaluated at sample mean values, with its predicted value when advertising increases by 1 percent.[55] As indicated in Table 4.2, actual Lerner Index estimates are close to 0, only 0.070 in the IV models. This is consistent with previous studies that find that the brewing industry has been relatively competitive. Based on IV model estimates, a 1 percent increase in advertising causes the Lerner Index to rise by 1.30 to 1.86 percent ($\%\triangle L$).[56] Because there is very little real difference in quality between the brands of beer produced by the macro brewers (e.g., Bud Light and Coors Light), these results suggest that the little market power exercised by the

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[55] That is, the new price is predicted from the regression model when advertising increases from its mean value by 1 percent, ceteris paribus.
[56] Given that our models are linear approximations of the true data generation process, this analysis is only valid for a marginal change in advertising.

U.S. macro brewers is likely due to advertising. This is consistent with the theoretical work by Tremblay and Polasky (2002) and Soberman and Parker (2004), who show that firms may use advertising in markets with little real product differentiation to avoid the Bertrand paradox of perfectly competitive pricing.

4.4 Conclusion

Our main goal has been to analyze the relationship between advertising and price in imperfectly competitive markets. Theoretical work on supermodular games provides a set of conditions that guarantee that advertising causes higher Nash prices. Advertising raises prices when a firm's own advertising and price are complements and when its advertising raises each of its rival's marginal returns to increasing advertising and price. These are only sufficient conditions, however, and advertising may still raise prices when one or more of these conditions are violated. For example, we show that for a duopoly with vertical differentiation, advertising that is purely persuasive or image creating need not support supermodularity even though it leads to higher prices. In the Hotelling model of duopoly with horizontal differentiation, however, we demonstrate that supermodularity is necessary and sufficient for persuasive, image creating or informative advertising to raise prices.

To further examine the advertising-price relationship, we develop an empirical model of prices in an oligopoly setting, and apply the model to firm level data from the U.S. brewing industry. This is a market where one might expect advertising to raise prices, as beer ads have been more persuasive and image enhancing than informative. Consistent with our expectations, we find that advertising raises prices and market power in this market. Because beer advertising raises market power, provides consumers with little information, and generates little or no positive externalities[57], our results suggest that advertising has been excessive from society's perspective.

[57] In fact, beer ads may produce negative externalities. That is, beer ads may encourage alcohol abuse. In this case, beer advertising would be excessive even if it had no effect on prices.

Table 4.1
Reduced form price equation estimates for the U.S. brewing industry

Independent Variables	(1) OLS	(2) IV	(3) OLS with T^2	(4) IV with T^2
Constant	-52.202***	-49.361***	-62.854***	-62.106***
	(8.017)	(6.569)	(6.851)	(4.769)
Marginal Cost	1.022***	0.998***	1.023***	0.980***
(mc)	(21.831)	(17.274)	(21.939)	(17.268)
Demographics	153.488***	157.863***	177.539***	196.246***
(DEM)	(8.499)	(6.202)	(6.688)	(4.269)
Capacity Utilization Rate	6.978***	7.362***	7.496***	8.745***
(CUR)	(4.367)	(3.979)	(4.327)	(3.402)
Herfindahl-Hirschman Index	-0.786***	-0.831***	-1.369***	-1.628***
(HHI)	(11.260)	(7.009)	(3.773)	(2.660)
Rivals' Output	-0.031***	-0.048***	-0.020	-0.050**
(q_{-i})	(2.072)	(1.984)	(1.479)	(1.714)
National Dummy	0.878	-0.086	0.857	-0.814
(D_N)	(0.873)	(0.076)	(0.837)	(0.529)
Own Advertising	1.281***	2.621***	1.287***	3.762***
(A_i)	(5.467)	(2.428)	(5.787)	(2.774)
Rivals' Advertising	0.065	-0.689	0.291	-1.065
(A_{-i})	(0.269)	(0.968)	(1.203)	(1.437)
Time-Squared			0.007*	0.009
(T^2)			(1.685)	(1.376)
R^2	0.951	0.943	0.951	0.931
F-Statistic	1118.37***	895.47***	987.81***	647.69***
Number of Observations	467	439	467	439

Notes: The absolute values of t-statistics are in parentheses, and are estimated from the heteroskedasticity-autocorrelation consistent covariance (HAC) matrix estimates. OLS represents ordinary least squares estimates and IV represents instrumental variables estimates. The number of observations is smaller in IV than in OLS because of lagged variables for instruments.

p-values: Statistical significance at 0.01 or better (***); between 0.01 and 0.05 (**); between 0.05 and 0.10 (*).

