“A model for efficiency analysis of the customer satisfaction process”

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A model for efficiency analysis of the customer satisfaction process

Abstract

It has been acknowledged that customer satisfaction is an important component of a firm's marketing strategies and tactics and has also been shown to be associated with improved outcomes for the firm like greater market share, higher profitability and increased shareholder value. Current research in customer satisfaction, while useful in determining the effectiveness of customer satisfaction creation and its consequences, does not help managers measure the efficiency of their customer satisfaction efforts. This paper presents a model for measuring the efficiency of the customer satisfaction process. It uses a Network Data Envelopment Analysis (Network DEA) model, an extension of the basic DEA approach, as it is consistent with the literature on firm level customer satisfaction formation and its consequences. The authors apply the Network DEA methodology to the *American Customer Satisfaction Index* framework. They estimate this model on 22 firms in the automobile industry using the American Customer Satisfaction Index (ACSI). Our results indicate that at least for certain firms there is room for improvement in efficiency of the customer satisfaction process. We further find that our DEA model is not just correctly identifying which firms are efficient in the customer satisfaction process, but also which firms in their competitive set are using their resources more efficiently than others and whom they could likely imitate.

Keywords: Network DEA, efficiency, customer satisfaction.

Introduction

Customer satisfaction is an important component of a firm's marketing strategies and tactics (Fornell, 2001). Recently, there has been an increased academic interest in customer satisfaction (Anderson and Mittal, 2000). Most academic research in customer satisfaction has focused on the antecedents and consequences of customer satisfaction (Yi, 1991). There is an established research stream looking at both individual-level as well as firm-level causes of customer satisfaction (Oliver, 1980; Westbrook and Oliver, 1991; Anderson, Fornell and Lehmann, 1994). There is also a growing body of literature linking customer satisfaction with individual-level consequences (Anderson and Sullivan, 1993) as well as accounting and financial measures of firm performance including operating margin (Rust, Zahorik and Keiningham, 1994; Bolton 1998, Morgan and Rego 2006), return on investment (Anderson, Fornell and Rust, 1997; Zeithaml, 2000), accounting returns (Ittner and Larcker; 1998, Ittner et al., 2009) and shareholder value (Anderson, Fornell and Mazvancheryl, 2004; Luo and Bhattacharya 2006). However, there is very little work on the efficiency of the customer satisfaction process as opposed to its effectiveness (Soteriou and Zenios, 1999; Kamakura et al., 2002; Mittal et al., 2005). Managers want to know how efficient their current customer satisfaction efforts are, before allocating any additional resources to increase satisfaction levels (Reichheld and Sasser, 1996; Klein and Einstein, 2003). For example, they would like to know if, compared to other firms in their industry, they should be achieving a higher level of customer satisfaction and loyalty, given their current level of spending. In the absence of such research, managers are likely to remain ambivalent towards using satisfaction as a key strategic metric (Srivastava, Shervani and Fahey, 1998; Ambler, 2000).

In this paper, we present a model for measuring the efficiency of the customer satisfaction process. We begin by applying the *Network Data Envelopment Analysis* (Network DEA) methodology of Lewis and Sexton (2004a) to the *American Customer Satisfaction Index* (ACSI) framework of Fornell et al. (1996). A 3-stage Network DEA model is developed that allows us to measure the overall efficiency of the customer satisfaction process as well as efficiencies in each of the stages of the process. We use our model to analyze the relative efficiency of the customer satisfaction process for firms in the automobile industry and investigate if there are any systematic differences in efficiency in the different stages of this process. Our findings indicate that a majority of the firms in the automobile industry may be inefficient in their customer satisfaction efforts. Further, there are significant differences in efficiency across the stages of the process. Our results have several important implications for managers in their usage and allocation of resources to customer satisfaction efforts.

1. The customer satisfaction process

In the well-established customer satisfaction literature, customer satisfaction is posited to be a function of customers' expectation about a product or service (Churchill and Suprenant, 1982; Westbrook, 1981), the perceived quality of the product (Oliver, 1980) as well as its perceived value (Johnson, 1984). The immediate consequences of increased customer satisfaction are lower levels of customer complaints (Hirshman, 1970) and increased customer loyalty (Fornell and Wernerfelt, 1988). This conceptual framework is the basis of the widely used ACSI methodology (Fornell et al.,

The order of authorship is alphabetical and does not reflect the relative contribution of each author.

1996) that consists of a causal model linking these six constructs (see Figure 1).

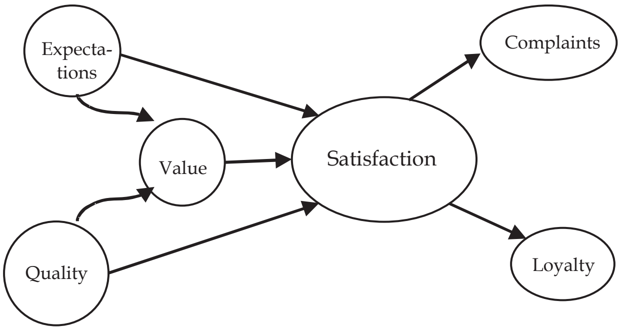

Fig. 1. The ACSI model of the customer satisfaction process

We identify the three distinct stages in the ACSI model as well as the measures that serve as inputs and outputs in each stage. In the first stage, referred to as the Value-Generation stage, customer expectations and perceived quality lead to perceived value. In the second stage, which we call the Satisfaction-Creation stage, this perceived value, together with the level of customer expectations and quality, leads to customer satisfaction. Finally, in the third stage, called the Loyalty-Building stage, customer complaints and loyalty are the consequences of satisfaction. This overall 3-stage framework together with the input and output measures in each stage is shown in Figure 2[1].

