The effect of Advertising on Collusion in the U.S. brewing industry: a trigger strategy approach

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February, 2011

Abstract: In response to dramatic reduction in the number of firms and enormous advertising expenditures in the U.S. brewing industry, we explore the effect of advertising cooperativeness on collusion likelihood. With advertising and pricing as strategic variables, we analyze an infinitely repeated symmetric game and model the degree of collusion through the trigger strategy. It is illustrated that the degree of advertising cooperativeness can decrease the critical discount factor above which collusion is sustainable by trigger strategies, and thus can support collusion, while predatory advertising is likely to break the collusion. The results may help to fill the gap between the empirical evidence and theoretical prediction about the advertising and the likelihood of collusion. We show that there could be more cooperative advertising when the degree of advertising cooperativeness is high, and we conjecture the advertising in the U.S. Brewing industry is more of the cooperative type.

Keywords and phrases: Advertising, collusion, trigger strategy, brewing industry.

JEL Classifications: L11, L13, L66.

1 Introduction

One striking feature in the U.S. brewing industry is that the number of independent mass beer producers decreased dramatically from 421 in 1947 to 24 in 2000. Tremblay and Tremblay (2005) conclude that "Today, beer production is concentrated in the hands of a few surviving firms: Anheuser-Busch, Coors, and Miller." The change in the concentration of an industry can have a profound effect on the behavior of firms and the economic performance of the market. As summarized in Tremblay and Tremblay (2005), there could be quite a few explanations for the change in industry concentration.

New technology change could increase the minimum efficient scale of production, so the firms that fail to adopt new technology might incur higher cost and exit the industry, thus comes the higher concentration level. However, the largest firms are much bigger than what is required by the minimum efficient scale (Kerkvliet et al. 1998). So the technology change might not explain all of the structural change. Advertising might play an important role in the industry concentration. For example, the industry average advertising expenditures per barrel for leading brands of beer generally exhibits an upward trend from 1977 to 2001, with the exception of the first half of 1990s as summarized in Table 7.7 of Tremblay and Tremblay (2005). Specifically, the advertising intensity of most premium brands rose and actually exceeded the industry average by the mid 1990s. Sutton (1991) provides analysis on the advertising. Advertising at national level could boost the demand for beer, which induces the producer to increase the production size under the antitrust merge constraint. Smaller producers can not afford large expenses on advertising, so lose the market share and respond by cutting price in order to avoid excess capacity. The competition drives small firms out of the market, and the initial huge sunk cost prevents potential entrants in the industry. The rising minimum efficient scale, the endogenous advertising, the huge sunk cost and tough price competition might contribute to higher concentration level. Although the above argument is consistent with the market evidence, the exact process, through which advertising determines the concentration, is not directly specified.

As mentioned in Martin (2002, page 134), "a sufficiently high level of concentration triggers the awareness of oligopolistic interdependence that allows joint- and single-firm exercise of market power." As concentration increases, or as N (number of firms) falls, the range of interest rates over which a trigger strategy will sustain noncooperative joint-profit maximization increase, which indicates more possibility of noncooperative collusion.

The U.S. brewing industry exhibits higher concentration level and simultaneously enormous advertising expenditure. One natural question to raise is whether the enormous expenditure is predatory or cooperative in nature (Friedman (1983)). Theory does not seem to offer a definite answer. On one hand, because the advertising expenditure is enormous and exhibits an upward trend, one might classify it as predatory. If firms are competing in advertising in order to gain a larger market share, there could be more advertising than needed, the famous advertising dilemma. But excessive predatory advertising is aiming at grabbing market share, so it might weaken the foundation of collusion. One the other hand, one would call the advertising cooperative, given the higher concentration level. If advertising is generating positive spillover, then firms are shunning the responsibility of advertising, which is costly. So the cooperative advertising, which could possibly contribute to more collusion, is far from enough from the viewpoint of joint-profit maximization.

In this paper, we explore the effect of advertising cooperativeness on the collusion possibility, and thus hope to shed light on the market structure and the nature of the advertising in the U.S. brewing industry. We analyze an infinitely repeated symmetric game and model the degree of collusion through the trigger strategy, with advertising and pricing as strategic variables. We show that the degree of advertising cooperativeness can decrease the critical discount factor above which collusion is sustainable by trigger strategies, and thus can support collusion, while predatory advertising is likely to break the collusion. Furthermore, there could be more cooperative advertising when the degree of advertising cooperativeness is high. We conjecture that the advertising in the U.S. Brewing industry is more of the cooperative type. Besides this introduction, we review the relevant literatures in section 2, model the oligopoly and the collusion in section 3, analyze the impact of the degree of advertising cooperativeness on collusion likelihood in section 4, and provide a numerical illustration and conclude in section 5.

2 Relevant Literatures

Symeonidis (2002) considers the implication of multiproduct firms for cartel stability in a horizontally differentiated market. Theoretical models predict that increase in product differentiation might help to sustain the collusion (Martin 2002), which is at odds with the empirical findings of Symeonidis (2001). Symeonidis (2002) addresses the inconsistency between theoretical predictions and empirical findings of the effect of market structure and product differentiation on the likelihood of collusion. Under quantity competition for given number of firms in the horizontally differentiated market, increase in the number of varieties produced by the firm will increase the critical discount factor, above which collusion through the trigger strategy is more possible. Thus, collusion could occur less frequently. Intuitively, when firm adds one more product which could compete equally with other products (not localized), the one period gain from staying in the cartel is dominated by the defection benefit, as cartel member is only rewarded equally. The inconsistency could be resolved by observing that the number of varieties has opposite effect on the critical discount factor from product differentiation and number of firms. The prediction of the model is consistent with the fact that for highly concentrated advertising-intensive consumer good industries, less price fixing could be expected, as these are typical examples of differentiated product industries with multiproduct firms.

