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Marketing communication efficiency in the Spanish automobile sector: Analysing the role of online advertising through DEA and stochastic frontiers*

Eficiencia publicitaria en el sector español de automóviles: análisis del papel de la publicidad en Internet mediante el uso de técnicas DEA y de fronteras estocásticas

ABSTRACT

The aim of this study is to examine the role of Internet advertising spending in achieving advertising efficiency. The application of a Data Envelopment Analysis model to a sample from the Spanish automobile industry revealed that online advertising positively affects the overall efficiency levels. Stochastic frontier analysis using three-year panel data corroborates this finding, revealing significant positive relationships between online advertising and sales.

Key words: advertising, efficiency, Internet, marketing metrics.

RESUMEN

El objetivo del trabajo es comprobar si la inversión en publicidad en Internet puede ayudar a mejorar la eficiencia publicitaria. La estimación de modelos de Análisis Envolvente de Datos en una muestra de la industria de automóviles en

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España revela que la inversión en publicidad en Internet mejora el nivel global de eficiencia. Estos resultados quedan confirmados al estimar Fronteras Estocásticas con datos de panel de tres años.

Palabras clave: publicidad, eficiencia, Internet, medidas de marketing.

1. INTRODUCTION

Nowadays consumers are becoming more demanding, seeking quality products at lower prices, thus placing emphasis on efficiency in marketing. Furthermore, in circumstances of fierce and constantly increasing competition, both locally and internationally, the pressure for marketing to demonstrate its value in improving company performance is greater than ever. This is because while expenditures in manufacturing and general management have been constantly declining, marketing costs have risen (Sheth & Sisodia, 1995). According to Ambler (2000), the biggest portion of marketing expenditures usually goes to advertising and promotion. Advertising has been found to enhance brand equity, contributing to long-term differentiation (Boulding, Lee & Staelin, 1994; Jedidi, Mela & Gupta, 1999), which has given rise to enormous levels in advertising budgets. However, advertising is under increasingly severe scrutiny (Bhargava, Donthu & Caron, 1994) because researchers claim that advertising is “rife with productivity problems” (Sheth & Sisodia, 1995, p. 19).

Alike academicians, practitioners are concerned about advertising inefficiency. Ever since John Wanamaker stated: “Half the money I spend on advertising is wasted; the trouble is I don’t know which half.” marketers and advertisers are looking for the reasons why there is such wastage of marketers’ money (Cheong & Leckenby, 2006). According to Greg Stuart, CEO of the Interactive Advertising Bureau, the problem is in the practice of basing advertising-campaign decisions on gut instinct rather than scientific research (www.adage.com). Online advertising spending is growing faster than any other media, since the Internet is believed to be more cost-effective than traditional media. Online and mobile advertising spending in the US reached $29.94 billion in 2007 (up 29.1% compared with 2006), with an annual growth rate of 31.4% over the 2002-2007 period (Lemonnier, 2008).

Among the most important drivers of increased online advertising spending are: the ability of online advertising for more precise targeting and two-way dialogue with customers (Briggs & Hollis, 1997), the Internet’s capability of addressing individual customers (Deighton, 1997), its interactivity and ability to store vast amounts of information (Peterson, Balasubramanian & Bronnenberg, 1997), and the fact that it allows customers to seek unique solutions to their needs (Sheth, Sisodia & Sharma, 2000). Empirical research in the field has investigated different Internet advertising formats such as banners (Becker-Olsen, 2003) or 3-D online advertising (Li, Daugherty & Biocca, 2002), and different features of Internet advertising such as home page complexity (Geissler, Zinkhan & Watson, 2006) or curiosity of the online advertising message (Menon & Soman, 2002).
However, there is still a lack of understanding on whether the Internet can contribute to the overall advertising efficiency. Therefore, the aim of this study is to address this gap in the literature and to assess advertising efficiency, with a focus on the role of the Internet. We compare two model specifications of measuring the efficiency during a period of three years: the first model only includes more “traditional” types of advertising like print, broadcast and outdoor; and the second includes online advertising expenditures as an input variable in addition to the former. In doing so, we verify whether the use of the Internet as an advertising tool affects the overall advertising efficiency and whether there is a change of the advertising efficiency over time. We employ Data Envelopment Analysis (DEA), a technique for measuring the efficiency that can deal with the concern in the marketing literature that advertising expenditure decisions are often made with competitors in mind (Rust, Ambler, Carpenter, Kumar & Srivastava, 2004a). Furthermore, the three year panel data stochastic frontier analysis permitted us to get deeper insights on the effect of different advertising media on sales and to complement the results obtained through DEA.