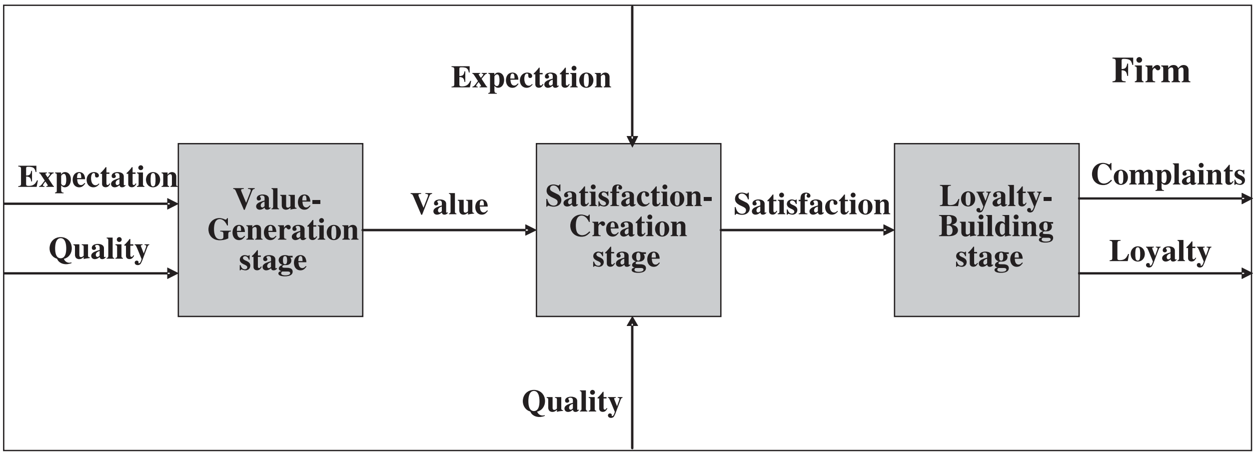

Fig. 2. The 3 stages of the customer satisfaction process

2. Efficiency measurement of the customer satisfaction process

To measure the efficiency of the customer satisfaction process, we turn to the technique of *Data Envelopment Analysis* (DEA). DEA has become a widely used methodology for evaluating relative efficiency in a variety of contexts in such diverse fields as education (Bessent et al., 1982), electricity production and distribution (Färe and Primont, 1984), recreation (Rhodes, 1982), and health care (Sexton et al., 1989; Hollingsworth et al., 1999). Tavares (2002) provides a comprehensive bibliography of the DEA literature. In past years, DEA has been applied to study research issues in marketing including the productivity of retail outlets (Kamakura et al., 1996; Donthu and Yoo, 1998; Dhontu et al., 2005), benchmarking of advertising spending (Luo and Donthu, 2001) the evaluation of the efficiency of the service profit chain (Kamakura et al., 2002), and the revenue efficiencies of a hotel chain (Keh et al., 2006). In a recent study Mittal et al. (2005) investigate the impact of customer satisfaction efficiencies on firm financial performance. They find that firms that achieve both revenue increases and cost performances simultaneously outperform those firms that do not pursue such a dual emphasis.

DEA's mathematical development can be traced to Charnes et al. (1978), who built on the work of Farrell (1957). DEA is designed specifically to measure relative efficiency in situations in which there are multiple inputs and outputs and there is no obvious objective way of aggregating either inputs or outputs into a meaningful index of productive efficiency. In its basic form, DEA considers a collection of *decision-making units* (DMUs) each of which uses certain levels of selected inputs to produce levels of selected outputs. DEA makes no assumptions regarding the manner in which a DMU converts inputs into outputs; each DMU is regarded as a "black box" with respect to its production process. DEA allows for differing assumptions regarding *returns-to-scale*. For example, using the variable returns-to-scale assumption, a DMU will be compared to other DMUs using similar levels of inputs and outputs. In addition, DEA models may be *input-oriented*, *output-oriented*, or *un-oriented*. Input-oriented models identify input reductions that would enable a DMU to become efficient while output-oriented models identify output increases that would achieve the same effect. Un-

[1] While a strict interpretation of the ACSI model would also require a linkage between expectations and quality, our simplified framework allows for a tractable 3-stage DEA model that preserves the relationships of the ACSI model.

oriented models identify a mix of input reductions and output increases that lead to efficiency.

DEA establishes an *efficient frontier* based on the observed best performing DMUs among those in the analysis and evaluates the efficiency of each DMU relative to this frontier. DMUs that lie on the frontier are *efficient*. DEA evaluates the efficiency of a DMU that does not lie on the frontier relative to a linear combination of the efficient DMUs. The efficient DMUs that receive positive weight in this linear combination constitute the *efficient reference set* for the inefficient DMU. This linear combination represents an empirically feasible *reference* DMU that dominates the inefficient DMU under evaluation in the sense that the reference DMU uses no more of each input while producing at least as much of each output as does the DMU under evaluation. The DEA model finds the most productive reference DMU and computes the efficiency of the DMU under evaluation relative to this reference DMU. The basic DEA model for a specific DMU can be formulated as a linear program. A complete DEA requires that one such linear program be solved for each DMU. The result is both the efficient reference set for each DMU and its relative efficiency.

