Advertising Efficiency and the Choice of Media Mix: A Case of Beer*

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This version: August 18, 2003.

Abstract:
In this paper we use techniques from the efficiency measurement literature to evaluate the performance of six U.S. beer firms in terms of their ability to translate advertising messages into sales. We employ quarterly data from the 1983-1993 period. Our results suggest that Anheuser-Busch was relatively efficient in its advertising and its choice of media mix, whereas most of the other firms in our sample were not.

*Thanks to Kumiko Okuyama for her patience and care with the empirical work. Thanks to Carol Tremblay; two anonymous referees; Steve Martin, editor; and our discussant, Douglas J. Young, at an Industrial Organization Society session at the 2001 Western Economic Association Annual Conference for helpful comments.

1 Introduction

Economic efficiency is closely linked to firm success and industry competition. Competition disciplines inefficient firms, while market power may enable firms to pursue goals other than profit maximization. To maximize profit requires both production and marketing/advertising efficiency. However, most productivity studies focus on the production side of the firm. This is unfortunate since firm performance in many consumer goods industries hinges on marketing and advertising as well as production success. In the U.S. brewing industry, for example, industry experts claim that advertising is 'much more important' to firm success than production [Scherer et al. (1975, p. 258)]. In addition, Sutton (1991) and Tremblay and Tremblay (forthcoming) find empirical evidence that advertising spending has raised sunk costs and industry concentration in brewing.

To the extent that advertising is more art than science when compared to production, one might also expect greater variability in productivity on the marketing side of the firm. Such variability may explain the dramatic differences in advertising intensities among firms within an industry. For example, in 2001 Gateway Computer's advertising-to-sales ratio was over three times that of the Dell Computer Company, and the advertising-to-sales ratio at Coors was over three times that of the Anheuser-Busch Brewing Company [*Advertising Age* web site at http://adage.com/dataplace/Ina/index.html]. This is even more evident in many consumer goods industries where heavily advertised national brands compete with generic counterparts that are advertised very little if at all [Scherer and Ross (1990, p. 581)].

Much of the research on the economics of advertising is based on the work by Dorfman and Steiner (1954) and Becker and Murphy (1993), which derive a firm's optimal quantities of output and advertising. Empirical examples using firm data that are based on this approach include Roberts and Samuelson (1988), Seldon and Jung (1993), and Slade (1995). This work assumes that it is appropriate to aggregate advertising expenditures from different media. This is inappropriate, however, if the marginal benefit of advertising differs for television, radio, and print advertising, for example.

There is a limited body of research that focuses on advertising by media. For example, Bresnahan (1984) and Seldon et al. (2000) find a high degree of substitutability

among television, radio and print advertising in the U.S. brewing industry. Silk et al. (2002) find weak substitutability as well as weak complementarity among various media. Ackoff and Emshoff (1975a and 1975b) analyze the effectiveness of advertising for a single firm, Anheuser-Busch, Inc. Farr et al. (2001) find that broadcast (television and radio) advertising is more pro-competitive than other forms of advertising in the U.S. cigarette industry. Finally, Pritchett et al. (1998) and Kinnucan and Miao (1999) use industry data to estimate an industry's optimal advertising mix and compare it to the mix that maximizes industry profits. Pritchett et al. (1998) find that U.S. milk producers spend too much on television advertising, and Kinnucan and Miao (1999) find that the catfish producers spend too much on television and newspaper advertising.

Our work extends this research by using data envelopment analysis (DEA) techniques [we follow Färe and Grosskopf (1985, 1996)] to estimate overall cost efficiency in advertising and the optimal mix of television, radio, and print advertising at the firm rather than the industry level. We use quarterly data (1983-1993) from 6 major brewing companies: Anheuser-Busch, Coors, Genesee, Heileman, Pabst, and Stroh. Brewing is an ideal industry for such a study, since it is imperfectly competitive and beer is intensively advertised [Tremblay and Tremblay (forthcoming)].

With these estimates, we are able to address two main issues. First, we estimate each firm's overall level of advertising efficiency and determine if a firm has systematically used too much or too little of one medium or another. Given the artistic nature of an advertising campaign, the marginal benefits of using a particular advertising medium may be uncertain and firms may not always choose the optimal media mix. Systematic errors indicate poorly managed firms, however. Second, we discuss the correlation between a firm's advertising efficiency and its overall success. Because marketing success may be more difficult to attain than production success in consumer good industries, one might expect a positive correlation between advertising efficiency and overall firm success.

Our research follows the literature previously cited in assuming that firms attempt to use advertising in a profit-maximizing manner. One might recall that this assumption is not without its critics. For example, Leibenstein (1973) argues that competition in imperfectly competitive markets may not be rigorous enough to ensure profit-maximizing behavior. It has been recognized that, while advertising-to-sales ratios vary across firms

in the same industry and more generally across industries, individual firms tend to allocate a (nearly) fixed ratio over time [see, for instance, Nerlove and Arrow (1962) and Grabowski (1970)]. This suggests that firms may engage in satisficing rule-of-thumb decision making in imperfectly competitive markets when faced with uncertainties regarding the effects of advertising. Because we use firm-level data, we will be able to shed some light on whether the more successful firms employ a profit-maximizing mix of media.

In the sections that follow, we introduce the notion of an advertising (or 'sales') cost function, then turn to the theoretical underpinnings of our empirical techniques. After a brief description of our data we take up our results. Our estimates reveal that most firms would improve their advertising efficiency if they spent less on television relative to other media. Although the evidence is primarily qualitative in nature, it indicates that a positive relationship exists between advertising efficiency and overall firm success.