Pharmaceutical industry undergoes important changes in the past years, which include international regulatory harmonization, controlled health care costs for aging population, and increased innovation cost. Given above structural changes together with increased toughness in competition and huge cost in advertising and R&D, Matraves (1999) predicts higher concentration level only at global level. The competitive mechanism is consistent with Sutton (1991) approach, with advertising, research and development (R&D) entering the model endogenously. Analysis in Matraves (1999) further shed light on why the pharmaceutical industry is relatively fragmented at national level or even EU level, with high advertising and R&D spending.

It is argued that the pharmaceutical industry could be properly characterized as type 2 low α industry, which follows the "proliferate mechanism." Type 2 market has vertically differentiated product and α is the unit cost of investing in quality. The firms usually invest in R&D across many technologies, and correspondingly, the substitutability is lower. α is likely to remain constant as escalation in one research project might not drive massive firms out of the market, so the concentration is not escalated with huge spending in advertising and R&D.

Cubbin (1983) cites the idea from Stigler (1964) that any profit maximizing groups will try to achieve a collusive solution, and the threat to the collusion is from the tendency to chisel (secretly cut the price). The underlying problem is on information, that is, how and how fast the cheating will be discovered and punished. It is argued that there exists a probability p that the cheating will be discovered and punished with lower profit. The higher p, which is called the degree of apparent collusion, the more possible to maintain the collusion, so it is a convenient way to characterize the oligopoly outcome. Friedman (1983) provides a complete analysis for N-firm, infinite horizon, and differentiated product oligopoly market characterized by noncooperative behavior, with quantity and advertising as strategic variables. He treats advertising as accumulative capital, which has some effect lasting into the future. He classifies advertising as predatory or cooperative by a parameter in his demonstration through a linear model, and he proves also the existence and uniqueness of the Nash equilibrium.

As it is well known that for search good, it is a good idea to provide informational advertising to concisely describe the characteristics of the good in advance (Martin (2002)). However, in the case of beer, it does little good to be told what the beer content would be beforehand. Beer must be bought and tasted. Correspondingly, advertising contains little information, if there is any. For the experience good, it is recognized advertising is a signal of product quality, not information. Even though advertising is a signal, it does influence people's utility. Symeonidis' (2002) analysis provides a good framework for analyzing effect of advertising on collusion. According to Matraves (1999), one might attempt to say the U.S. brewing industry is of high α, however, how the advertising determines collusion is still not clear.

Inspired by the above literatures, I attempt to analyze the effect of advertising on collusion in the oligopoly market. Instead of using the terminology of informational or persuasive advertising, I would like to use the predatory or cooperative advertising (as in Friedman 1983) to capture the effect on cooperation. Intuitively, predatory type advertising will serve as the "chisel" in Cubin (1983), and it is predicted that it will reduce the degree of collusion. However, cooperative advertising enlarges the pie in the market, thus possibly enhancing the collusion. In next section, I characterize the collusion in the oligopoly market where advertising and pricing are the strategy variables by the trigger strategy (Friedman 1971), and illustrate the effect of degree of advertising cooperativeness on collusion through the critical discount factor.

3 A Model of Oligopoly and Collusion

Consider an industry with $N(N \geq 2)$ firms, and each firm produce one product. Each product is offered by exactly one firm, and thus the total number of products offered in the market is N. The firms' interaction is modeled as an infinitely repeated discrete period game. Firms decide noncooperative price and advertising level simultaneously. We take N as given and do not consider sunk cost, or assume that they have been determined prior to the game. The assumption is consistent with the fact that entry into this industry is long run decision, so in the short run, price and advertising are easier to change than N or the sunk cost. The symmetric firm structure will be considered in this paper as asymmetric case is difficult to analyze in the context.

The utility function for each consumer is a standard quadratic utility function

$$U = \sum_i (aq_i - \frac{1}{2}bq_i^2 + \alpha q_i A_i) - b\theta \sum_i \sum_{l \neq i} q_i q_l + \alpha\phi \sum_i \sum_{l \neq i} q_i A_l + m \tag{1}$$

where the sum is across different products or firms, q_i is the quantity for firm i, and for total income Y, $m = Y - \sum_i p_i q_i$ denotes the expenditures on goods from outside products. So we ignore the income effects on the industry and perform only partial equilibrium analysis. The utility function has been considered by, among others, Symeonidis (2002), Sutton (1997) and Martin (2001). The parameter $\theta \in [0,1]$ could be considered as some type of product differentiation parameter. When $\theta = 0$, the products are independent. $\theta = 1$, they are perfect substitutes. The smaller θ, the larger the degree of product differentiation. The difference of (1) from Symeonidis is that the advertising enters the utility function. A_i is the stock of advertising goodwill enjoyed by firm i at certain time period, and it is generally determined by past and current advertising. Given that we only observe the actual level or expenditure on advertising, we let A_{it} to be the current period advertising level by firm i, which depends on the goodwill stock at the current and past periods. The quadratic function assumption is restrictive, however, the aim of this paper is to illustrate the effect of advertising on collusion and the linear demand function produced by the utility function simplifies the analysis of the model and facilitates the comparative statics arguments.