3. The Network DEA model of customer satisfaction

Recent research (Lewis and Sexton, 2004a; Sexton and Lewis, 2003; Castelli et al., 2001; Färe and Grosskopf, 2000) has extended the DEA methodology to enable analysts to look inside processes with complex internal structures. This research enables us to more accurately model complex processes that include several stages such as the customer satisfaction process shown in Figure 2. We can thus measure the efficiency of both the overall process as well as the individual stages.

We present a Network DEA model of the customer satisfaction process based on the methodology in Lewis and Sexton (2004a). We first solve the standard DEA model for each stage of the process. This gives us a relative efficiency measure for each stage. In order to measure the organizational efficiency, we then sequentially resolve the individual DEA models assuming that all previous stages are efficient. For example, while solving the model for the Satisfaction-Creation stage, we use the level of perceived value that the Value-Generation stage would have produced had it been efficient. Similarly, while solving the model for the Loyalty-Building stage we use the level of customer satisfaction that the Satisfaction-Creation stage would have produced had both the Value-Generation stage and the Satisfaction-Creation stage been efficient.

We model each stage of the process using an output orientation. Further, each stage is assumed to have a variable returns-to-scale.

Let k denote the index of the DMU under analysis, d denote the index of the DMUs, $d = 1,\ldots,D$, thus we define that:

- λ_{d1k} = Weight placed on the Value-Generation stage in DMU d by the Value-Generation stage in DMU k;
- λ_{d2k} = Weight placed on the Satisfaction-Creation stage in DMU d by the Satisfaction-Creation stage in DMU k;
- λ_{d3k} = Weight placed on the Loyalty-Building stage in DMU d by the Loyalty-Building stage in DMU k;
- θ_{1k} = Inverse efficiency of Value-Generation stage at DMU k;
- θ_{2k} = Inverse efficiency of Satisfaction-Creation stage at DMU k;
- θ_{3k} = Inverse efficiency of Loyalty-Building stage at DMU k; and
- E_{3k} = Efficiency of the Loyalty-Building stage at DMU k.

Next, following Figure 2, we define the inputs and outputs of the three stages:

- EXP_d = Expectation index of DMU d;
- QUA_d = Quality index of DMU d;
- VAL_d = Value index of DMU d;
- SAT_d = Satisfaction index of DMU d;
- COM_d = Complaints index of DMU d; and
- LOY_d = Loyalty index of DMU d.

We begin by calculating the inverse efficiency scores for each stage. This involves solving three DEA models for each DMU. The Value-Generation stage uses two inputs (*EXP* and *QUA*) and produces one intermediate product (*VAL*). The DEA model for the Value-Generation stage at DMU k is:

$$\text{Maximize } \theta_{1k} \text{ subject to}$$

$$\sum_{d=1}^{D} \lambda_{d1k}(EXP)_d \leq (EXP)_k,$$

$$\sum_{d=1}^{D} \lambda_{d1k}(QUA)_d \leq (QUA)_k,$$

$$\sum_{d=1}^{D} \lambda_{d1k}(VAL)_d \geq \theta_{1k}(VAL)_k,$$

$$\sum_{d=1}^{D} \lambda_{d1k} = 1,$$

$$\lambda_{d1k} \geq 0, \ d = 1,\ldots,D,$$

$$\theta_{1k} \geq 0.$$

Model 1

The Satisfaction-Creation stage uses two inputs (*EXP* and *QUA*) as well as one intermediate product (*VAL*), to produce one intermediate product (*SAT*). Therefore, the DEA model for the Satisfaction-Creation stage at DMU *k* is:

$$
\begin{aligned}
&\textit{Maximize } \theta_{2k} \textit{ subject to} \\
&\sum_{d=1}^{D} \lambda_{d2k} (EXP)_d \le (EXP)_k, \\
&\sum_{d=1}^{D} \lambda_{d2k} (QUA)_d \le (QUA)_k, \\
&\sum_{d=1}^{D} \lambda_{d2k} (VAL)_d \le (VAL)_k, \\
&\sum_{d=1}^{D} \lambda_{d2k} (SAT)_d \ge \theta_{2k} (SAT)_k, \\
&\sum_{d=1}^{D} \lambda_{d2k} = 1, \\
&\lambda_{d2k} \ge 0, \; d = 1, \ldots, D, \\
&\theta_{2k} \ge 0.
\end{aligned}
$$

Model 2

The Loyalty-Building stage uses one intermediate product (*SAT*) and produces two outputs (*LOY*) and (*COM*)[2] The DEA model for the Loyalty-Building stage at DMU *k* is:

$$
\begin{aligned}
&\textit{Maximize } \theta_{3k} \textit{ subject to} \\
&\sum_{d=1}^{D} \lambda_{d3k} (SAT)_d \le (SAT)_k, \\
&\sum_{d=1}^{D} \lambda_{d3k} (COM)_d \le E_{3k} (COM)_k, \\
&\sum_{d=1}^{D} \lambda_{d3k} (LOY)_d \ge \theta_{3k} (LOY)_k, \\
&\theta_{3k} E_{3k} = 1, \\
&\sum_{d=1}^{D} \lambda_{d3k} = 1, \\
&\lambda_{d3k} \ge 0, \; d = 1, \ldots, D, \\
&\theta_{3k}, E_{3k} \ge 0.
\end{aligned}
$$