Table 4.2
Estimated Lerner indexes for the U.S. brewing industry

Model	L	L'	$\%\Delta L$
No Trend			
OLS	0.07226	0.07270	0.60344
IV	0.07004	0.07095	1.29603
With trend (T^2)			
OLS	0.07226	0.07270	0.60057
IV	0.07004	0.07134	1.85960

Notes: $L = \left(\overline{P} - \overline{AC}\right)/\overline{P}$, where $\overline{P} = \frac{1}{T \cdot N}\sum_t \sum_n P_{t,n}$, and $\overline{AC} = \frac{1}{T \cdot N}\sum_t \sum_n AC_{t,n}$, $L' = \left(P' - \overline{AC}\right)/P'$, where P' is a predicted price evaluated at means of independent variables except advertising, which is increased by 1%. $P_{t,n}$, and $AC_{t,n}$ are firm n's price and average costs in year t, respectively. T is the total time period, and N is the total number of firms in our sample. $\%\Delta L = \left(L' - L\right)/L \times 100$, where L and L' are measured to the 5th decimal place.

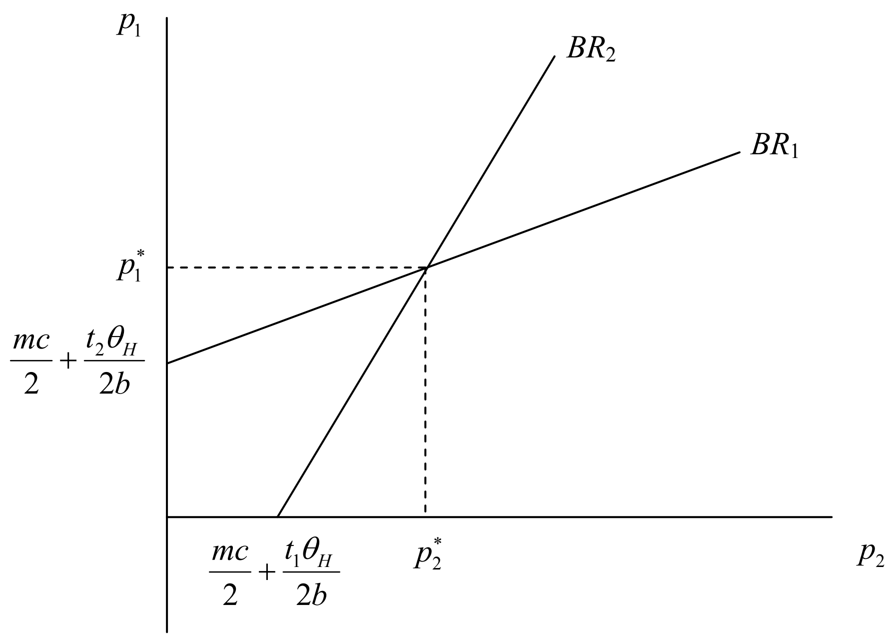

Figure 4.1: Best Reply Functions, Horizontal Product Differentiation.

Note: The slope of BR_2 equals 2, and the slope of BR_1 equals 1/2.