Differentiating the utility function and introducing time period $t = 1, 2, 3, ...$ to the above model, we obtain the consumer's inverse demand for good $i = 1, ..., N$,

$$P_{it} = a + \alpha(A_{it} + \phi \sum_{j \neq i} A_{jt}) - b(q_{it} + \theta \sum_{j \neq i} q_{jt}), \tag{2}$$

where $a > 0$, $b > 0$, so we have a negatively sloped demand function, and $\alpha > 0$ so that advertising by firm i will push up the price of i product. This is also the inverse demand appeared in Martin (2002, page 293) and Friedman (1983). So the price for firm i at period t is P_{it}, output q_{it}, and advertising level A_{it}. Then the strategy for the firm i is σ_i, which is composed of the sequence P_{it} and A_{it}, $\sigma_i = (P_{i1}, A_{i1}; P_{i2}, A_{i2}; ...)$. The total profit for firm i at time t is

$$\pi_i(P_t, A_t) = P_{it} q_{it}(P_t, A_t) - C(q_{it}) - C(A_{it}) \tag{3}$$

Let $\sigma = (\sigma_1, ..., \sigma_n)$, and the discount parameter be $\delta_i \in (0,1)$. So the firm's objective is to maximize the sum of discounted profit

$$G_i(\sigma) = \sum_{t=1}^{\infty} \delta_i^{t-1} \pi_i(P_t,\, A_t) \tag{4}$$

The noncooperative Nash equilibrium of the game described above exists, as in Friedman (1983). $C(A_{it})$ is required to be nonnegative, strictly increasing, twice continuously differentiable and convex on $\Re_+$. So the higher the level of A_{it}, the higher the cost, and marginal cost is nondecreasing as output increases. We pick $C(A_{it}) = A_{it}^2$, which easily satisfies the requirement. In the case of production cost, we assume constant return to scale for simplicity. So $C(q_{it}) = cq_{it}$.

The interesting advertising parameter when firms are competing in quantity is $\phi = \frac{\frac{\partial P_{it}}{\partial A_{jt}}}{\alpha}$. If we assuming $\alpha > 0$, or firm i's advertising drives up the its own price, then $\phi > 0$ is interpreted as cooperative in Friedman (1983), as the externality is positive and the advertising of one will benefit all, irrespective of which firm is undertaking advertising. The typical example is in the milk industry, in which oblivious consumers expand their consumption in general after seeing the advertisement. However, if $\phi < 0$, it is regarded as predatory advertising as the size of the market is not enlarged, but the allocation of the share is influenced. Here, since we consider the firms compete in price instead of quantity, we determine the advertising parameter which can control the degree of cooperative or predatory advertising in this set-up.

By inverting the system of N equations in (2) for fixed t, we obtain the expression of demand of good i at time t:

$$\begin{aligned} q_{it} = \quad & \frac{(a-P_{it})[1+\theta(N-2)]-\theta\sum_{l\neq i}(\alpha-P_{lt})+\alpha[1+\theta(N-2)](A_{it}+\phi\sum_{l\neq i}A_{lt})}{b(1-\theta)[1+\theta(N-1)]} \\ & -\frac{\alpha\theta\sum_{j\neq i}[A_{jt}+\phi\sum_{l\neq j}A_{lt}]}{b(1-\theta)[1+\theta(N-1)]}. \end{aligned} \tag{5}$$

The above expression can be simplified as

$$q_{it} = \beta_1 - \beta_2 P_{it} + \beta_3 \sum_{l\neq i} P_{lt} + \beta_4 A_{it} + \beta_5 \sum_{l\neq i} A_{lt}, \tag{6}$$

where

$$\begin{aligned} \beta_1 &= \frac{a[1+\theta(N-2)]-(N-1)\theta\alpha}{b(1-\theta)[1+\theta(N-1)]} \\ \beta_2 &= \frac{1+\theta(N-2)}{b(1-\theta)[1+\theta(N-1)]} \\ \beta_3 &= \frac{\theta}{b(1-\theta)[1+\theta(N-1)]} \\ \beta_4 &= \frac{[1+\theta(N-2)-(N-1)\theta\phi]\alpha}{b(1-\theta)[1+\theta(N-1)]} \end{aligned}$$

$$\beta_5 \quad = \quad \frac{\alpha(\phi-\theta)}{b(1-\theta)[1+\theta(N-1)]}$$

It is easy to see that β_1, β_2 and β_4 converge to a constant, and β_3 and β_5 converge to zero, as N approach infinity. The results are expected since as more competitors appear, the impact from other competitors (β_3 and β_5) is getting smaller. By normalizing the above demand function and the cost function for advertising using β_4, we obtain the following model for price and advertising setting game. Let

$$u=\frac{c\beta_2+\beta_1}{\beta_4},\quad b_1=-\frac{\beta_3}{\beta_4},\quad w=\frac{\beta_5}{\beta_4},\quad \delta_0=\frac{2}{\beta_4},\quad a_1=\frac{2\beta_2}{\beta_4},\quad \beta_0=-\frac{c\beta_1}{\beta_4},$$

$$\begin{array}{rl} q_{it} & = -\frac{\beta_0}{c}-\frac{a_1}{2}P_{it}-b_1\sum_{l\neq i}P_{lt}+A_{it}+w\sum_{l\neq i}A_{lt} \\ c(q_{it}) & = cq_{it}, c(A_{it})=\frac{\delta_0}{2}A_{it}^2 \\ \pi_{it} & = \beta_0+uP_{it}-\frac{a_1}{2}P_{it}^2-b_1(P_{it}-c)\sum_{l\neq i}P_{lt}+P_{it}A_{it}+w(P_{it}-c)\sum_{l\neq i}A_{lt}-cA_{it}-\frac{\delta_0}{2}A_{it}^2. \end{array} \tag{7}$$

To capture the basic demand and cost feature, we let a_1, c, $\delta_0, u>0$, and $\beta_0<0$, since $u=-\frac{\beta_0}{c}+\frac{a_1c}{2}$. Furthermore we assume $b_1<0$ to represent the case that the increase in the price of the other goods will generally lead to increase in demand of own good. Here w plays the same role as ϕ in the game with quantity as strategic variable. If $w>0$, then increase in other firms' (or goods') advertising will increase firm i's profit, so advertising is cooperative, while $w<0$ indicates predatory advertising in the market. For reasonable advertising, we expect $-\frac{1}{n-1}<w<1$ so the impact of the predatory advertising will not go without bound.