2. CONCEPTUAL BACKGROUND

There are different dimensions to measure a business unit’s performance. In marketing literature focus has been on: a) effectiveness, or the extent to which products and programs are successful and achieve the objectives; b) efficiency, or the outcome in relation to the resources employed in implementing it, or what is also referred to as marketing productivity; and c) adaptability, or the ability of a business to respond to environmental changes over time and to catch new opportunities (Walker & Ruekert, 1987). As stressed by Morgan, Clark and Gooner (2002), the marketing productivity research stream has made two major contributions to the assessment of marketing performance: first, it has provided a managerially relevant conceptual model of the efficiency dimension of marketing performance; and second, marketing productivity analysis has greatly increased understanding concerning the identification and measurement of marketing costs and revenue.

Diverse marketing productivity measures have been proposed in the literature and the practice. Among the most commonly used financial measures in linking marketing with performance are return on investment (ROI), internal rate of return, net present value and economic value added. In all these cases the financial impact reflects the return generated by the marketing action against the expenditure to produce that return (Rust et al., 2004a). However, scholars have identified that environment and competition has to be taken into account when assessing the productivity of marketing actions. As Rust et al. (2004a) argue, firm performance is fundamentally affected by competition and it changes over time, therefore it is necessary to capture both dimensions (competition and time) in marketing productivity measurement.

2.1. Advertising efficiency

Previous research assessed advertising performance using several indicators such as advertising ROI, advertising cost/sales ratio or econometric models (Assmus, Farley & Lehmann, 1984;
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Dhalla, 1978; Smith & Park, 1992). However, we contend that when measuring the efficiency of advertising, competition and time have a crucial role. Firstly, since the consideration of competing brands is a central element of brand choice (Guadagni & Little, 1983), and competition has an impact on each consumer’s purchase decisions (Rust, Lemon & Zeithaml, 2004b), it is indispensable to include competition in the measurement of efficiency. Secondly, advertising affects long-run marketing productivity by creating knowledge and maintaining acceptance about brands (Berkowitz, Allaway & D’Souza, 2001; Cobb-Walgren, Ruble & Donthu, 1995; Ehrenberg, Barnard, Kenney & Bloom, 2002). Therefore, advertising efficiency in our study is defined as the efficiency of the expenditures in advertising made by a company in generating sales relative to its competitors and tracked over time. We adopt the definition of output-oriented technical efficiency, i.e. the ability to obtain maximum output from a given input vector (Kumbhakar & Lovell, 2000).

The time dimension within advertising has been extensively studied (Simon & Sullivan, 1993). However, the research objectives of these studies have been far from assessing advertising efficiency. Much of the literature used distributed lag models that capture the relationship between advertising flows and sales flows. The competition dimension, on the other hand, has received considerably less attention in the advertising research. Only recently researchers have started to examine the effect of advertising in competitive settings (e.g., Vákratsas & Ma, 2005; Yoo & Mandhachitara, 2003). Nevertheless, scholars recognize that competitive activities could change dramatically the advertising performance (Dekimpe & Hassens, 1995).

There have been studies applying DEA to evaluate advertising efficiency in competitive settings (Büsckken, 2007; Färe, Grosskopf, Seldon & Tremblay, 2004; Luo & Donthu, 2001). Luo and Donthu (2001) assess the best advertising practices among the top 100 U.S. advertisers. Färe et al. (2004) estimate the cost efficiency of advertising in the U.S. beer industry and Büschken (2007) reveals eight percent inefficiency of brand advertising spending in the German car market.

Luo and Donthu (2005) compare two frontier methodologies –DEA and Stochastic frontier model– to benchmark inefficiency. The results demonstrate about 20% inefficiency of media spending for U.S. top 100 advertisers. The authors claim that both parametric stochastic frontier and nonparametric frontier methodologies should be used when estimating efficiency, because they do not always produce similar results. In this study, we follow the approach of Luo and Donthu (2005) and we add the time dimension assessing the efficiency over a three-year period.