2 The sales (advertising) cost function

The production of beer requires inputs that differ from those required for sales. While a production function relates the levels of inputs to the quantity produced, our sales function relates advertising messages to sales. Advertising induces sales for at least one of two reasons: advertising may be informative and/or advertising may be persuasive. In the former case, advertising informs consumers that a good, a brand of beer in our case, exists; it may describe characteristics of the beer, and may also inform the consumers where the good can be bought and at what price. In the latter case, advertising encourages consumers to try the brand for real or imagined benefits.

The total cost function, composed of a production cost function and a sales cost function, is separable. There are several reasons why this should be true. First, as argued by Bresnahan (1984), the inputs used for production and for sales differ. Thus, suppose for the moment that the firm produces y units of a good in period t and wishes to sell all y units in the same period. Let the total cost function be

$$C_{\mathsf{T}}(w_{\mathsf{P}}, w_{\mathsf{S}}; y) = C_{\mathsf{P}}(w_{\mathsf{P}}; y) + C_{\mathsf{S}}(w_{\mathsf{S}}; y) \tag{1}$$

in period t, where w_{P} is a vector of prices of production inputs, w_{S} is a vector of prices associated with advertising messages in the different media, C_{P} is the production

cost function given that the firm wishes to produce y units of the good, and C_{S} is the sales cost function given that the firm wishes to sell the same quantity, y units, of the good. Then we can estimate the production cost function and the sales cost function separately. Second, there is no reason for the firm to be constrained to sell its total production in the same period as that in which it is produced. Because the firm may wish to build or deplete its inventory, the quantities in the production cost function and sales cost function may be different; and we would then have two separate functions, $C_{\mathsf{P}} = C_{\mathsf{P}}(w_{\mathsf{P}}; y_{\mathsf{P}})$ and $C_{\mathsf{S}} = C_{\mathsf{S}}(w_{\mathsf{S}}; y_{\mathsf{S}})$ where the quantities differ. Once again, this justifies the separate estimation of production and sales.[1] For the above reasons, we are justified in concentrating upon the sales function independently of the production function.

3 Theoretical underpinnings

In this section we introduce the model and the measures we apply in our analysis of advertising efficiency in the beer industry based on the separable sales cost function discussed in the previous section. In what follows we suppress the sales subscript S to simplify notation. The underlying separable technology is represented by the advertising input requirement sets, specifically

$$L(y) \;=\; \{x : x \text{ can produce } y\}, \tag{2}$$

where x is a vector of various advertising inputs and y is an output vector. In our particular case the subtechnology involves selling a single output, namely beer, through advertising, where beer sales are 'produced' from a vector of inputs comprised of advertising messages, as discussed in Seldon et al. (2000). These consist of three advertising categories: television, radio, and print (including outdoor) media.

In our empirical application we employ activity analysis or data envelopment analysis (DEA) to construct our input sets. Given $k = 1, \ldots, K$ observations of advertising

[1] According to Brewers Almanac (various issues), the gap between consumption and production averaged 5.5 percent of production (with a range of 4.2 to 7.2 percent) in the U.S. brewing industry between 1983 and 1993. For a more detailed discussion of this separability issue, see Seldon and Jung (1993) and Seldon et al.(2000).

messages and beer sales $(x^{\mathsf{k}}, y^{\mathsf{k}}) = (x_{\mathsf{k}1}, \ldots, x_{\mathsf{k}\mathsf{N}}, y_{\mathsf{k}})$, the input requirement set for observation $k^{'}$ is written as

$$
\begin{aligned}
L(y^{\mathsf{k}^{'}}) = \{(x_1, \ldots, x_{\mathsf{N}}) : \quad & \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} y_{\mathsf{k}} \geqq y_{\mathsf{k}'}, \\
& \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} x_{\mathsf{k}\mathsf{n}} \leqq x_{\mathsf{n}}, \quad n = 1, \ldots, N, \\
& z_{\mathsf{k}} \geqq 0, \qquad\quad k = 1, \ldots, K \\
& \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} \;=\; 1 \qquad \}.
\end{aligned}
\tag{3}
$$

For a detailed discussion see Färe and Grosskopf (1996). The z_{k} variables are known as intensity variables in activity analysis; the originator of this model was von Neumann (1938; 1945).

This model allows for increasing, constant and decreasing returns to scale [which is typically dubbed variable returns to scale (VRS)] through the restriction on the intensity variables

$$\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} \;=\; 1.$$

This model also imposes strong disposability of inputs and outputs through the inequalities in the constraints above. Strong disposability of output is modeled by

$$y \geqq y^{'} \text{ implies that } L(y^{'}) \subseteq L(y),$$

and strong disposability of inputs is modeled as

$$x^{'} \geqq x \text{ and } x \in L(y) \text{ imply } x^{'} \in L(y),$$

The data that are readily available on advertising are in cost rather than quantity terms. Thus our data consist of $(c^{\mathsf{k}}, y^{\mathsf{k}}) = (c_{\mathsf{k}1}, \ldots, c_{\mathsf{k}\mathsf{N}}, y_{\mathsf{k}})$ where $c_{\mathsf{k}\mathsf{n}}$ is the dollar amount of spending by firm k on the n^{th} type of advertising. To adjust our model for this type of data we need to assume that each observation k faces the same price for each type of advertising in any given period.[2] Of course, input prices are allowed to change over time.

[2]Thus we assume that advertising agencies act as competitive firms. This assumption follows from Jung and Seldon's (1995) test of market power in the advertising industry.