Model 3

Next, we calculate the organizational inverse efficiency score for each DMU. This involves solving two more DEA models for each DMU. We resolve the model for the Customer-Satisfaction stage using the level of *VAL* the Value-Generation stage could have produced had it been efficient. We denote this by VAL^*. Thus, we modify the third constraint in Model 2 above as follows:

$$\sum_{d=1}^{D} \lambda_{d2k} (VAL)_d \le (VAL)_k^*. \tag{1}$$

Finally, we re-solve the DEA model for the Loyalty-Building stage using the level of *SAT* that the Satisfaction-Creation stage could have produced had both the Value-Generation stage and the Satisfaction-Creation stage been efficient. We denote this by $^*SAT^*$. Thus the first constraint in Model 3 above is modified as follows:

$$\sum_{d=1}^{D} \lambda_{d3k} (SAT)_d \le^* (SAT)_k^*. \tag{2}$$

The value of θ_{3k} for this DEA model is the organizational inverse efficiency.

4. An application to the U.S. automobile industry

4.1. The Data. We use data from the ACSI. The ACSI methodology provides a uniform, independent, customer-based cumulative firm level satisfaction measure for nearly 200 companies in 40 industries over 7 sectors of the U.S. economy. It covers over 40% of the gross domestic product (GDP) of the U.S. and includes both the private sector and the public sector. The raw data for the ACSI is collected using random telephone surveys of customers (at least 200 customers per firm) who have recently consumed the specific brand of product or service of the firm. Respondents are asked questions on 15 measurement variables, which are then used as indicators of the 6 latent variables or constructs shown in Figure 1. Each of these constructs can range from 0 to 100 and are comparable across firms. Fornell et al. (1996) describes the latent variable estimation technique used.

We apply the customer satisfaction efficiency model described above to the U.S. automobile industry. There are 22 such firms in the ACSI sample. We use the indexed data from 1998 for each of the following six constructs: customer expectation (*EXP*), perceived quality (*QUA*), perceived value (*VAL*), customer satisfaction (*SAT*), complaints (*COM*) and loyalty (*LOY*). This data is shown in Table 1.

4.2. Results. *4.2.1. Industry results.* We present the results of applying our output-oriented Network DEA model to the data shown in Table 1. Our analysis yields an inverse efficiency for each of the 3 stages as well as an organizational inverse efficiency score for each of the 22 firms. These results as well as summary statistics are presented in Table 2.

[2] Note that *COM* is a reverse quantity, i.e., larger values indicate lower output levels (Lewis and Sexton, 2004b).

Table 1. Customer satisfaction data for the automobile industry

Firm name	Expectation	Quality	Value	Satisfaction	Complaints	Loyalty
Volvo	90.16	86.10	82.33	81.00	30.65	62.48
Mercedes Benz	93.57	89.01	86.57	85.68	24.08	67.62
BMW	91.05	88.80	85.15	85.72	28.40	61.88
Subaru	86.49	87.42	84.70	83.44	22.04	61.91
Hyundai	75.40	79.23	78.89	71.70	35.17	48.71
Mazda	83.92	83.29	81.09	76.65	27.35	54.80
Volkswagen	84.01	84.40	83.76	78.18	31.17	58.78
Nissan	83.47	83.49	79.97	76.91	28.16	54.50
Honda	88.33	86.75	85.37	81.20	18.47	61.96
Toyota	89.39	89.39	85.40	85.07	20.16	65.61
Chrysler-Jeep/Eagle	82.40	80.64	76.56	76.74	35.95	51.98
Chrysler-Dodge-Plymouth	83.24	83.48	79.19	78.00	28.28	58.05
Chrysler-Chrysler	84.18	83.58	79.29	79.54	28.98	58.04
Ford-Lincoln-Mercury	87.06	87.76	83.67	83.41	23.79	62.50
Ford-Ford	83.18	83.48	79.40	77.27	24.29	56.70
GM-Saturn	84.81	89.84	88.65	84.75	16.33	64.38
GM-Pontiac	83.13	83.17	78.78	76.01	30.71	53.29
GM-Chevrolet-GEO	83.89	84.56	80.15	79.25	26.94	58.50
GM-Buick	87.58	88.65	84.87	84.02	31.41	66.60
GM-Oldsmobile	85.72	87.24	84.07	82.38	28.05	61.27
GM-Cadillac	92.08	91.51	87.01	88.36	25.21	70.63
GM-GMC	83.12	81.72	76.47	77.98	32.10	60.90

Table 2. Inverse efficiency scores for each automobile firm and industry-wide summary statistics