2.2. Internet advertising

The advertising mix has changed dramatically since the early 1990s, when Internet advertising has started to grow exponentially. This is because the Internet is believed to be more effective than traditional media in accomplishing certain advertising objectives (Li & Leckenby, 2004). The web offers unique advantages over other media in terms of targeting and direct marketing (Briggs & Hollis, 1997). What features drive those advantages?
The Internet provides a targeted means for reaching consumers (Burke, 1997). Moreover, Deighton (1997) underlines two critical features: addressability and responsiveness. Besides, because of its ability to transmit information quickly and inexpensively, the Internet is expected to have greater impact on marketing communications than on other marketing elements (Peterson et al., 1997). Most importantly, online advertising is interactive, which makes it a substantial advertising vehicle because advertisers can identify and differentiate consumers, and on the other hand consumers have more influence on the process by deciding when and how to interact (Pavlou & Stewart, 2000; Roberts & Ko, 2001; Rodgers & Thorson, 2000; Steuer, 1992; Stewart & Pavlou, 2002).

Besides, there is a shift in advertising strategy in favor of deriving maximum response from selected target groups instead of maximum exposure to many unknown audience groups (Yoon & Kim, 2001). This makes web-based advertising efforts more efficient and effective and leads to the expectation of further growth of online advertising (Brackett & Carr, 2001; Hollis, 2005; Sharma & Sheth, 2004). In addition to that, latest developments in Internet advertising suggest that it maximizes its impact when integrated with conventional advertising. Li and Leckenby (2004) suggest that the integration of traditional and new media is nowadays essential for many advertising campaigns, and therefore we need better understanding of cross-media usage and the relative impact of different advertising media. Saeed, Hwang and Grover (2003) found evidence about the complementary effect of website value and offline advertising. In their study, performance was influenced by advertising expenditures complemented by website features facilitating product search, product choice and the product-ownership experience. Besides, Ilfeld and Winer (2002) found that both online and offline advertising increase web traffic and this in turn increases brand equity.

Therefore we test the following hypothesis:

**H1:** The investment in Internet advertising will increase the overall advertising efficiency, having positive effect on sales generation.

### 3. METHODOLOGY

#### 3.1. Data Envelopment Analysis

DEA is a non-parametric, linear programming based technique designed to measure the relative performance of decision making units (DMUs) where the presence of multiple inputs and outputs poses difficulties for comparisons. DEA uses the ratio of weighted inputs and outputs to produce a single measure of productivity (relative efficiency). Efficient DMUs are those for which no other DMU generates as much or more of every output (with a given level of inputs) or uses as little or less of each input (with a given level of outputs). The efficiency of each unit, therefore, is measured in comparison to all other units. An important feature of DEA is that it builds an efficient frontier comprising of all the efficient units, thus allowing comparison to the best performers (Charnes, Cooper & Rhodes, 1978). The efficient DMUs have an efficiency score of one (or 100%), while the inefficient ones have an efficiency score
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of more than one (or more than 100%) in the output oriented DEA model, and less than one but greater than zero in an input oriented model. An input oriented model will look for efficiency by proportionately reducing inputs, while an output oriented model will focus on increasing outputs given the observed inputs consumption. In the case of measuring advertising efficiency, the output oriented model seems to be preferable since advertising budgets are usually preliminarily decided and the goal is maximization of output with the available budget (Low & Mohr, 1999; Piercy, 1987). The DEA models employed in our study are, therefore, output oriented and with variable returns to scale in order to control for possible different economies of scale at which companies operate. The model is presented below.

Max., \( \beta \)

\[
\begin{align*}
\sum_{k=1}^{K} \lambda_k \cdot y_{it} & \geq \beta \cdot y_{it}^o, \quad i = 1, \ldots, I, \\
\sum_{k=1}^{K} \lambda_k \cdot x_{jt} & \leq x_{jt}^o, \quad j = 1, \ldots, J, \\
\sum_{k=1}^{K} \lambda_k &= 1, \\
\lambda_k &\geq 0.
\end{align*}
\]

Where \( \beta \) is the efficiency coefficient for the unit under analysis in period \( t \) (\( \beta = 1 \) indicates that the DMU under analysis is efficient and \( \beta > 1 \) that this DMU is inefficient. \( \beta - 1 \) determines the output growth rate required to reach the frontier), \( y_{it}^o \) is the observed outputs vector of the DMU under analysis in period \( t \) (in our case, \( y_{it}^o \) is a scalar because we only define one output), \( x_{jt}^o \) is the observed inputs vector of the DMU under analysis in period \( t \), \( y_{ik} \) and \( x_{jk} \) refer to outputs and inputs vectors for the \( k \) (\( k=1, \ldots, K \)) DMUs forming the total sample and \( \lambda \) stands for the activity vector.