Thus we have

$$w_{\mathsf{n}} \sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} x_{\mathsf{kn}} \leqq x_{\mathsf{n}} w_{\mathsf{n}}, n = 1, \ldots, N, \tag{4}$$

and therefore

$$\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} c_{\mathsf{kn}} \leqq c_{\mathsf{n}}, n = 1, \ldots, N, \tag{5}$$

where $c_{\mathsf{kn}} = w_{\mathsf{n}} x_{\mathsf{kn}}$. Using this result our input requirement sets may be written as

$$\begin{aligned} L(y^{\mathsf{k}'}) = \{(c_1, \ldots, c_{\mathsf{N}}) : \quad & \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} y_{\mathsf{k}} \geqq y_{\mathsf{k}'}, \\ & \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} c_{\mathsf{kn}} \leqq c_{\mathsf{n}}, \quad n = 1, \ldots, N, \\ & z_{\mathsf{k}} \geqq 0, \qquad\quad k = 1, \ldots, K, \\ & \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} \;=\; 1\}. \end{aligned} \tag{6}$$

This empirical model also satisfies VRS and free disposability of beer sales.

Input disposability is now cost disposability,

$$c^{'} \geqq c \text{ and } c \in L(y) \text{ imply } c^{'} \in L(y),$$

thus spending more on advertising does not decrease sales.

To illustrate our model, suppose that we have three observations $k = 1, 2, 3$ and two types of advertising. Then if each k achieves the same level of beer sales, the advertising input set may take the form illustrated in Figure 1. The three observations are denoted by $1, 2, 3$, respectively, and both 1 and 2 belong to the boundary of the input set $L(y)$ while 3 lies in the interior of the set. We now formulate an algorithm for estimation of the efficiency of an observation like 3. We follow Farrell (1957) and use a radial input oriented measure of efficiency.

For each $k^{'}$ we define the cost technical efficiency measure as

$$F_{\mathsf{i}}(y^{\mathsf{k}'}, c^{\mathsf{k}'}) = \min \lambda : \quad \textstyle\sum_{\mathsf{k}=1}^{\mathsf{K}} z_{\mathsf{k}} y_{\mathsf{k}} \geqq y_{\mathsf{k}'}, \tag{7}$$

$$\begin{aligned} \textstyle\sum_{k=1}^{K} z_k c_{kn} &\leqq \lambda c_{n,k'} \quad n = 1, \ldots, N, \\ z_k &\geqq 0, \qquad\qquad k = 1, \ldots, K, \\ \textstyle\sum_{k=1}^{K} z_k &= 1. \end{aligned}$$

This measure contracts the advertising cost vector $(c_{k'1}, \ldots, c_{k'N})$ proportionally as much as is feasible, i.e., until $F_i(y^{k'}, c^{k'}) \cdot c^{k'}$ belongs to the boundary (here the isoquant) of $L(y^{k'})$. In our figure, the efficiency score for observations 1 and 2 are equal to one, while observation 3 has a score less than one, which implies that it is inefficient.

The second efficiency question we address is whether resources are optimally allocated among the various cost categories, $(c_1, \ldots, c_N)$. To answer this question we first estimate the optimal allocation by minimizing total costs, i.e., we solve

$$\begin{aligned} C^*(k') = \quad & \min c_1 + c_2 + \cdots + c_N \\ s.t. \quad & \textstyle\sum_{k=1}^{K} z_k y_k \geqq y_{k'}, \\ & \textstyle\sum_{k=1}^{K} z_k c_{kn} \leqq c_n, \qquad n = 1, \ldots, N, \\ & z_k \geqq 0, \qquad\qquad k = 1, \ldots, K \\ & \textstyle\sum_{k=1}^{K} z_k = 1. \end{aligned} \tag{8}$$

The solution to this minimization problem gives the lowest total cost $C^*(k')$ and its optimal allocation $(c^*_{k'1}, \ldots, c^*_{k'N})$. We may now compare the minimum cost to observed total cost

$$C^*(k') / \sum_{n=1}^{N} c_{k'n} \tag{9}$$

and also compare the optimal media share to observed media share

$$C^*_n(k')/C^*(k') - c_{k'n} / \sum_{n=1}^{N} c_{k'n}, n = 1, \ldots, N. \tag{10}$$

The first ratio tells us if brewery k' is minimizing the cost of advertising to yield sales $y_{k'}$. The $n = 1, \ldots, N$ differences tell us if the firm spends the correct share of advertising dollars in each media category. For the former, efficiency is signaled by values

equal to one; for the latter efficiency is signaled by values equal to zero.

Under our assumption that all firms face the same input prices within a given time period, the optimal values above derived from (7) will be identical to those computed from the traditional cost minimization problem:

$$\begin{aligned} C^*(y^{k'}, w) = \quad & \min \textstyle\sum_{n=1}^{N} w_n x_n \\ s.t. \quad & \textstyle\sum_{k=1}^{K} z_k y_k \geqq y_{k'}, \\ & \textstyle\sum_{k=1}^{K} z_k x_{kn} \leqq x_n, \quad n = 1, \ldots, N, \\ & z_k \geqq 0, \qquad k = 1, \ldots, K \\ & \textstyle\sum_{k=1}^{K} z_k \; = \; 1. \end{aligned} \tag{11}$$

Multiplication of the x_n by their associated prices w_n in the $n = 1, \ldots, N$ advertising media constraints above yields (7), and does not alter the problem, since the same scalar price appears on the right and left hand sides in any given period for each different type of input under our assumption.