Firm name	Inverse efficiency scores			
	Value-Generation	Satisfaction-Creation	Loyalty-Building	Firm-level
Volvo	1.0459	1.0220	1.0198	1.0467
Mercedes Benz	1.0241	1.0027	1	1.0034
BMW	1.0411	1	1.0984	1.0984
Subaru	1.0331	1	1.0459	1.0459
Hyundai	1	1	1	1
Mazda	1.0256	1.0365	1.0258	1.1115
Volkswagen	1.0068	1.0274	1.0308	1.0694
Nissan	1.0426	1.0330	1.0434	1.1210
Honda	1.0167	1.0273	1	1.0289
Toyota	1.0381	1.0094	1.0051	1.0149
Chrysler-Jeep/Eagle	1.0316	1	1.1211	1.1211
Chrysler-Dodge-Plymouth	1.0350	1.0159	1.0220	1.0574
Chrysler-Chrysler	1.0351	1.0025	1.0633	1.0668
Ford-Lincoln-Mercury	1.0334	1.0041	1.0405	1.0479
Ford-Ford	1.0323	1.0259	1	1.0578
GM-Saturn	1	1	1	1
GM-Pontiac	1.0363	1.0389	1.0469	1.1433
GM-Chevrolet-GEO	1.0369	1.0117	1.0425	1.0647
GM-Buick	1.0298	1.0074	1	1.0098
GM-Oldsmobile	1.0220	1.0081	1.0542	1.0649
GM-Cadillac	1.0189	1	1	1
GM-GMC	1.0477	1	1	1
MEAN	1.0288	1.0124	1.03	1.0534
SD	0.0135	0.0135	0.0336	0.0444
MINIMUM	1	1	1	1
MEDIAN	1.0327	1.0078	1.0239	1.0526
MAXIMUM	1.0477	1.0389	1.1211	1.1433

We expect that a mature and well-developed industry like the U.S. automobile industry would be fairly efficient. Our results confirm this as the mean inverse efficiencies for the 3 stages are 1.028, 1.012 and 1.030 respectively. The organizational mean inverse efficiency is 1.053. While these inverse efficiency scores seem relatively small, we must remember that the implications of improving efficiency by even a small amount can have a significant impact on the financial performance of a firm. For example, Kamakura et al. (2002) find a strong link between increasing customer loyalty and increasing firm profitability. In addition, Anderson, Fornell and Mazvancheryl (2004) find that increasing customer satisfaction by just one point (for firms in the ACSI sample) increases shareholder value, on average, by $ 275 million. Also, only a few of the firms are efficient in any given stage, indicating that most firms in our sample have at least some room for improvement. Specifically, only 2 out of 22 firms (9.1%) are efficient in the first or the Value-Generation stage. Only 7 out of 22 firms (31.8%) are efficient in the Satisfaction-Creation stage and only 8 out of 22 firms (36.3%) are efficient in the final or Loyalty-Building stage. Organizationally, just 4 firms out of 22 (18.1%) are efficient. Even among these 4 firms, only 2 (GM-Saturn and Hyundai) are efficient in all 3 stages. The other 2 organizationally efficient firms (GMC and GM-Cadillac) can improve their efficiency in the Value-Generation stage. In particular, GMC has an inverse efficiency score of 1.0477 in the Value-Generation stage and therefore may want to focus efforts on this stage.

The spread of the inverse efficiency scores as measured by the standard deviation, shows that the Loyalty-Building stage has the highest standard deviation (0.034) relative to the Value-Generation stage (0.0135) and the Satisfaction-Creation stage (0.0135). The standard deviation of organizational inverse efficiency scores is 0.044. Thus, in order to improve the overall efficiency of the customer satisfaction process, managers might need to focus their efforts on Loyalty-Building as well as on Value-Generation. This finding is also supported by the literature, which suggests that building loyalty might be harder than generating value or creating customer satisfaction (Bloemer and Kasper, 1995).

4.2.2. Firm-level results. For each inefficient DMU in each stage as well as for the organization, the Network DEA model provides us with an efficient reference DMU, which is a linear combination of efficient DMUs in that stage. This reference DMU uses no more of each input and produces at least as much of each output as does the inefficient DMU. The efficient DMUs in each stage reference themselves with a weight of 1. The reference sets for the Value-Generation stage are shown in Table 3, for the Satisfaction-Creation stage are shown in Table 4 and for the Loyalty-Building stage are shown in Table 5. Finally, the reference sets for the organization are shown in Table 6.

Table 3. Value-Generation stage reference set weights and inverse efficiency scores

Firm name	Reference set weights		
	Hyundai	GM-Saturn	Inverse efficiency
Volvo	0.2599	0.7401	1.0459
Mercedes Benz	0	1	1.0241
BMW	0	1	1.0411
Subaru	0.1177	0.8823	1.0331
Hyundai	1	0	1
Mazda	0.5626	0.4374	1.0256
Volkswagen	0.4430	0.5570	1.0068
Nissan	0.5411	0.4589	1.0426
Honda	0.1898	0.8102	1.0167
Toyota	0	1	1.0381
Chrysler-Jeep/Eagle	0.9912	0.0088	1.0316
Chrysler-Dodge-Plymouth	0.6852	0.3148	1.0350
Chrysler-Chrysler	0.6744	0.3256	1.0351
Ford-Lincoln-Mercury	0.2241	0.7759	1.0334
Ford-Ford	0.6852	0.3148	1.0323
GM-Saturn	0	1	1
GM-Pontiac	0.7186	0.2814	1.0363
GM-Chevrolet-GEO	0.5688	0.4312	1.0369
GM-Buick	0.1282	0.8718	1.0298
GM-Oldsmobile	0.2801	0.7199	1.0220
GM-Cadillac	0	1	1.0189
GM-GMC	0.8748	0.1252	1.0477