3.2. The stochastic frontier panel data approach

Stochastic frontier (SF) models were proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). In the beginning, these models were based on cross sectional data, but similar models have also been developed for panel data. The disturbance term in a SF model has two components: one of them is assumed to have a strictly non-negative distribution and is referred to as the inefficiency term; the second is assumed to have a symmetric distribution and this is the idiosyncratic error. In the time-invariant model the inefficiency term is assumed to have a truncated-normal distribution.
Following Kumbhakar and Lovell (2000), assuming that we have observations on \( K \) firms, indexed by \( k=1, \ldots, K \), through \( T \) time periods, indexed by \( t=1, \ldots, T \), over one output and \( J \) inputs, indexed by \( j=1, \ldots, J \), a Cobb-Douglas production frontier with time-invariant technical efficiency can be written as follows:

\[
\ln y_{kt} = \beta_0 + \sum_{j=1}^{J} \beta_j \ln x_{jt} + v_{kt} - u_k
\]  

where \( v_{kt} \) is random statistical noise and \( u_k \) represents technical inefficiency.

SF is a parametric approach, which explicitly considers the stochastic properties of the data (thus correcting some of the drawbacks of DEA), and distinguishes between firm-specific effects, and random shocks or statistical noise. However, SF is not without criticism. Among the problems with stochastic frontiers are that the implementation requires the choice of an explicit functional form for the production function, which is not always appropriate, and that the researcher imposes strong distributional assumptions on the error term. Nevertheless, the stochastic frontier production function is a significant contribution to the econometric modeling of production and the estimation of technical efficiency. We employ the widely used time-invariant fixed-effects SF inefficiency model. The efficiency score is derived from the specification of the unobserved non-negative variables \( u_k \), accounting for inefficiency. The efficiency score is defined as the predicted value of the production given actual calculated \( u_k \), divided by the predicted value if \( u_k = 0 \); therefore the larger the \( u_k \), the larger the value of the inefficiency variables, the lower the efficiency scores.

As indicated previously, the model specification is a Cobb-Douglas production function with the following components:

\[
\ln y_{kt} = \beta_0 + \beta_1 \cdot \ln PR_{kt} + \beta_2 \cdot \ln BROAD_{kt} + \beta_3 \cdot \ln OUTD_{kt} + \beta_4 \cdot \ln INT_{kt} + v_{kt} - u_k
\]

Where:
- \( y_{kt} \) = firm \( k \)'s sales revenue at time \( t \),
- \( PR_{kt} \) = firm \( k \)'s print advertising expenditures at time \( t \),
- \( BROAD_{kt} \) = firm \( k \)'s broadcast advertising expenditures at time \( t \),
- \( OUTD_{kt} \) = firm \( k \)'s outdoor advertising expenditures at time \( t \),
- \( INT_{kt} \) = firm \( k \)'s Internet advertising expenditures at time \( t \),
- \( \beta_0 \) = constant,
- \( \beta_1, \beta_2, \beta_3, \beta_4 \) = coefficients indicating the output elasticity for each input,
- \( v_{kt} \) = random statistical noise, and
- \( u_k \) = technical inefficiency.

Furthermore, it has been suggested that when possible, both DEA and SF models should be used because they do not always produce similar results (e.g. Luo & Donthu, 2005). This is because while DEA is quite flexible, SF assumes inflexible functional form. Comparing the results from the two methods, therefore, would give us deeper understanding of the advertising efficiency.
4. DATA AND RESULTS

4.1. Input and output variables

In this research we focus on tourism cars advertising and sales. Seventeen car dealers operating in Spain have been considered as suitable for the study because of the availability of all the necessary data for input and output variables. Data for input variables have been obtained from the INFOADEX (Information for Advertising Expenditures) database. INFOADEX provides detailed information on advertising expenditures made in Spanish media (Television, newspapers, magazines, Sunday supplements, radio, cinema, Internet and outdoor) as well as in non-conventional media such as direct marketing, mailings, etc. INFOADEX computes advertising expenditure, monitoring daily communication markets and their prices. Initially, two DEA models were constructed. In the first model three categories were included as input variables: 1) print, 2) broadcast and 3) outdoor advertising expenditures. The second DEA model is built on the first one, but it includes one additional input variable – expenditures for Internet advertising (includes only paid advertising, i.e. fees advertisers pay to Internet advertising companies, without considering the companies’ own web pages). This allows comparison of the relative efficiency of the DMUs under different specifications and consequently conclusions can be drawn about the effect of this new variable on the efficiency of advertising. Sales revenue is considered as output variable for the models, and is available from the SABI (Sistema de Análisis de Balances Ibéricos) database. Data has been obtained for three years: 2002, 2003 and 2004, which allows us to track the effect of advertising expenditures on sales over time. Descriptive statistics for the variables are presented in Table 1.