We assume the firms are using the "grim" trigger strategies in the infinitely repeated symmetric game, that is, each firm is charging the collusive price and is applying the collusive advertising level each period as long as no defection has not occurred in the past, but switch to static Nash equilibrium forever once the deviation happens (Friedman 1971). Let π_i^B, π_i^C, π_i^D denote the Bertrand Nash equilibrium profit, the collusion profit and the deviation profit for firm i. Let $\delta_i\in[0,1]$ be the discount factor. Then it is known that collusion is sustainable as a subgame-perfect equilibrium of the game as long as

$$\sum_{t=0}^{\infty}\delta_i^t\pi_i^C>\pi_i^D+\sum_{t=1}^{\infty}\delta_i^t\pi_i^B.$$

So if we let δ_i^* be the critical discount factor, above is equivalent to

$$\delta_i \geq \delta_i^* = \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^B}. \tag{8}$$

We utilize the standard way for examining the impact of exogenous factors on cartel stability, that is, to calculate the comparative statics of the critical discount factor δ_i^*. Specifically, any factor that increases δ_i^* will make collusion less likely as collusion is sustainable for a smaller set of δ_i's.

4 Effect of advertising on collusion

Due to the quadratic utility structure and the symmetry in the firms, the model proposed above has an analytical solution for the price, advertising and profit. We derive them in the following three cases:

4.1 Competition case

When firms are competing with each other on both price and advertising, the advertising and price levels can be derived from the first order conditions on the profit in (7) with symmetric firms.

$$\begin{aligned}
\frac{\partial \pi_{it}}{\partial P_{it}} &= u - a_1 P_{it} - b_1 \sum_{l \neq i} P_{lt} + A_{it} + w \sum_{l \neq i} A_{lt} = 0, \\
\frac{\partial \pi_{it}}{\partial A_{it}} &= P_{it} - c - \delta_0 A_{it} = 0.
\end{aligned}$$

The above first order conditions for N firms can be represented by the matrix form:

$$\begin{aligned}
A &= \begin{bmatrix} -a & -b & \cdots & -b \\ -b & a & \cdots & -b \\ \vdots & \vdots & \ddots & \vdots \\ -b & \cdots & \cdots & a \end{bmatrix}, \\
B &= \begin{bmatrix} 1 & w & \cdots & w \\ w & 1 & \cdots & w \\ \vdots & \vdots & \ddots & \vdots \\ w & \cdots & \cdots & 1 \end{bmatrix}, \\
\begin{bmatrix} A & B \\ I & -\delta I \end{bmatrix} \begin{bmatrix} P_t \\ A_t \end{bmatrix} &= \begin{bmatrix} -u\underline{1} \\ c\underline{1} \end{bmatrix}.
\end{aligned}$$

This system of equations can be solved by inverting the above matrix. The results are

$$\begin{array}{rl} A_{it}^{BB} = & \frac{c[a_1+(N-1)b_1]-u}{[1+(N-1)w]-\delta_0[a_1+(N-1)b_1]} \\ A_{it}^{B} = & \max\{A_{it}^{BB}, 0\} \\ P_{it}^{B} = & \frac{u}{a_1+(N-1)b_1} + \frac{1+(N-1)w}{a_1+(N-1)b_1} A_{it}^{B} \end{array} \tag{9}$$

In order for the system of equations to have unique solutions, we need have the following restrictions:

$$\delta_0 > \frac{w}{b_1}, \quad \delta_0 > \frac{1-w}{a_1-b_1}, \quad \delta_0 > \frac{1+(N-1)w}{a_1+(N-1)b_1}. \tag{10}$$

The restrictions above have interesting interpretation. First, the last restriction above is more general, as it implies the first when N approaches infinity and the second when $N = 0$. Second, from the first order condition for profit maximization, we know that δ_0 satisfies $\frac{\partial \pi_{it}}{\partial A_{it}} = P_{it} - c - \delta_0 A_{it} = 0$. Thus, we could interpret δ_0 as the marginal increase in price that is necessary to compensate for additional unit of advertising. Since the firms are symmetric, from the other first order condition that

$$\frac{\partial \pi_{it}}{\partial P_{it}} = u - a_1 P_{it} - b_1(N-1)P_{it} + A_{it} + w(N-1)A_{it} = 0,$$

we observe a unit change in advertising level has two effect on $\frac{\partial \pi_{it}}{\partial P_{it}}$. The first is through the advertising level directly. Since advertising changes the quantity by $(1 + w(N-1))$ as in equation (7), the induced change on $\frac{\partial \pi_{it}}{\partial P_{it}}$ is also $(1 + w(N-1))$. The second is through δ_0. One unit change in price will change $\frac{\partial \pi_{it}}{\partial P_{it}}$ by $-(a_1 + (N-1)b_1)$, thus the second change from one unit change in advertising is $-\delta_0(a_1 + (N-1)b_1)$. So the restriction is equivalent to the marginal change in $\frac{\partial \pi_{it}}{\partial P_{it}}$ through advertising is negative, or the second order condition for profit maximization is satisfied.