Table 4. Satisfaction-Creation stage reference set weights and inverse efficiency scores

Firm name	Reference set weights							
	BMW	Subaru	Hyundai	Chrysler-Jeep/Eagle	GM-Saturn	GM-Cadillac	GM-GMC	Inverse efficiency
Volvo	0.6191	0	0	0	0	0	0.3809	1.0220
Mercedes Benz	0.9254	0	0	0	0	0.0746	0	1.0027
BMW	1	0	0	0	0	0	0	1
Subaru	0	1	0	0	0	0	0	1
Hyundai	0	0	1	0	0	0	0	1
Mazda	0	0.2152	0	0	0.0431	0	0.7417	1.0365
Volkswagen	0	0.1520	0	0	0.2236	0	0.6244	1.0274
Nissan	0	0	0.0030	0	0.2190	0	0.7780	1.0330
Honda	0.4159	0	0	0	0	0.2132	0.3709	1.0273
Toyota	0	0.2354	0	0	0.0541	0.6009	0.1096	1.0094
Chrysler-Jeep/Eagle	0	0	0	1	0	0	0	1
Chrysler-Dodge-Plymouth	0	0	0.0328	0	0.2171	0	0.7501	1.0159
Chrysler-Chrysler	0	0.3076	0	0	0.0130	0	0.6795	1.0025
Ford-Lincoln-Mercury	0	0	0	0	0.2520	0.3921	0.3559	1.0041
Ford-Ford	0	0	0.0427	0	0.2307	0	0.7266	1.0259
GM-Saturn	0	0	0	0	1	0	0	1
GM-Pontiac	0	0	0.0387	0	0.1820	0	0.7793	1.0389
GM-Chevrolet-GEO	0	0	0	0	0.2724	0.0340	0.6935	1.0117
GM-Buick	0	0	0	0	0.3101	0.4391	0.2509	1.0074
GM-Oldsmobile	0	0.1884	0	0	0.3658	0.1508	0.2949	1.0081
GM-Cadillac	0	0	0	0	0	1	0	1
GM-GMC	0	0	0	0	0	0	1	1

Table 5. Loyalty-Building stage reference set weights and inverse efficiency scores

Firm name	Reference set weights								
	Mercedes Benz	Hyundai	Honda	Ford-Ford	GM-Saturn	GM-Buick	GM-Cadillac	GM-GMC	Inverse efficiency
Volvo	0	0	0.0041	0	0	0	0.2891	0.7067	1.0198
Mercedes Benz	1	0	0	0	0	0	0	0	1
BMW	0	0	0.0965	0	0	0	0.7159	0.1877	1.0984
Subaru	0	0	0.6444	0	0	0	0.3257	0.0299	1.0459
Hyundai	0	1	0	0	0	0	0	0	1
Mazda	0	0.1278	0	0.7469	0	0	0	0.1253	1.0258
Volkswagen	0	0	0.0822	0.0943	0	0	0	0.8235	1.0308
Nissan	0	0.0933	0	0.6907	0	0	0	0.2160	1.0434
Honda	0	0	1	0	0	0	0	0	1
Toyota	0	0	0.2714	0	0.3742	0	0.3544	0	1.0051
Chrysler-Jeep/Eagle	0	0.1884	0	0.0781	0	0	0	0.7335	1.1211
Chrysler-Dodge-Plymouth	0	0	0.0957	0.4002	0	0	0	0.5041	1.0220
Chrysler-Chrysler	0	0	0.3315	0	0	0	0.0477	0.6208	1.0633
Ford-Lincoln-Mercury	0	0	0.4900	0	0	0	0.3712	0.1388	1.0405
Ford-Ford	0	0	0	1	0	0	0	0	1
GM-Saturn	0	0	0	0	1	0	0	0	1
GM-Pontiac	0	0.2617	0	0.4575	0	0	0	0.2808	1.0469
GM-Chevrolet-GEO	0	0	0.4122	0.0824	0	0	0	0.5054	1.0425
GM-Buick	0	0	0	0	0	1	0	0	1
GM-Oldsmobile	0	0	0.2235	0	0	0	0.3549	0.4216	1.0542
GM-Cadillac	0	0	0	0	0	0	1	0	1
GM-GMC	0	0	0	0	0	0	0	1	1