Table 1
Descriptive Statistics for Input and Output Variables.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Mean</th>
<th>St. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
</tr>
<tr>
<td>Print (th €)</td>
<td>4245.5</td>
<td>1732.0</td>
<td>3045.8</td>
</tr>
<tr>
<td>Broadcast (th €)</td>
<td>51.5</td>
<td>2969.4</td>
<td>4310.1</td>
</tr>
<tr>
<td>Outdoor (th €)</td>
<td>0.2</td>
<td>17.5</td>
<td>15.3</td>
</tr>
<tr>
<td>Internet (th €)</td>
<td>0.0</td>
<td>0.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Sales (mln €)</td>
<td>6760</td>
<td>6024</td>
<td>6409</td>
</tr>
</tbody>
</table>

There is a requirement in applying DEA that input and output variables should be positively correlated (Luo & Donthu, 2005). A correlation analysis has been run in order to see the relationship between the variables (see Table 2). As it can be observed, all input variables are positively correlated to the output variables. In most of the cases this relationship is significant (exception is the variable outdoor advertising).

Since our objective is to see not only the short-term efficiency of advertising but also its (possible) change over time as well as the long-run efficiency, we construct a contemporaneous
efficiency frontier\(^1\) for each of the three years as well as one additional frontier which considers accumulated inputs for the three years (2002-2004) and the accumulated output (2002-2004). This allows for measuring the effect of advertising on sales both in a relatively short term (one year) and in a longer three-year period. Therefore, both for Model 1, defined with three inputs (print, broadcast and outdoor), and Model 2, with four inputs (print, broadcast, outdoor and Internet), we include estimations of efficiency frontiers for the years 2002, 2003 and 2004 as well as an additional estimation of the efficiency, which considers the sum of inputs for the three years (2002-2004) and the sum of outputs (2002-2004), thus constructing a long-run efficiency frontier by using the accumulated inputs as well as the accumulated outputs.

### Table 2
Correlations between Input and Output Variables.

<table>
<thead>
<tr>
<th></th>
<th>Print [I]</th>
<th>Broadcast [I]</th>
<th>Outdoor [I]</th>
<th>Internet [I]</th>
<th>Sales Revenues [O]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print [I]</td>
<td>1</td>
<td>0.506(^*)</td>
<td>0.447</td>
<td>0.210</td>
<td>0.740(^{**})</td>
</tr>
<tr>
<td>Broadcast [I]</td>
<td>0.456</td>
<td>1</td>
<td>0.191</td>
<td>0.624(^{**})</td>
<td>0.817(^{**})</td>
</tr>
<tr>
<td>Outdoor [I]</td>
<td>0.459</td>
<td>0.282</td>
<td>1</td>
<td>0.207</td>
<td>0.277</td>
</tr>
<tr>
<td>Internet [I]</td>
<td>0.452</td>
<td>0.325</td>
<td>0.343</td>
<td>1</td>
<td>0.682(^{**})</td>
</tr>
<tr>
<td>Sales Revenues [O]</td>
<td>0.698(^{**})</td>
<td>0.777(^{**})</td>
<td>0.361</td>
<td>0.514(^*)</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

\(^{**}\)Correlation is significant at the 0.01 level (2-tailed).
\(^*\)Correlation is significant at the 0.05 level (2-tailed).
Note: 2004 correlations are above the diagonal. 2003 correlations are below the diagonal.

In order to complement the results obtained by DEA and to compensate for the drawbacks of non-parametric models, we make use of the same variables described above (print, broadcast, outdoor and Internet advertising expenditures, and sales revenue) in a parametric stochastic frontier panel data model, as specified in equation 2. Three-year panel data is used to build stochastic frontier model following the suggestions in the literature to use both DEA and SF to verify to what extent results are consistent across these different methodological approaches.

### 4.2. Results

The results of DEA for Model 1 and Model 2 are reported in Table 3. Model 1 reveals that the efficiency frontier is shaped by DAIMLER CHRYSLER, LAND ROVER and RENAULT, which are efficient in all the years as well as in the cumulative estimation. BMW appears as efficient in the cumulative estimation along with CITROEN, HYUNDAI, PEUGEOT and SEAT. HONDA and ROVER appeared as the most inefficient firms in the cumulative estimation.