4 The data

Our data cover the period 1983:Q1 through 1993:Q4, a total of 44 quarters, for six firms, namely Anheuser-Busch, Coors, Genesee, Heileman, Pabst, and Stroh. These brewers accounted for about 74.5 percent of total beer consumption in 1993.[3] Our data do not cover the period after 1994 because this was a time when the industry was in disequilibrium and experienced considerable structural change. Heileman faced growing excess capacity and financial stress before being acquired by Stroh in 1996. Stroh was in turn acquired by Pabst, Miller and Yuengling in 1999. By 1999, only three major brewers survived: Anheuser-Busch, Coors and Miller. Pabst remains but only as a contract brewer; Miller produces all of Pabst's beer.[4]

Ad $ Summary [Competitive Media Reporting, (1983-1993)] reports year-to-date quarterly advertising expenditures by media for the 1000 largest advertisers in the U.S.

[3]The only major brewer missing from our sample is Miller. Because Miller was owned by the conglomerate Philip Morris, we are unable to isolate the company's expenditures on beer advertising. In 1993, over 97 percent of domestic beer was produced by Miller and the other 6 brewers sampled.

[4]See Tremblay and Tremblay (forthcoming) for a more complete account of merger activity and structural change in brewing.

This is the reason that our data set is composed of variables from large national and regional breweries. Also for this reason, there are missing observations for some of the included firms: in quarters where a firm's advertising decreases sufficiently it will not be reported in the publication. Missing observations can cause us to lose more than one quarter's data for the year. For the second, third, and fourth quarters, the year-to-date information for the present quarter (year-to-date) is subtracted from the preceding quarter's data (year-to-date) to obtain spending within the single quarter. If data are missing for the last quarter of a year, then the last quarter will be the only missing data for the year. But if there is a missing observation for the first, second, or third quarter then, because the data are year-to-date, we cannot do the necessary subtraction to obtain the data for more than one quarter.[5] Table 1 displays descriptive statistics of the variables used in our empirical work.

Ad $ *Summary* also reports total advertising expenditures for the firms. In some cases, the sum of the media expenditures does not equal the reported total advertising expenditures. In these cases, the reported total expenditures seem inconsistent with the time series of total advertising expenditures, so we use the sum of the media expenditures in place of the reported total expenditures.

Annual sales data in millions of barrels are available from *Beverage Industry* [Beverage Producers Association, (various issues)]. These annual data must be converted to quarterly data. We convert the data in a manner that preserves the seasonality of sales. Monthly total beer sales in the U.S. are reported for the years of our sample in *Brewers Almanac* [Beer Institute, (1994)]. We add sales for each month of each quarter to obtain quarterly totals and then determine the percentage of annual sales for each quarter of every year of our sample. We then apply these seasonal percentages to the firms' annual sales to construct a quarterly sales series for each firm.

[5]Thus, for example, if the first quarter's data are missing then we cannot obtain the data for the first or second quarter; if data are missing for the second quarter then we cannot obtain the data for the second or third quarter; and similarly for missing data in the third quarter.

5 Results

Our model specification includes the total quantity of beer sales, and three media inputs (in expenditure terms): print, television, and radio. These are used to estimate the overall advertising cost efficiency in (9) and the optimal mix of media inputs used to compute media mix efficiency in (10). As discussed in the previous section, using expenditures as our media quantities is appropriate under our assumption that firms face the same set of input prices in any given period.

The mix of television, radio, and print advertising that minimizes the cost of generating the market level of output are calculated with the *OnFront2* software package (1998) for each of the six companies in our sample. Table 2 provides the means, standard deviations, maximum and minimum efficiency values for each firm, based on annual estimates. Figures 2-7 compare the annual averages of media mix indices for each firm by media.

Recall that the *overall cost efficiency index* derives from (9) and is defined as the ratio of minimum advertising expenditure divided by the actual advertising expenditure required to generate a given level of sales. A firm uses advertising efficiently when the advertising spending is not wasted and when the firm uses the optimal mix of print, television, and radio advertising. A firm is overall cost efficient when the index is one and is increasingly *inefficient* as the index falls below one. This overall index suggests that none of our firms is consistently minimizing advertising costs, however, Anheuser-Busch exhibits the best overall performance on average.[6]

The *media mix index of efficiency* identifies whether or not the firm has chosen the optimal mix of advertising by comparing the optimal expenditures to the actual expenditures by media type, where print = print advertising, tv = television advertising, and radio = radio advertising. Specifically we take the difference between the optimal media share and the observed media share based on (10) in section 3. When the index equals zero, the firm has chosen the optimal share for that particular media type. A positive

[6]Like Seldon et al. (2000) we find that the average firm operates in the region of decreasing returns to scale in advertising. At low levels of sales, however, increasing returns are observed. Our estimates indicate that efficient scale ranges from about 2.5 to 3.5 million barrels of beer sales. Thus Anheuser-Busch, Coors, Heileman and Stroh operated in the region of decreasing returns.

value indicates under-utilization and a negative value indicates over-utilization.