Table 6. Firm-level reference set weights and inverse efficiency scores

Firm name	Reference set weights									
	Mercedes Benz	Hyundai	Honda	Chrysler-Chrysle	Ford-Ford	GM-Saturn	GM-Buick	GM-Cadillac	GM-GMC	Inverse efficiency
Volvo	0	0	0	0	0	0	0.1091	0.3983	0.4927	1.0467
Mercedes Benz	0	0	0.2463	0	0	0	0	0.6883	0.0654	1.0034
BMW	0	0	0.0965	0	0	0	0	0.7159	0.1877	1.0984
Subaru	0	0	0.6444	0	0	0	0	0.3257	0.0299	1.0459
Hyundai	0	1	0	0	0	0	0	0	0	1
Mazda	0	0	0.4815	0	0.1199	0	0	0	0.3986	1.1115
Volkswagen	0	0	0.1211	0	0	0	0	0.1881	0.6908	1.0694
Nissan	0	0	0.4704	0	0.0724	0	0	0	0.4571	1.1210
Honda	0	0	0.4513	0	0	0.4749	0	0.0738	0	1.0289
Toyota	0	0	0.0716	0	0	0.5478	0	0.3806	0	1.0149
Chrysler-Jeep/Eagle	0	0.1884	0	0	0.0781	0	0	0	0.7335	1.1211
Chrysler-Dodge-Plymouth	0.0023	0	0.3892	0	0	0	0	0.0049	0.6037	1.0574
Chrysler-Chrysler	0	0	0.3274	0	0	0	0	0.0685	0.6041	1.0668
Ford-Lincoln-Mercury	0	0	0.4771	0	0	0	0	0.4201	0.1028	1.0479
Ford-Ford	0	0	0.4762	0	0.3391	0	0	0	0.1848	1.0578
GM-Saturn	0	0	0	0	0	1	0	0	0	1
GM-Pontiac	0	0	0.3394	0	0.0791	0	0	0	0.5815	1.1433
GM-Chevrolet-GEO	0	0	0.4517	0	0	0	0	0.0931	0.4552	1.0647
GM-Buick	0	0	0	0	0	0	0.8374	0.1626	0	1.0098
GM-Oldsmobile	0	0	0.2082	0	0	0	0	0.4240	0.3678	1.0649
GM-Cadillac	0	0	0	0	0	0	0	1	0	1
GM-GMC	0	0	0	0	0	0	0	0	1	1

Consider the example of Mazda. We define Mazda has an inverse efficiency score of 1.026 in the Value-Generation stage. In this stage, Mazda references two efficient firms, Hyundai and Saturn with weights of 0.563 and 0.437, respectively. A reference DMU formed by combining Hyundai and Saturn in the respective proportions uses hypothetical input levels of 84.01 and 79.29 of quality and expectation, respectively and produces a hypothetical output of value equal to 83.16. If we look at the actual inputs and output of Mazda in this stage (quality = 84.01; expectation = 83.92 and value = 81.09), we see that the reference DMU uses no more of each input while producing a higher level of output. The ratio of the hypothetical output to the actual output is the inverse efficiency score for Mazda. Thus, Mazda has room for improvement in creating value. Table 7 presents this analysis along with similar analyses for the Satisfaction-Creation and the Loyalty-Building stages.

Table 7. Stage-level DEA results for Mazda

Inverse efficiency of the Value-Generation stage							
Firm name	Mazda	Hypothetical	Ratio	Firm name	Hyundai	GM-Saturn	
Expectation	83.92	79.52		Expectation	75.40	84.81	
Quality Adj	84.01	84.01		Quality Adj	79.95	89.24	
Value	81.09	83.16	1.0256	Value	78.89	88.65	
		Inverse efficiency	1.0256	Weights	0.5626	0.4374	
Inverse efficiency of the Satisfaction-Creation stage							
Firm name	Mazda	Hypothetical	Ratio	Firm name	Subaru	GM-Saturn	GM-GMC
Expectation	83.92	83.92		Expectation	86.49	84.81	83.12
Quality	83.29	83.29		Quality	87.42	89.84	81.72
Value	81.09	78.77		Value	84.70	88.65	76.47
Satisfaction	76.65	79.45	1.0365	Satisfaction	83.44	84.75	77.98
		Inverse efficiency	1.0365	Weights	0.2152	0.0431	0.7417
Inverse efficiency of the Loyalty-Building stage							
Firm name	Mazda	Hypothetical	Ratio	Firm name	Hyundai	Ford-Ford	GM-GMC
Satisfaction	76.65	76.65		Satisfaction	71.70	77.27	77.98
Complaints	27.35	26.66	1.0258	Complaints	35.17	24.29	32.10
Loyalty	54.80	56.21	1.0258	Loyalty	48.71	56.70	60.90
		Inverse efficiency	1.0258	Weights	0.1278	0.7469	0.1253

In many applications of DEA, there are factors, called *site characteristics*, that can influence the ability of a DMU to operate efficiently but that are beyond the control of the DMU's management. In our application, we consider whether the automobile firm is domestic or foreign as a site characteristic. Sexton et al. (2002) and Fried et al. (1999) present similar but distinct approaches for dealing with site characteristics in standard DEA models. The method of Sexton et al. (2002) requires us to adjust quality in the Value-Generation stage. Thus, in Table 7 above and Table 8 below, we use the adjusted level of quality as an input to the Value-Generation stage. None of the other ACSI data requires adjustment.

In determining the organizational inverse efficiency scores, the model uses the output of the reference DMU in a stage as the input to the next stage assuming all previous stages of the process are efficient. Thus, in Mazda's case, the level of value (= 83.16) that would have been produced by the Value-Generation stage had it been efficient, is used as an input to the Satisfaction-Creation stage. In turn, the level of satisfaction (= 79.45) that would have been produced by the Satisfaction-Creation stage had both the Value-Generation and Satisfaction-Creation stages been efficient, is used as an input to the Loyalty-Building stage. This produces the levels of complaints and loyalty of a reference DMU equal to 24.60 and 60.91, respectively.

The organizational inverse efficiency score of 1.1115 is the minimum of the so-called *factor inverse efficiencies* of each variable. In this particular case, the factor inverse efficiencies for both loyalty and complaints are identical. However, this is not necessarily the case in general. Table 8 shows the results of this analysis.