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\(^1\) A contemporaneous frontier refers to a reference production set constructed at each point in time from the observations made at that time only, i.e. successive production sets so constructed are unrelated to one another and may or may not overlap in any possible way.
tion. In Model 2 CITROEN, LAND ROVER, RENAULT and VOLVO stand as efficient in all the years as in the first model. However, there are two additional units that appear to be efficient throughout the years considered: HYUNDAI and SEAT. Moreover, HONDA, KIA, PEUGEOT and TOYOTA are efficient according to the cumulative score, although not always efficient during the years. The most inefficient units are NISSAN and ROVER. Similar to Model 1, DAIMLER CHRYSLER, LAND ROVER and RENAULT stand as efficient, but on the efficiency frontier for all the years are also HYUNDAI and SEAT. Moreover, BMW, CITROEN, HONDA, KIA and PEUGEOT are efficient in long term.

Table 3
Efficiency Scores.

<table>
<thead>
<tr>
<th>DMU</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>Model 1 cumulative</th>
<th>Model 1</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>Model 2 cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>123.99%</td>
<td>152.67%</td>
<td>109.16%</td>
<td>100.00%</td>
<td>109.87%</td>
<td>152.67%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>CITROEN</td>
<td>100.00%</td>
<td>172.76%</td>
<td>185.58%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>102.48%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>DAIMLER CHR</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>FIAT</td>
<td>130.72%</td>
<td>151.36%</td>
<td>151.26%</td>
<td>137.98%</td>
<td>130.72%</td>
<td>110.27%</td>
<td>150.01%</td>
<td>118.91%</td>
<td>100.00%</td>
</tr>
<tr>
<td>FORD</td>
<td>159.91%</td>
<td>100.00%</td>
<td>126.32%</td>
<td>126.67%</td>
<td>159.91%</td>
<td>104.38%</td>
<td>117.39%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>HONDA</td>
<td>100.00%</td>
<td>794.95%</td>
<td>690.47%</td>
<td>660.05%</td>
<td>223.47%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>HYUNDAI</td>
<td>141.05%</td>
<td>223.44%</td>
<td>146.95%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>KIA</td>
<td>100.00%</td>
<td>100.00%</td>
<td>297.21%</td>
<td>123.24%</td>
<td>100.00%</td>
<td>179.62%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>LAND ROVER</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>MITSUBISHI</td>
<td>100.00%</td>
<td>145.94%</td>
<td>176.49%</td>
<td>144.42%</td>
<td>100.00%</td>
<td>175.92%</td>
<td>112.17%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>NISSAN</td>
<td>147.79%</td>
<td>223.86%</td>
<td>171.73%</td>
<td>183.86%</td>
<td>147.79%</td>
<td>209.88%</td>
<td>168.14%</td>
<td>183.86%</td>
<td>100.00%</td>
</tr>
<tr>
<td>PEUGEOT</td>
<td>107.09%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>107.09%</td>
<td>100.00%</td>
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</tr>
<tr>
<td>RENAULT</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
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</tr>
<tr>
<td>ROVER</td>
<td>379.02%</td>
<td>342.61%</td>
<td>100.00%</td>
<td>343.25%</td>
<td>379.02%</td>
<td>252.25%</td>
<td>321.38%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>SEAT</td>
<td>100.00%</td>
<td>100.00%</td>
<td>111.08%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>TOYOTA</td>
<td>162.72%</td>
<td>309.80%</td>
<td>225.85%</td>
<td>220.40%</td>
<td>162.31%</td>
<td>162.85%</td>
<td>133.79%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>VOLVO</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>104.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>104.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Mean efficiency score</td>
<td>132.49%</td>
<td>195.14%</td>
<td>176.01%</td>
<td>167.29%</td>
<td>132.08%</td>
<td>120.20%</td>
<td>123.03%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean inefficiency</td>
<td>32.49%</td>
<td>95.14%</td>
<td>76.01%</td>
<td>67.29%</td>
<td>32.08%</td>
<td>20.20%</td>
<td>23.03%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From a methodological point of view, these results call for attention when assessing advertising efficiency since the choice of variables to be included in the model is crucial. Earlier studies have used DEA to reveal the level of inefficiency in advertising; however, when an important input is omitted (Internet does not appear as input in these earlier studies) there is a bias and the model is not fully realistic. Thus, HONDA and HYUNDAI for example, artificially appear as inefficient in Model 1, but in reality are efficient according to Model 2.

Descriptive statistics for the efficiency scores obtained for both models revealed that the mean efficiency score in Model 1 is higher than the one in Model 2 for all the years as well as
for the cumulative estimation. The average inefficiency for Model 1 (cumulative estimation) is 67% and for Model 2 it is 23% (see Table 3).