Because there is likely to be considerable uncertainty about the expected benefit of an advertising campaign in a particular medium, firms may not always choose the optimal total amount or the optimal media mix of advertising, ex post. Our results support this conclusion, with the possible exception of Anheuser-Busch. Table 2 indicates that Anheuser-Busch has the highest cost efficiency index and has allocated the proper amount of its total advertising budget to television, an important medium for national producers, as its television index is not significantly different from zero. In addition, by comparing the results in Figures 2-7, one can see that Anheuser-Busch has chosen the most efficient mix of media, as its media mix indices are all closest to zero. This is consistent with Anheuser-Busch's status as the dominant firm in the industry and its ranking as one of the top ten most admired companies in the U.S. by *Fortune* magazine [Perry (1984)]. In contrast, our estimates indicate that Pabst, listed among the least admired U.S. corporations, has chosen the most inefficient mix of advertising media in our sample. Thus, a firm's overall success appears to be linked with its advertising success, at least in these two cases.[7]

Our results also demonstrate that the index of overall cost efficiency in advertising is very low for most firms. This may be partially explained by the risky nature of an advertising campaign, but it is also due to the fact that most firms spent either too much or too little on one advertising medium versus another. For example, Coors, Genesee, and Pabst spent too much on television advertising in every year sampled. Heileman spent too much on television advertising and Stroh spent too little on print advertising in all but one year (see Figures 5 and 7). In each of these cases, Table 2 shows that the mean efficiency scores for these firms and the specified media are significantly different from zero. Since these are systematic errors, there appear to be unexploited benefits from redistributing advertising budgets among media for most brewers. In our sample, all firms except Anheuser-Busch and Stroh would benefit from redistributing their advertising spending from television to other media.

[7]According to Tremblay and Tremblay (forthcoming), Anheuser-Busch is considered successful and the dominant firm in the industry because it is a price leader, is the largest brewer in the world, experienced continued growth in market share, and earned above average accounting profits per barrel during the period.

Other managerial decisions or exogenous events may also be linked to a particular firm's advertising efficiency. For example, Table 2 shows that the cost efficiency index for Coors is among the lowest of the firms sampled, indicating that its advertising spending was relatively ineffective at generating sales. This can be partially explained by Coors' strategy to go national by investing heavily in advertising and expanding into new geographic markets [Baum (2001)]. This investment generated some benefits to the firm, however, as consumers had high recall of Coors' advertisement and Coors won an award for best advertising in the industry in 1992 [*Modern Brewery Age* (1985c) and *Food and Beverage* (1992)]. The only other major event in Coors' history during the sample period was its attempt to purchase Stroh in1989-1990, a merger that was effectively challenged by the U.S. Department of Justice on antitrust grounds. This appears to have had little or no effect on its media mix efficiency, however (see Figure 3).

Estimates reported in Figure 4 and in Table 2 indicate that Genesee's advertising cost efficiency was low and that the firm consistently chose too much television relative to radio and print advertising. Although there is little information about the firm during the period for which data are available (1983-1988), the firm did change advertising agencies in 1990 and again in 1991. Then, its advertising agency resigned in 1992 [*Advertising Week* (1990, 1991, and 1992)]. This suggests an awareness of Genesee's advertising ineffectiveness.

Figure 5 demonstrates that Heileman chose a relatively efficient marketing mix until 1991 when it began to use too much television advertising. Heileman was a relatively successful firm until it was purchased by the Bond Corporate Holding of Australia in 1987. One goal of Bond management was to expand marketing efforts in order to increase Heileman's market share from fifth to third in the nation [*Business Week* (1987), *Beverage World* (1/88, p. 18), and Teinowitz (1989)]. This effort failed, however, and Heileman filed for bankruptcy in 1991 [Berg (1991)]. Thus, Heileman's lack of overall success and its failure to choose the optimal marketing mix are highly correlated during the 1991-1993 period.

As discussed above, Pabst was an unsuccessful firm with an inefficient advertising program. Pabst was under financial pressure during the early 1980s before being

purchased by S&P Inc. in 1985. In an attempt to revive the company, new management increased advertising spending for its flagship brand, Pabst Blue Ribbon [*Modern Brewery Age* (1985a) and Hume (1985)]. Our results suggest that this was done with an improper mix of advertising media. Pabst won two awards for its radio advertising in 1986 [*Marketing and Media Decisions* (1987)], but our evidence indicates that Pabst underestimated the effectiveness of its radio ads. In spite of increasing its radio advertising budget by 182 percent between 1985 and 1986, the firm still chose too little radio relative to television and print advertising in 1986.

Compared to its rivals, Stroh was a productive advertiser, choosing an efficient media mix through 1989. Stroh ranked third in size and was a relatively successful brewer until about 1988, when its market share began a dramatic decline. In 1989-90, Stroh owners agreed to sell the company to Coors, a merger that was stopped by the Department of Justice. Although the attempted merger was not disruptive to Coors, it appears to have adversely affected Stroh's advertising efficiency or to have coincided with the general decline at Stroh that lasted through 1992. By 1993, however, the firm's market share began to rise and its media mix efficiency improved to pre-merger levels.

Although qualitative in nature, the evidence above suggests that a negative relationship exists between firm success and advertising inefficiency, i.e., the greater the degree of advertising *in*efficiency, the lower is firm success. Unfortunately, data limitations limit quantitative analysis. Data on market share and accounting profits per barrel are available for most observations, and might be considered as proxies for firm success.[8] The correlation coefficients between a firm's index of cost efficiency in advertising with its profit rate and its market share are 0.515 and 0.683, respectively. Thus overall cost efficiency in advertising is positively related to these two proxies of firm success. We also compute the correlation coefficients between firm profit rates and our estimates of media mix inefficiency; they are all negative (-0.3214, -0.2130, and -0.0888 respectively for print, tv and radio). This too confirms that advertising efficiency is positively related to profitability; recall that zero signals media mix efficiency (i.e., optimal share by media type), the absolute values for inefficient media mix indexes are greater than zero.[9] These

[8]In Brewing, firm size is also important, since most firms that have exited the industry have been the smaller brewers [Tremblay and Tremblay (forthcoming)].