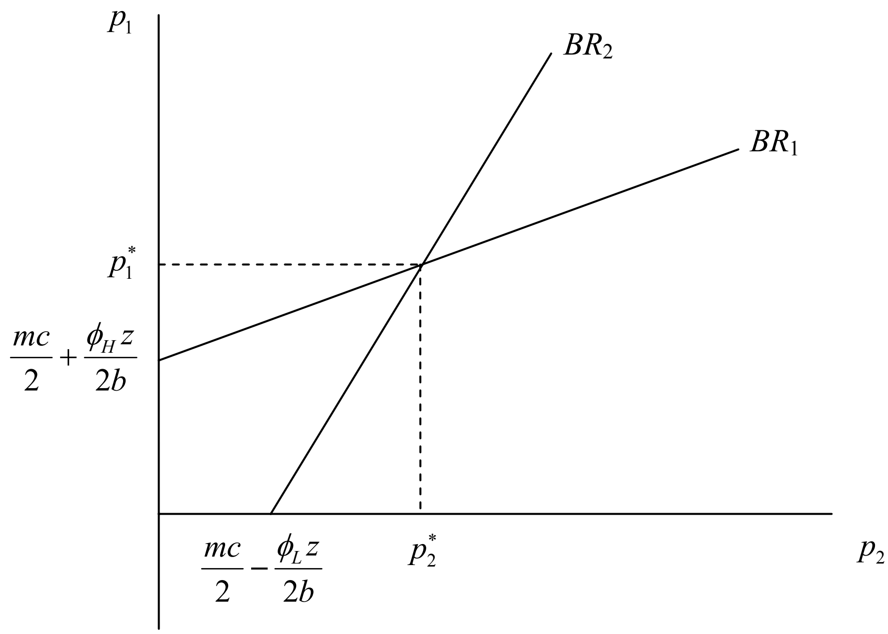

Figure 4.2: Best Reply Functions, Vertical Product Differentiation.

Note: The slope of BR_2 equals 2, and the slope of BR_1 equals 1/2.

Appendix

Data Description and Sources

Firm level beer data include 467 observations of 36 firms from 1950 through 2003. These data derive from a variety of sources. For a complete description and a copy of the data, see Tremblay and Tremblay (2005). The price is measured as a firm's total revenue from the sale of beer divided by its total output. Rival output (advertising) is defined as industry output minus firm *i*'s output (advertising). Marginal cost is approximated by average production cost. Except for differences in capacity utilization rates, which are accounted for in the model, this approximation will be accurate since the macro brewers generally produce at a large enough scale to reach constant returns to scale. To estimate the Herfindahl-Hirschman index, we use the actual output data from the largest 100 brewers. Output data for the remaining brewers are very small and are assumed to be equal.

The Consumer Price Index, the Producer Price Index, and population data are obtained from the *Statistical Abstract of the United States*. The advertising cost index for the years 1950-1959 is obtained from Schmalensee (1972); for the years 1960-2003, the index is obtained from Universal McCann Inc., 622 Third Avenue, New York, NY 10017. Advertising expenditures are deflated by the advertising cost index.

Chapter 5

General Conclusion

In this project, we analyze lobbying, brand and generic advertising, and the advertising-price relationship in imperfectly competitive markets. In Chapter 2, we investigated socially beneficial lobbying conducted by firms in monopoly and duopoly markets. In Chapter 3, we analyze the effect of generic advertising on the level of the firm's brand advertising and profits in duopoly models with vertical and horizontal product differentiation and in a supermodular setting. In Chapter 4, we scrutinize conditions under which advertising raises price and then estimate the advertising-price relationship in the U.S. brewing industry using firm level data.

Lobbying for political favors has received considerable criticism in previous studies. However, in Chapter 2, we show that under a reasonable set of conditions firm lobbying intended to reduce an excise tax can be welfare improving. Also, it is shown that this type of firm lobbying will be undersupplied from society's perspective. Our analysis suggests that restricting all forms of lobbying may reduce social welfare.

In Chapter 3, we argue that a low quality firm will not advertise to promote its brand and is more likely to gain than a high quality firm from generic advertising. On the other hand, in a market with horizontally differentiated products, it was shown that both firms advertise to promote their brands and that a symmetric outcome on the effect of generic advertising on brand advertising and profits is more likely.

These two models of product differentiation analyze duopoly markets. We investigate the effect of generic advertising in the case of *n* firms by applying supermodularity and find that the relationship between generic advertising and brand advertising is clear when firms play a supermodular game. In this setting, regardless of the type of product differentiation, increases in the generic advertising may induce firms to increase their expenditures on brand advertising.

In Chapter 4, we argue that supermodularity is a sufficient but not necessary condition for advertising to raise price by examining conditions of supermodularity in markets with vertically and horizontally differentiated products. We show that while the conditions hold in a market with horizontal product differentiation, the conditions do not hold in a market with vertical product differentiation. However, advertising can still raise price in both markets.

To investigate the advertising-price relationship empirically, we estimate a reduced form price equation. Our empirical results show that advertising raises price and is oversupplied in the U.S. brewing.

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