In order to test whether the differences of the median efficiency scores obtained with the two models are significant, a Wilcoxon test was used. The results are reported in Table 4. As it can be observed, the median scores are significantly different for all the years and the cumulative estimation, with the exception of year 2002 (however, it is very close to 0.10 significance level).

Table 4
Wilcoxon Signed Ranks Test.

<table>
<thead>
<tr>
<th></th>
<th>Test statistics Model 1 – Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>-1.604</td>
<td>0.109</td>
</tr>
<tr>
<td>2003</td>
<td>-2.521</td>
<td>0.012</td>
</tr>
<tr>
<td>2004</td>
<td>-2.934</td>
<td>0.003</td>
</tr>
<tr>
<td>cumulative</td>
<td>-2.366</td>
<td>0.018</td>
</tr>
<tr>
<td>Z (a)</td>
<td>Asymp. Sig. (2-tailed)</td>
<td></td>
</tr>
</tbody>
</table>

(a) Based on positive ranks.

The results of the Wilcoxon test have essential implications for this study. As it has been mentioned, the appropriate choice of input and output variables is very important in DEA. In our case, the Wilcoxon test detects significant differences between Model 1 and Model 2. Therefore, misspecification would occur if we do not consider all relevant input variables in the model. Internet advertising appears to be an important input and leaving it out would result in not fully realistic model.

In Table 5 we present the results from the stochastic frontier panel data analysis. The results reveal a significant positive relationship of broadcast advertising on sales revenue as well as a positive effect of print and Internet advertising on sales revenue, albeit marginally significant.

Table 5
Stochastic Frontier Maximum Likelihood Estimation Results.

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Err.</th>
<th>z</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print</td>
<td>0.171</td>
<td>0.104</td>
<td>1.65</td>
<td>0.100</td>
</tr>
<tr>
<td>Broadcast</td>
<td>0.109</td>
<td>0.038</td>
<td>2.87</td>
<td>0.004</td>
</tr>
<tr>
<td>Outdoor</td>
<td>-0.008</td>
<td>0.018</td>
<td>-0.42</td>
<td>0.674</td>
</tr>
<tr>
<td>Internet</td>
<td>0.011</td>
<td>0.006</td>
<td>1.70</td>
<td>0.089</td>
</tr>
<tr>
<td>Constant</td>
<td>3.191</td>
<td>2.021</td>
<td>1.58</td>
<td>0.114</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-14.870251</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wald chi2(4)</td>
<td>22.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob &gt; chi2</td>
<td>0.0002</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The final step in our analysis is to compare the inefficiency obtained by DEA and SF methods. To make comparison feasible, since we employ a time-invariant panel data stochastic frontier model, we also construct an intertemporal DEA efficiency frontier. An intertemporal frontier is constructed using the whole sample as the reference production set, i.e., we merge the data for the three years under analysis (2002-2004) into one set (Tulkens & Vanden Eckaut, 1995). The results obtained are in line with the findings revealed with the contemporaneous frontiers. There was a statistically significant increase of efficiency when Internet was included in the analysis.

Table 6 reports the comparison between the DEA intertemporal frontier and SF inefficiency results. In the literature these two methods often produce different results. In our case the mean inefficiency with DEA is 71% and with SF – 59%. These results are fairly acceptable because the deterministic method (DEA) provides more inefficiency than the stochastic method (SF). In addition to that, the Wilcoxon test reveals that DEA and SF produce similar results (there is no statistically significant difference between the two scores). To further reassure this finding we run a Paired t test, Spearman rank correlation and Kendall rank correlation. All of them confirm that indeed the results produced by DEA and SF are in concordance.

### Table 6

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEA inefficiency</strong></td>
<td>0.71</td>
<td>1.17</td>
<td>0.00</td>
<td>5.97</td>
</tr>
<tr>
<td><strong>SF inefficiency</strong></td>
<td>0.59</td>
<td>0.28</td>
<td>0.08</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Tests between DEA and SF</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wilcoxon test</td>
<td>Z= -0.750</td>
<td>Sig. 0.453</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired t test</td>
<td>t=0.797</td>
<td>Sig. 0.429</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spearman test</td>
<td>Correlation coef. = 0.308***</td>
<td>Sig. 0.028</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kendall test</td>
<td>Correlation coef. = 0.276***</td>
<td>Sig. 0.008</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** Significant at 0,01 level; ** Significant at 0,05 level.