[9]Profit data are obtained from Beer Industry Update (various issues) but are unavailable for Genesee

coefficients are small, as one would expect, since accounting profits are used and other factors for which data are not available undoubtedly affect firm success.

Two results emerge from our analysis. First, the overall cost efficiency index for advertising is low in brewing and there is considerable variability in media-mix efficiency among firms and over time. This seems reasonable, as the expected benefits of advertising are uncertain and will vary from ad to ad. For example, four of the six firms sampled spent too much on television relative to advertising in other media in almost every period. Second, there is a positive relationship between overall firm success and advertising efficiency. This is not surprising since Kerkvliet et al. (1998) find little evidence of inefficiency on the production side of brewing in the U.S. Thus, overall firm success in brewing may depend more critically upon advertising performance. In any case, our results show that most firms could improve their overall performance with a better mix of television, radio, and print advertising.

6 Conclusion

Most productivity studies have focused on the production side of the firm even though advertising performance may be just as important to overall firm success. In contrast, we use DEA techniques to evaluate the advertising efficiency for a set of firms in a single industry, U.S. brewing. We are able to determine if a firm has spent too much on advertising overall and if it spent too much of its advertising dollars on one medium versus another.

Our efficiency estimates show that most firms made systematic errors when allocating their advertising dollars among different media. In general, Coors, Genesee, Heileman and Pabst spent too much on television advertising and Stroh spent too little on print advertising relative to other media. Anheuser-Busch is the only firm that has chosen a mix of media consistent with profit maximization. Perhaps Anheuser-Busch is better at identifying an optimal advertising strategy. Alternatively, since the expected benefit of an advertising campaign is highly uncertain, firms may be making media-mix decisions based on a rule-of-thumb, indicating that Anheuser-Busch's success is simply due to good luck. Still another possibility is that Anheuser-Busch makes decisions that

in 1988, Heileman in 1983, Pabst in1985-1986, and Stroh in 1983 and 1991-1993.

are with profit-maximizing while other less successful firms base their decisions on a rule-of-thumb.

The evidence also reveals a positive relationship between advertising efficiency and overall firm success. That is, larger and more profitable firms appear to use advertising more efficiently. This is consistent with comments from industry insiders who claim that advertising is more important than production to success in brewing [Scherer et al. (1975)]. The evidence and the fact that U.S. beer production is highly efficient suggest that advertising efficiency may be an important determinant of firm success in the U.S. brewing industry.

In terms of future research in this area it might be fruitful to directly investigate the link between advertising productivity and overall firm success. In addition, since national television advertising is thought to be a powerful marketing tool in consumer goods industries [Porter (1976), Lancaster and Miracle (1978), Albion and Ferris (1981), and Tremblay (1985)], it may also be useful to separate firms into national and regional producers.

References

Ackoff, Russell L. and James R. Emshoff, "Advertising Research at Anheuser-Busch, Inc., (1963-68)," *Sloan Management Review*, 16 (2), Winter 1975a, 1-15.

_____, "Advertising Research at Anheuser-Busch, Inc., (1968-74)," *Sloan Management Review*, 16 (2), Spring 1975b, 1-15.

Advertising Week, "Genesee to Choose New Advertising Agency," October 1, 1990, 55.

_____, "Advertising Account to Mullen," January 1, 1991, 6.

_____, "Mullen Resigns," August 31, 1992, 28.

Albion, Mark S. and Paul W. Farris, *The Advertising Controversy: Evidence on the Economic Effects of Advertising*, Boston, MA: Auburn House Publishing Company, 1981.

Baum, Dan, *Citizen Coors: A Grand Family Saga of Business, Politics and Beer*, New York, New York: Perennial, 201.

Beer Industry Update: A Review of Recent Developments.

Becker, Gary S. and Kevin M. Murphy, "A Simple Theory of Advertising as a Good and Bad," *Quarterly Journal of Economics*, 108 (4), November 1993, 941-964.

Beer Institute, *Brewers Almanac*, 1994, Beer Institute, Washington, D.C.

Berg, Eric N., "Heileman in Chapter 11, but Upbeat," *New York Times*, January 25, 1991, D1- D5.

Business Week, "Alan Bond Hoists Heileman," October 5, 1987, 44.

Beverage Producers Association, Various Issues, *Beverage Industry.* Stagnito Publishing, Northbrook, IL.

Beverage World, "Marketing Moves," January 18, 1988.

Bresnahan, T.F., "The Demand for Advertising by Medium: Implications for the Economies of Scale in Advertising." In Ippolito, P.M., Scheffman, D.T. (Eds.), *Empirical Approaches to Consumer Protection Economics.* Federal Trade Commission, Washington, D.C., 1984, 135-163.

Competitive Media Reporting, Annual Issues 1983-93. *Ad* $ *Summary.* Competitive Media Reporting, New York.

Dorfman, Robert and Peter O. Steiner, "Optimal Advertising and Optimal Quality," *American Economic Review*, 44 (5), December 1954, 824-836.

Färe, Rolf and Shawna Grosskopf, "A Nonparametric Cost Approach to Scale Efficiency," *Scandinavian Economic Journal*, 87 (4), 1985, 594-604.

Färe, Rolf and Shawna Grosskopf (1996). *Intertemporal Production Frontiers: With Dynamic DEA*, Boston: Kluwer Academic Publishers, 1996.

Farr, Stephen J., Carol Horton Tremblay, and Victor J. Tremblay, "The Welfare Effect of Advertising Restrictions in the U.S. Cigarette Industry," *Review of Industrial Organization*, 18 (1), March 2001, 147-160.