We could obtain the following expressions for the effect of advertising cooperativeness on the equilibrium advertising and price levels:

$$\begin{array}{rl} \frac{\partial A_{it}^{B}}{\partial w} & = -\frac{[c[a_1+(N-1)b_1]-u](N-1)}{\{[1+(N-1)w]-\delta_0[a_1+(N-1)b_1]\}^2}, \\ \frac{\partial P_{it}^{B}}{\partial w} & = \frac{N-1}{a_1+(N-1)b_1} A_{it}^{B} + \frac{1+(N-1)w}{a_1+(N-1)b_1} \frac{\partial A_{it}^{B}}{\partial w}. \end{array} \tag{11}$$

By the restrictions imposed on parameters above, we could have $u > c[a_1 + (N-1)b_1]$ for A_{it}^B to be nonnegative, which implies $\frac{\partial A_{it}^B}{\partial w} > 0$ and $\frac{\partial P_{it}^B}{\partial w} > 0$. So the model predicts that the increase in the cooperativeness on advertising is contributing to the increment in advertising and price level. The profit level can be obtained by plugging A_{it}^B and P_{it}^B into equation (7). When N is large, $A_{it}^{BB} \to \frac{b_1 c}{w-\delta_0 b_1} < 0$, so when $c \neq 0$, $A_{it}^B = 0$. When $c = 0$, then $A_{it}^{BB} \to 0$ as the bottom expression in (9) goes to $+\infty$. As $N \to \infty$, $P_{it}^B \to 0$, which is the perfect competitive outcome when $c = 0$. The observation is consistent with intuition that as more competitors show up, individual firm reduces the advertising, and charges price at marginal cost level.

4.2 Collusion case

When firms are all colluding on price and advertising, it seems natural to assume the collusion involves maximization of joint profits for all N firms, since firms are symmetric. The first order conditions become

$$\begin{aligned}
\frac{\partial \pi_{it}}{\partial P_{it}} &= [u + b_1 c(N-1)] - a_1 P_{it} - 2b_1 \sum_{l \neq i} P_{lt} + A_{it} + w \sum_{l \neq i} A_{lt} = 0 \\
\frac{\partial \pi_{it}}{\partial A_{it}} &= (1 + w(N-1))P_{it} - c[1 + w(N-1)] - \delta_0 A_{it} = 0
\end{aligned}$$

The system of equations can be solved similarly,

$$\begin{aligned}
A_{it}^{CC} &= \tfrac{[1+w(N-1)][c[a_1+(N-1)b_1]-u]}{[1+(N-1)w]^2-\delta_0[a_1+2(N-1)b_1]}, \\
A_{it}^{C} &= \max\{A_{it}^{CC}, 0\}, \\
P_{it}^{C} &= \tfrac{u+b_1 c(N-1)}{a_1+2(N-1)b_1} + \tfrac{1+(N-1)w}{a_1+2(N-1)b_1} A_{it}^{C}.
\end{aligned} \tag{12}$$

Correspondingly, the restrictions are

$$\delta_0 > \frac{w[1 + w(N-1)]}{2b_1}, \quad \delta_0 > \frac{(1-w)(1 + w(N-1))}{a_1 - 2b_1}, \quad \delta_0 > \frac{(1 + (N-1)w)^2}{a_1 + 2(N-1)b_1}. \tag{13}$$

The restrictions have similar interesting interpretation. First, similar to the competition case, the last restriction above is more general. The restriction is also equivalent to that the marginal change in $\frac{\partial \pi_{it}}{\partial P_{it}}$ through advertising is negative. Second, we note the condition is true for a broader range of parameter values, given $b_1 < 0$ and $\delta_0 > 0$. From the first order conditions above, we notice δ_0, or the marginal increase in price that is necessary to compensate for additional unit of advertising, changes to be $1+w(N-1)$, instead of just 1 in the competition case. The additional term $w(N-1)$ comes from the profits function of the other firms under collusion. Thus, the effect of advertising on price could be much larger, if the advertising is of cooperative type, i.e., for $w > 0$.

Based upon the above conditions, we could sign the effect of advertising cooperativeness as

$$\begin{aligned}\frac{\partial A_{it}^C}{\partial w} &= \frac{(N-1)[c[a_1+(N-1)b_1]-u]\{[1+(N-1)w]^2-\delta_0[a_1+a_1(N-1)b_1]\}}{\{[1+(N-1)w]^2-\delta_0[a_1+2(N-1)b_1]\}^2} \\ &\quad \frac{-2(N-1)[1+w(N-1)]^2[c[a_1+(N-1)b_1]-u]}{\{[1+(N-1)w]^2-\delta_0[a_1+2(N-1)b_1]\}^2} > 0, \\ \frac{\partial P_{it}^C}{\partial w} &= \frac{N-1}{a_1+2(N-1)b_1}A_{it}^C + \frac{1+(N-1)w}{a_1+2(N-1)b_1}\frac{\partial A_{it}^C}{\partial w} > 0.\end{aligned} \tag{14}$$

When N is large, for $c \neq 0$, $A_{it}^{CC} \to \frac{wcb_1}{w^2} < 0$ for $w > 0$, so $A_{it}^C = 0$. If $c = 0$, the bottom of $A_{it}^{CC} \to \infty$, so $A_{it}^C = 0$. $P_{it}^C \to \frac{c}{2}$ for $c \neq 0$, while for $c = 0$, $P_{it}^C = 0$. Compared with result in competition case above, we observe the expected result that the collusion price is larger than competition price even when N is large.