5. DISCUSSION

With the objective to discover the role of Internet advertising in the advertising mix, this study followed a sequence of techniques. First we constructed contemporaneous efficiency frontiers for the three years of analysis (2002-2004) to reveal the inefficiency levels for each year. We then built a cumulative estimation model that considered the sum of inputs and output from the three years in order to gain deeper insights into the long-term effects of Internet advertising. After that we used panel data SF estimation and we compared the results with the results obtained through DEA. Since the specifications of the cumulative DEA model and the SF model are very different, the inefficiency levels obtained were also very different. That is why we constructed an additional intertemporal DEA efficiency frontier which has a specification closer to the panel data SF model.

The results of this study shed light on a number of important concerns in the contemporary research in marketing. First, similar to other studies regarding advertising efficiency (Färe et al.,
2004; Luo & Donthu, 2001; Luo & Donthu, 2005), with the contemporaneous DEA model we found that companies could have achieved around 20% more sales with the marketing expenditures they have employed. Second, online advertising seems to be a promising way to increase advertising efficiency. The results obtained sustain our hypothesis: the model with inclusion of Internet advertising revealed statistically significant increase of the overall advertising efficiency and the SF model revealed a positive effect of Internet advertising on sales.

Based on the results of Model 1 for years 2002-2004, with constantly increasing inefficiency levels, one could hold that the critics of the productivity of marketing activities are right. Indeed, there is a great deal of inefficiency. However, the cumulative inefficiency for Model 1 is smaller than the inefficiency scores per years. Furthermore, considering the cumulative effect and the inclusion of online advertising in Model 2, ten units appeared as efficient. This result is in line with the claim of the marketers that the performance of marketing expenditures should be measured in the long term, taking into account the accumulated effect.

However, it is important to take into account that the choice of technique to use can lead to very different results. While the cumulative estimation gave a level of inefficiency of around 20%, the inefficiency rose to 70% with the intertemporal frontier. The explanation lies in specification differences between the two models and in the fact that the intertemporal frontier does not control for the different stages at which the companies might be in the implementation of their advertising strategies.

Further, the results from the SF panel data permit us to draw some additional conclusions. Although the coefficient of Internet advertising is not high, it is positive and statistically significant. We should bear in mind that during the first and second year of our dataset not all the companies had investment in Internet advertising (see Table 1). Nevertheless, companies recognize that this is an important medium and in 2004 all of the companies had included online ads in their advertising mix. However, still the most important media are broadcast and print. Internet is complementing the mix and its effect is increasing over the time.

6. CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH LINES

In line with one of the top research priorities in the field of marketing nowadays, this paper focuses on assessing the efficiency of advertising. We first provide a conceptual background to measure advertising efficiency. We employ two methodologies –one parametric stochastic and one non-parametric deterministic– and both of them revealed that Internet has gained its position in the advertising mix.

The application of DEA and SF to a sample of 17 companies from the Spanish automobile industry revealed that there is a room for improving the efficiency of advertising expenditures, as advertising inefficiency was found to be around 20% even considering the accumulated effect of advertising on sales. Marketers should think about ways to improve the efficiency and including Internet in the advertising mix is likely to be one possible way.

However, this study is not free of some limitations. The Cobb-Douglas production function is known as inflexible and therefore other more flexible functional forms (e.g. translog)
should also be considered. On the other hand, the selection of variables is very important in DEA and therefore other output variables such as brand equity, or shareholder value, should be included in the analysis to obtain a better view of the advertising efficiency and the effects on firm performance. This could be a way in which companies benchmark their marketing spending considering the goals set to be achieved (market share, profit, etc.). Moreover, the number of units and the number of years are limited and therefore, future research should expand the sample and the time period. In addition, case studies might complement the analysis by getting more insights about the strategies employed as regards the advertising mix and consequently comparing and linking them to the DEA and SF results. Such a qualitative approach would help address in-depth the questions how and why online advertising helps in increasing the efficiency levels. Moreover, the results of our study could be country-specific and therefore, it is desirable to do comparative studies across countries. Finally, this research presents results based on accumulated advertising expenditures without differentiating among the diverse Internet advertising formats. It is only paid Internet advertising to external parties that is considered in this research, i.e. the investments in advertising in web-sites other than the own webs of the companies. Further research should explore the relative efficiency of the various advertising formats and should include the companies’ own web pages as well since they are considered a powerful marketing tool.

Albena Pergelova tiene un M. S. y es becaria de investigación en el Departamento de Economía de la Empresa, Universitat Autònoma de Barcelona. Sus intereses académicos comprenden los siguientes temas: marketing interactivo, interacciones entre empresas y consumidores, innovación, marketing de ciudades y regiones, y marketing de centros de educación superior.

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