Farrell, M.J. "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society*, Series A, General 120, (1957), 253-281.

Food and Beverage, "Coors Marketing Program," December 1992, 32.

Grabowski, Henry G., "Demand Shifting, Optimal Firm Growth, and Rule-of-Thumb Decision Making," *The Quarterly Journal of Economics*, 84 (2), May 1970, 217-235.

Hume, Scott, "Pabst is Back with Ads," *Advertising Age*, May 13, 1985, 4 and 119.

Jung, Chulho and Barry J. Seldon, "The Degree of Competition in the Advertising Industry," *Review of Industrial Organization*, 10 (1), February 1995, 41-52.

Kerkvliet, Joe R., William Nebesky, Carol Horton Tremblay, and Victor J. Tremblay, "Efficiency and Technological Change in the U.S. Brewing Industry," *Journal of Productivity Analysis*, 10 (3), 1998, 271-288.

Kinnucan, Henry W. and Yuliang Miao, "Media-Specific Returns to Generic Advertising: The Case of Catfish," *Agribusiness*, 15 (1), Winter 1999, 81-99.

Lancaster, Kent M. and Gordon E. Miracle, "Advertising and Market Concentration: Some Empirical Evidence on Selected Product Categories," in Stephen E. Permut (eds.), *Proceedings of the American Academy of Advertising*, Columbia SC: American Academy of Advertising, 1978, 41-47.

Leibenstein, Harvey, "Competition and X-Efficiency," *Journal of Political Economy*, 81 (3), May 1973, 765-777.

Marketing and Media Decisions, "Anheuser-Busch Tops Spot in Radio," May 1987, 144.

McGough, Robert, "A Different Perspective," *Forbes*, October 24, 1983, 88.

Modern Brewery Age, "Pabst Completes Acquisition with S&P," March 18, 1985a, 1.

_____, "Advertising Award for Budweiser," April 22, 1985b, 4.

_____, "Consumers Recall Beer Advertising," June 17, 1985c, 3.

_____, "1994 Year in Review," March 13, 1995, 8-40.

Nerlove, Mark, and Kenneth J. Arrow, "Optimal Advertising Policy Under Dynamic Conditions," *Economica*, 29 (114), May 1962, 129-142.

OnFront2, Economic Measurement and Quality in Lund Corporation, 1998-2000.

Perry, Nancy J., "American's Most Admired Corporations," *Fortune*, January 9, 1984, 50-64.

Porter, Michael E, "Interbrand Choice, Media Mix, and Market Performance," American Economic Review, 66 (2), May 1976, 398-406.

Pritchett, James G., Donald J. Liu, and Harry M. Kaiser, "Optimal Choice of Generic Milk Advertising Expenditures by Media Outlet," *Journal of Agricultural and Resource Economics*, 23 (1), July 1998, 155-169.

Roberts, Mark J. and Larry Samuelson, "An Empirical Analysis of Dynamic, Nonprice Competition in an Oligopolistic Industry," *Rand Journal of Economics*, 19 (2), Summer 1988, 200-220.

Scherer, Frederick M., Alan Beckenstein, Erich Kaufer and R. Dennis Murphy, *The Economics of Multi-Plant Operation: An International Comparison*, Cambridge: Harvard University Press, 1975.

Scherer, Frederic M. and David Ross, *Market Structure and Economic Performance*, Boston: Houghton Mifflin, 1990.

Seldon, Barry J. and Chulho Jung, "Derived Demand for Advertising Messages and Substitutability Among the Media," *The Quarterly Review of Economics and Finance*, 33 (1), Spring 1993,71-86.

Seldon, Barry J., R. Todd Jewell and Daniel M. O'Brien, "Media Substitution and economies of scale in advertising," *International Journal of Industrial Organization* 18 (8), December 2000, 1153-1180.

Silk, Alvin J., Lisa R. Klein and Ernst R. Berndt, 'Intermedia Substitutability and Market Demand by National Advertisers," *Review of Industrial Organization*, 20 (4), June 2002, 323-348.

Slade, Margaret E., "Product Rivalry with Multiple Strategic Weapons: An Analysis of Price and Advertising Competition," *Journal of Economics and Management Strategy*, 4 (3), Fall 1995, 445-476.

Stavro, Barry, "Is the Game Over?," *Forbes*, January 16, 1984, 95.

Sutton, John, *Sunk Costs and Market Structure*, Cambridge: MIT Press, 1991.

Teinowitz, Ira, "Heileman in High Gear," *Advertising Age*, February 13, 1989, 1 and 66.

Tremblay, Carol Horton, and Victor J. Tremblay, *The U.S. Brewing Industry: Data and Economic Analysis*, Cambridge: MIT Press, forthcoming.

Tremblay, Victor J., "Strategic Groups and the Demand for Beer," *Journal of Industrial Economics*, 34 (2), December 1985, 183-198.

von Neumann, John, "Über ein ökonomishes gleichungssystem und eine Verallgemeinerung des Brouwerschen Fixpunktsatzes," in K. Menger *Ergebnisse eines Mathematischen Kolloquiums*, reprinted as 'A Model of General Economic Equilibrium,' *Review of Economic Studies*, 13:1, (1938; 1945), 1-9.