4.3 Deviation case

In the case of deviation, we consider only the situation that all the other firms are holding their level of price and advertising at the collusive level. We derive the following first order conditions:

$$\begin{aligned}\frac{\partial \pi_{it}}{\partial P_{it}} &= [u - b_1(N-1)P_{it}^C + w(N-1)A_{it}^C] - a_1 P_{it}^D + A_{it}^D = 0, \\ \frac{\partial \pi_{it}}{\partial A_{it}} &= P_{it}^D - c - \delta_0 A_{it}^D = 0.\end{aligned}$$

The solution is

$$\begin{aligned}A_{it}^{DD} &= \frac{a_1 c - u + (N-1)[b_1 P_{it}^C - w A_{it}^C]}{1-a_1\delta_0}, \\ A_{it}^D &= \max\{A_{it}^{DD}, 0\}, \\ P_{it}^D &= \frac{u}{a_1} - \frac{(N-1)b_1}{a_1}P_{it}^C + (N-1)\frac{w}{a_1}A_{it}^C + \frac{1}{a_1}A_{it}^D.\end{aligned} \tag{15}$$

The only restriction on the parameters is $a_1\delta_0 > 1$, which shares similar interpretation as in competitive and collusive cases considered above. In the case of deviation, the sign of $\frac{\partial A_{it}^D}{\partial w}$ and $\frac{\partial P_{it}^D}{\partial w}$ can be determined to be positive easily with conditions above. Given $A_{it}^D > 0$, we have

$$\begin{aligned}\frac{\partial A_{it}^D}{\partial w} &= -\frac{N-1}{1-a_1\delta_0}A_{it}^C + \frac{N-1}{1-a_1\delta_0}[b\frac{\partial P_{it}^C}{\partial w} - w\frac{\partial A_{it}^C}{\partial w}] \\ \frac{\partial P_{it}^D}{\partial w} &= -\frac{(N-1)b_1}{a-1}\frac{\partial P_{it}^C}{\partial w} + \frac{N-1}{a_1}A_{it}^C + \frac{(N-1)w}{a_1}\frac{\partial A_{it}^C}{\partial w} + \frac{1}{a_1}\frac{\partial A_{it}^D}{\partial w}.\end{aligned} \tag{16}$$

So the signs of $\frac{\partial A_{it}^D}{\partial w}$ and $\frac{\partial P_{it}^D}{\partial w}$ can be determined to be positive when $[a_1 + (N-1)b_1]w > b_1$ in addition to the assumptions above. Thus, the higher the degree of advertising cooperativeness, the higher the deviation advertising level and price.

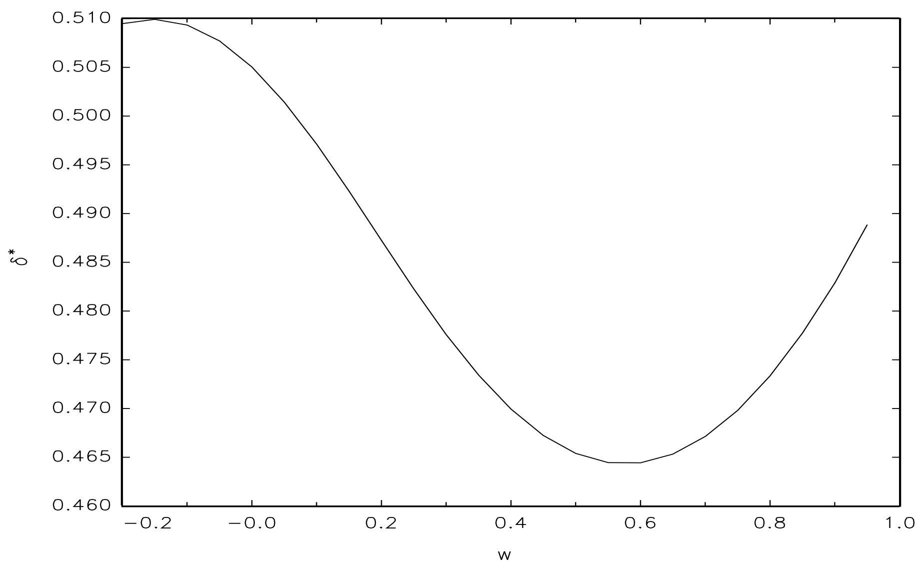
Based on the results above, one could obtain an analytic expression for the comparative statics on the critical discount factor defined in equation (8). However, as we will show in next section, the comparative statics depend on the advertising cooperative coefficient w and the number of firms N in a nonlinear fashion. Thus, we investigate the comparative statics results for w and N, and illustrate results obtained above numerically.

5 Numerical illustration and conclusion

To illustrate the effect of advertising cooperativeness on the degree of collusion, we assign some reasonable values to the parameters in the model (7), $\beta_0 = -6$, $c = 1$, $a_1 = 11$, $b_1 = -0.4$, $\delta_0 = 27$, $u = -\frac{\beta_0}{c} + \frac{a_1 c}{2} = 11.5$ for $N = 2, 3, ...10$, which satisfy the restrictions assumed in previous section. Because we assume $-\frac{1}{N-1} < w < 1$, we let w increase in this interval with step increment of 0.05. The assigned parameters correspond to the demand function in equation (7). Specifically, $-\frac{\beta_0}{c} = 6$ is the intercept of the demand, $-\frac{a_1}{2} = -5.5$ represents the marginal impact of own price on quantity demanded. $b_1 = -0.4$, so the other firms' product has a reasonable impact on the quantity. The assigned values of parameters satisfy the restrictions (10), (13) and obviously $a_1\delta_0 > 1$ for the deviation cases, which imply maximized profits in each case. Furthermore, the implied values of advertising level and price are positive. The corresponding graphs are provided in Figures 1-5.

Figure 1 shows the impact of w on the critical discount factor δ^*. The larger the critical discount factor, the less likely collusion will happen. As we expected, the higher the degree of predatory advertising ($w < 0$ and large in absolute value), the larger the critical discount factor, thus the collusion is less likely to happen. On the other hand, the higher the degree of advertising cooperativeness ($w > 0$ and larger), the more likely to incur collusion. However, there is a threshold at $w = 0.6$, beyond which it is harder to maintain the collusion. One explanation might be that when the degree of advertising cooperativeness is high, the deviation temptation in terms of deviating profit is large as well (see also Figure 4). This might contribute to the breaking down of collusion.

FIGURE 1: IMPACT OF w ON δ^* WHEN $N = 5$.



Figures 2-4 demonstrate the impact of w on advertising level, price and profit. As shown in the comparative static results, the increase in w could contribute to higher level of advertising and price. The figures show also that profit can be increased too. In Figure 2 when $w > 0$, the larger the value of w, the more collusive advertising. Furthermore, the collusive advertising level could be much higher than those in competition and deviation, which are close to a constant. However, when the advertising is of predatory type, i.e., $w < 0$, the competition and deviation advertising levels are higher than collusion advertising. Figure 3 demonstrates the impacts of w on the price change. We observe that collusive price level is higher than competing or deviating price. In Figure 4, we find the expected result that deviation profit is higher than that of collusion, followed by that of competition.

Figure 2: impact of w on advertising level when $N = 5$.

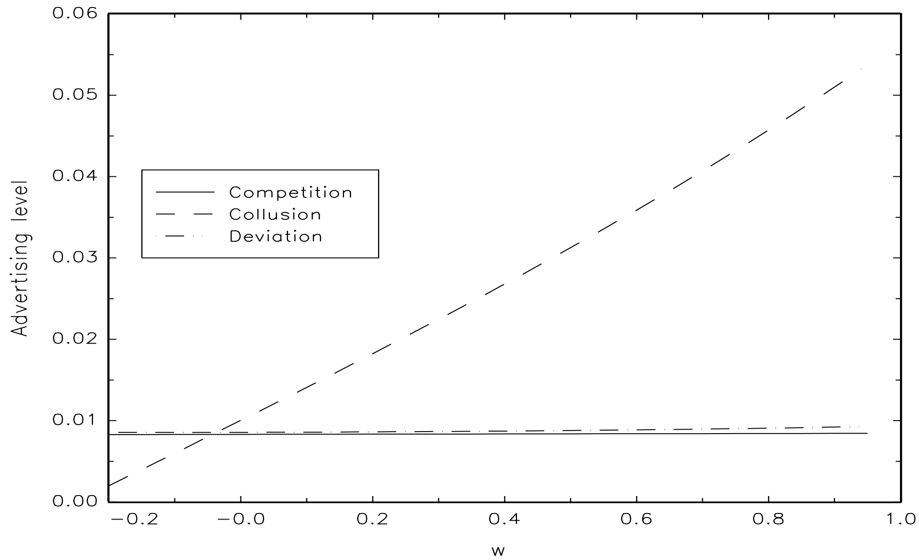


Figure 3: impact of w on price when $N = 5$.

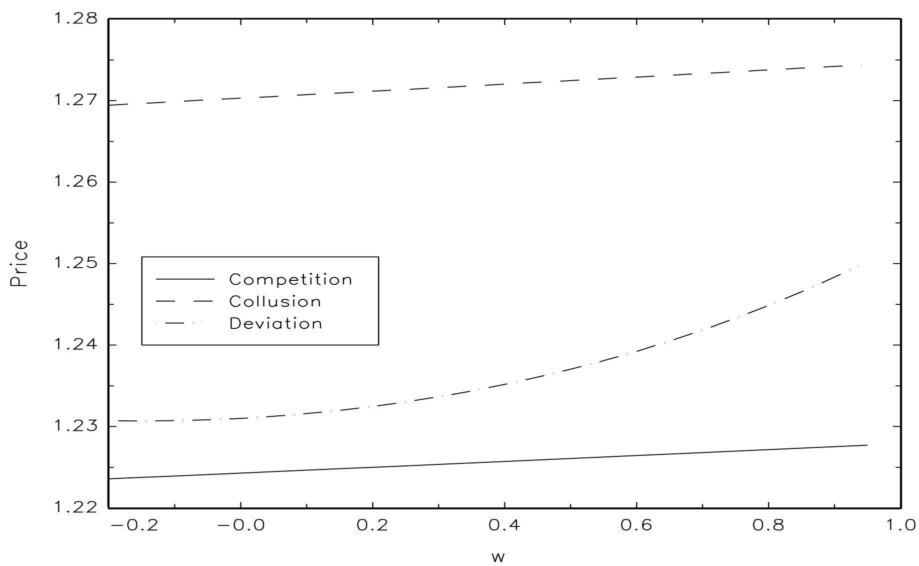
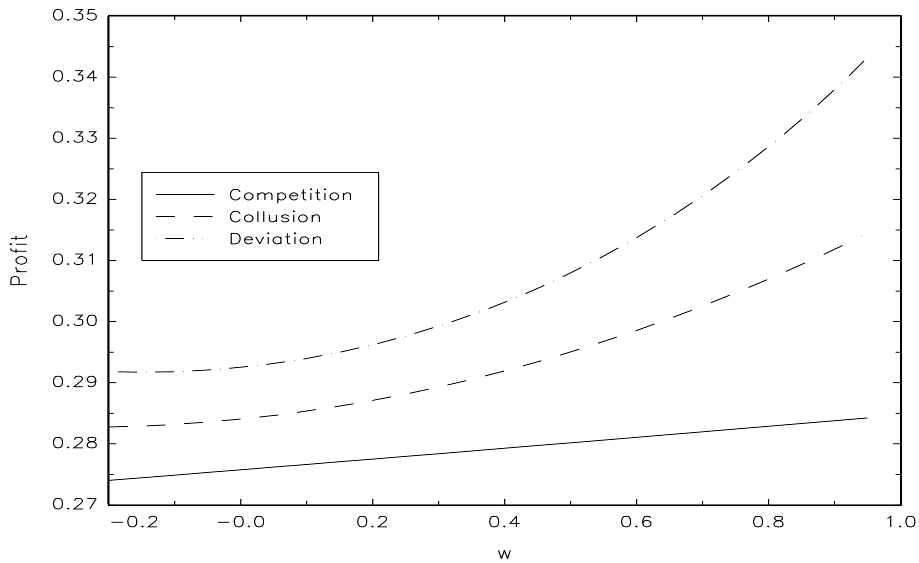
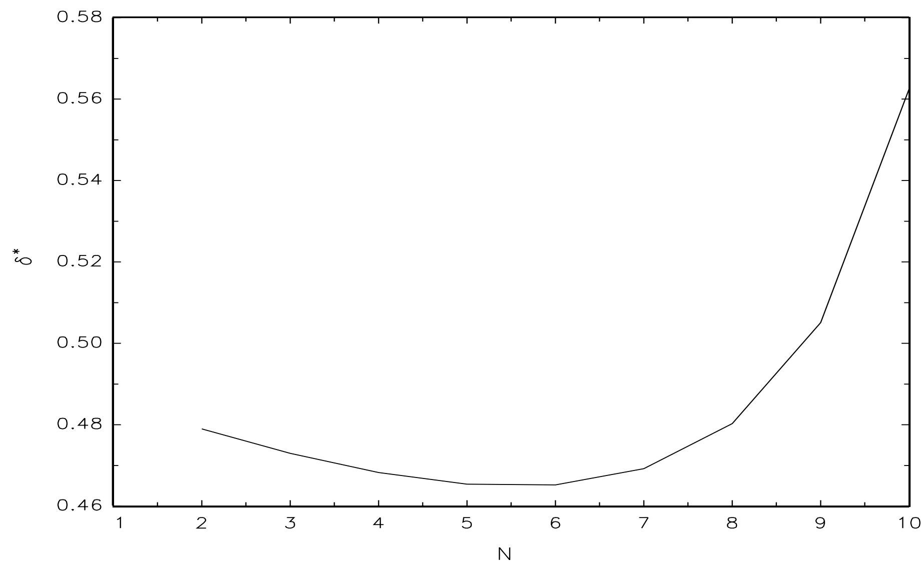