Table 1

Descriptive Statistics: Six Beer Firms 1983-1993

All Six Firms

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	189	7.3530355	6.8143173	0.5745709	23.7615552
PRINT	189	1818.77	2279.11	0.4563447	11582.27
TELEVISION	189	21325.35	23711.91	151.0366217	92509.39
RADIO	189	933.3232342	1976.29	0	17523.89

Anheuser-Busch

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	44	19.2090898	2.8648823	13.1991338	23.7615552
PRINT	44	5356.49	2046.11	2132.91	11582.27
TELEVISION	44	60687.20	12737.58	37873.88	92509.39
RADIO	44	3201.12	2936.42	72.7167035	17523.89

Coors

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	44	4.1931816	0.7039854	2.8426686	5.3903528
PRINT	44	1213.12	892.3334283	28.8788339	2973.02
TELEVISION	44	18514.94	6499.51	5086.65	31319.25
RADIO	44	353.5891945	939.7624882	0	5572.70

Genesee

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	16	0.7279980	0.0969264	0.5745709	0.8910854
PRINT	16	130.2229192	137.4729204	0.4563447	463.1968557
TELEVISION	16	1611.02	1248.61	442.0490263	5050.31
RADIO	16	0.0898961	0.3595843	0	1.4383374

Heileman

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	38	3.5120987	0.7833678	2.0544390	4.8731235
PRINT	38	627.8977856	568.8998606	40.7633996	2484.62
TELEVISION	38	3675.77	2609.70	484.4649237	13165.62
RADIO	38	212.3745737	665.8781687	0	3481.50

Pabst

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	6	2.6817450	0.6500750	1.4979270	3.3056284
PRINT	6	299.1155464	225.6795048	81.6775100	716.7270544
TELEVISION	6	6713.27	9220.51	1560.39	25297.84
RADIO	6	3.6399663	8.9160602	0	21.8397979

Stroh

Variable	N	Mean	Std Dev	Minimum	Maximum
QOUTPUT	41	4.8494042	1.1785000	2.8990417	6.7666801
PRINT	41	657.2211151	596.9904352	45.5164443	2430.11
TELEVISION	41	8289.32	5888.35	151.0366217	21246.35
RADIO	41	290.1797246	952.6539095	0	2952.73

Table 2

Average Overall Cost Efficiency[a] and Media Mix Efficiency[b]: for Six U.S. Brewing Companies (1983-1993)

Firm Medium	Mean	Standard Deviation	Maximum Value	Minimum Value
Anheuser-Busch				
Overall Cost Eff.	0.655	0.117	0.837	0.506
Television	0.014	0.029	0.063	0.027
Radio	-0.040*	0.018	-0.010	-0.067
Print	0.026*	0.019	0.050	-0.016
Coors				
Overall Cost Eff.	0.l54	0.033	0.204	0.110
Television	-0.107*	0.095	-0.003	-0.309
Radio	0.014*	0.052	0.120	-0.050
Print	0.093*	0.046	0.189	0.051
Genesee				
Overall Cost Eff.	0.264	0.051	0.300	0.193
Television	-0.513*	0.044	-0.451	-.580
Radio	0.267*	0.001	0.267	0.266
Print	0.246*	0.044	0.312	0.183
Heileman				
Overall Cost Eff.	0.423	0.254	0.779	0.144
Television	-0.083*	0.103	0.047	-0.322
Radio	0.036	0.058	0.157	-0.049
Print	0.047	0.090	0.212	-0.082
Pabst				
Overall Cost Eff.	0.133	0.106	0.198	0.010
Television	-0.438*	0.104	-0.411	-0.553
Radio	0.230*	0.055	0.267	0.167
Print	0.208*	0.069	0.286	0.156
Stroh				
Overall Cost Eff.	0.533	0.099	0.754	0.373
Television	0.000	0.085	0.213	-0.088
Radio	-0.053	0.090	0.035	-0.263
Print	0.053*	0.032	0.098	-0.016

[a] A mean value of one indicates the firm is overall efficient, i.e., minimum cost is equal to observed cost, see (9).

[b] A zero mean value indicates the firm is using the efficient amount in a particular medium, a positive value indicates underutilization, a negative value indicates overutilization, see (10).

*Significantly different from 0 at the 95% level of confidence.

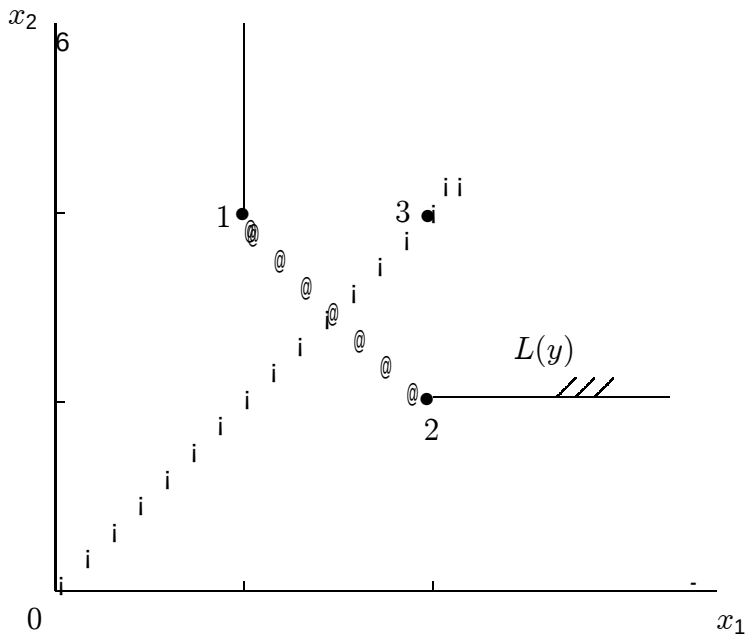

Figure 1: Advertising input requirement set and technical efficiency