FIGURE 4: IMPACT OF w ON PROFIT WHEN $N = 5$.



When I vary the number of firms from $N = 2$ to $N = 10$, we obtain graphs of similar pattern. Figure 5 illustrates the impact of the number of firms on the collusion possibility. As symmetric firms are assumed in our analysis, when N is small, increase in N might expand the market size or explore the benefit from labor specialization, thus it is more likely to maintain some level of collusion. As we could infer, large N (for $N > 6$) will lead to deviation of collusion.

Figure 5: impact of N on δ^* when $w = 0.5$.



To summarize, we model the degree of collusion among symmetric firms through trigger strategy, with advertising and pricing as strategic variables. We illustrate that the degree of advertising cooperativeness can decrease the critical discount factor above which collusion is sustainable by trigger strategy, so it can support collusion. Furthermore, there could be more collusion advertising than competition or deviation advertising. Predatory advertising, on the other hand, is likely to break the collusion. Since U.S. brewing industry is characterized by higher concentration level and enormous advertising spending, we conjecture that the advertising is more of the cooperative type.

References

1. Cubbin, J.,1983, Apparent Collusion and Conjectural Variation in Differentiated Oligopoly, *International Journal of Industrial Organization* , 1,122-163.

2. Elzinga, K. G., 1982, The Beer Industry, *The Structure of American Industry* , 6th ed., ed. by W. Adams, New York, Macmillan.

3. Friedman, J.W., 1971, A Non-cooperative Equilibrium for Supergames, *Review of Economic Studies* , 38(1), 1-12.

4. Friedman, J.W., 1983, Advertising and Oligopolistic Equilibrium, *Bell Journal of Economics*, 14(2), 464-473.

5. Greer, D. F., 1970, Product Differentiation and Concentration in the Brewing Industry, *Journal of Industrial Economics* , vol. 18, 201-219.

6. Greer, D. F., 1981, The Causes of Concentration in US Brewing, *Quarterly Review of Economics and Business* , vol. 21, 87-106.‘

7. Kerkvliet, J., W. Nebesky, C. H. Tremblay, and V. Tremblay, 1998, On the Measurement of Efficiency and Technological Change: US Brewing, *Journal of Productivity Analysis,* vol. 10, 271-288.

8. Martin, S., 2002, Advanced Industrial Economics, 2nd Edition, Blackwell Publishers Inc..

9. Matraves, C., 1999, Market Structure and Advertising in the Pharmaceutical Industry, *The Journal of Industrial Economics* , XLVII, 169-194.

10. Stigler, G.J., 1964, A Theory of Oligopoly, *Journal of Political Economy* , 52, 44-61.

11. Sutton, J., 1991, *Sunk Costs and Market Structure: Price Competition, Advertising and the Evolution of Concentration.* , MIT Press.

12. Sutton, J., 1997, One Smart Agent, *Rand Journal of Economics,*28, 605-628.

13. Symeonidis, G., 2001, The Effects of Competition, MIT Press, Cambridge, MA.

14. Symeonidis, G., 2002, Cartel Stability with Multiproduct Firms, *International journal of Industrial Organization* , 20, 339-352.

15. Tremblay, V. J., and C. H. Tremblay, 2005, The U.S. Brewing Industry: Data and Economic Analysis, Cambridge, MA: The MIT Press.