Since we are using a variable returns-to-scale model, the reference sets consist of firms that operate at a comparable scale, i.e., they use similar levels of inputs and outputs. For example, if we look at Mercedes in the Satisfaction-Creation stage, we see that it references two of the efficient firms in that stage, BMW and Cadillac (see Table 4) with weights of 0.925 and 0.075, respectively. However, Mercedes does not reference Hyundai, which is another efficient firm. As shown in Table 9, the input and output levels of both BMW and Cadillac are very similar to those of Mercedes. On the other hand, the input and output levels of Hyundai are very different from those of Mercedes.

Table 8. Firm-level DEA results for Mazda

Organizational inverse efficiency							
Firm name	Mazda	Hypothetical	Ratio	Firm name	Hyundai	GM-Saturn	
Expectation	83.92	79.52		Expectation	75.40	84.81	
Quality Adj	84.01	84.01		Quality Adj	79.95	89.24	
Value	81.09	83.16	1.0256	Value	78.89	88.65	
		Inverse efficiency	1.0256	Weights	0.5626	0.4374	
Firm name	Mazda	Hypothetical	Ratio	Firm name	Subaru	GM-Saturn	GM-GMC
Expectation	83.92	83.92		Expectation	86.49	84.81	83.12
Quality	83.29	83.29		Quality	87.42	89.84	81.72
Value	83.16	78.77		Value	84.70	88.65	76.47
Satisfaction	76.65	79.45	1.0365	Satisfaction	83.44	84.75	77.98
		Inverse efficiency	1.0365	Weights	0.2152	0.0431	0.7417
Firm name	Mazda	Hypothetical	Ratio	Firm name	Honda	Ford-Ford	GM-GMC
Satisfaction	79.45	79.45		Satisfaction	81.20	77.27	77.98
Complaints	27.35	24.60	1.1115	Complaints	18.47	24.29	32.10
Loyalty	54.80	60.91	1.1115	Loyalty	61.96	56.70	60.90
		Inverse efficiency	1.1115	Weights	0.481	0.119	0.3986

Table 9. Satisfaction-Creation stage input/output data for Mercedes relative to BMW, Cadillac, and Hyundai

Firm name	Expectation	Quality	Value	Satisfaction
Mercedes Benz	93.57	89.01	86.57	85.68
BMW	91.05	88.80	85.15	85.72
GM-Cadillac	92.08	91.51	87.01	88.36
Hyundai	75.40	79.23	78.89	71.70

Discussion and conclusions

The above research presents an appropriate methodology, i.e., Network DEA to measure the overall efficiency as well as stage-by-stage efficiency of an important marketing process, i.e., the customer satisfaction process. This efficiency measurement complements the existing research on the consequences of customer satisfaction that focuses almost exclusively on the effectiveness of the customer satisfaction process. Further, we demonstrate an application of our methodology using data on the automobile industry from a widely accepted customer satisfaction database, i.e., ACSI. We find that while efficiency scores are relatively "good" across the industry, there are some differences in efficiency scores across the different stages of the process as well as across individual firms.

Our industry-level results demonstrate that even in a mature and competitive industry like the U.S. auto industry, customer satisfaction efforts of the firms are, overall, not efficient with the inefficiencies being greatest at the Loyalty-Building stage. This suggests that recent efforts by automobile manufacturers to 'buy' customer loyalty through large amounts of cash discounts and other financial incentives might actually be a very inefficient tool if the objective is to build customer loyalty, rather than increase short-term sales.

The firm-level results are also illuminating. One of the interesting results is that firms that are efficient at the Value-Generation stage (Hyundai and Saturn) are relatively recent entrants that are positioned in the value segment of the U.S. automobile market. Similarly, firms that have long been positioned in the luxury segment of the market like Mercedes and GM-Cadillac also seem to be the most efficient in the Loyalty-Building stage. While further research is needed to confirm this, our findings seem to suggest that a firm's successful position is related to its' efficient use of resources in creating that positioning.

The reference weights that are shown in Table 6 are also interesting. The inefficient firms typically place most of their reference weights on efficient firms that would be considered as being in the same competitive set. For example, Mazda places most of its reference weight on Honda and GMC. Mercedes on the other had places most of its weight on Cadillac. This suggests that our DEA model is not just correctly identifying which firms are efficient in the customer satisfaction process, but also which firms in their competitive set are using their resources more efficiently and whom they could likely imitate.

Finally, we use Figures 3 and 4 to present perceptual maps comparing measures of efficiency and effectiveness in the automobile industry. In both figures, we use the firm-level inverse efficiency as the efficiency measure. In Figure 3 we use satisfaction as the measure of effectiveness, while in Figure 4 we use loyalty as the measure of effectiveness. The vertical and horizontal lines in each map represent median values. Firms in the lower-right region of the maps (Buick, Cadillac, Honda, Lincoln/Mercury, Mercedes Benz, Saturn, Subaru, Toyota, and Volvo) are both efficient and effective. Firms in the upper-right region of the maps (BMW and Oldsmobile) are inefficient but effective. Firms in the upper-left region of the maps (Chevrolet/GEO, Chrysler, Dodge/Plymouth, Ford, Jeep/Eagle, Mazda, Nissan, Pontiac, and Volkswagon) are inefficient and ineffective. Finally, firms in the lower-left region of the maps (GMC and Hyundai) are efficient but ineffective.

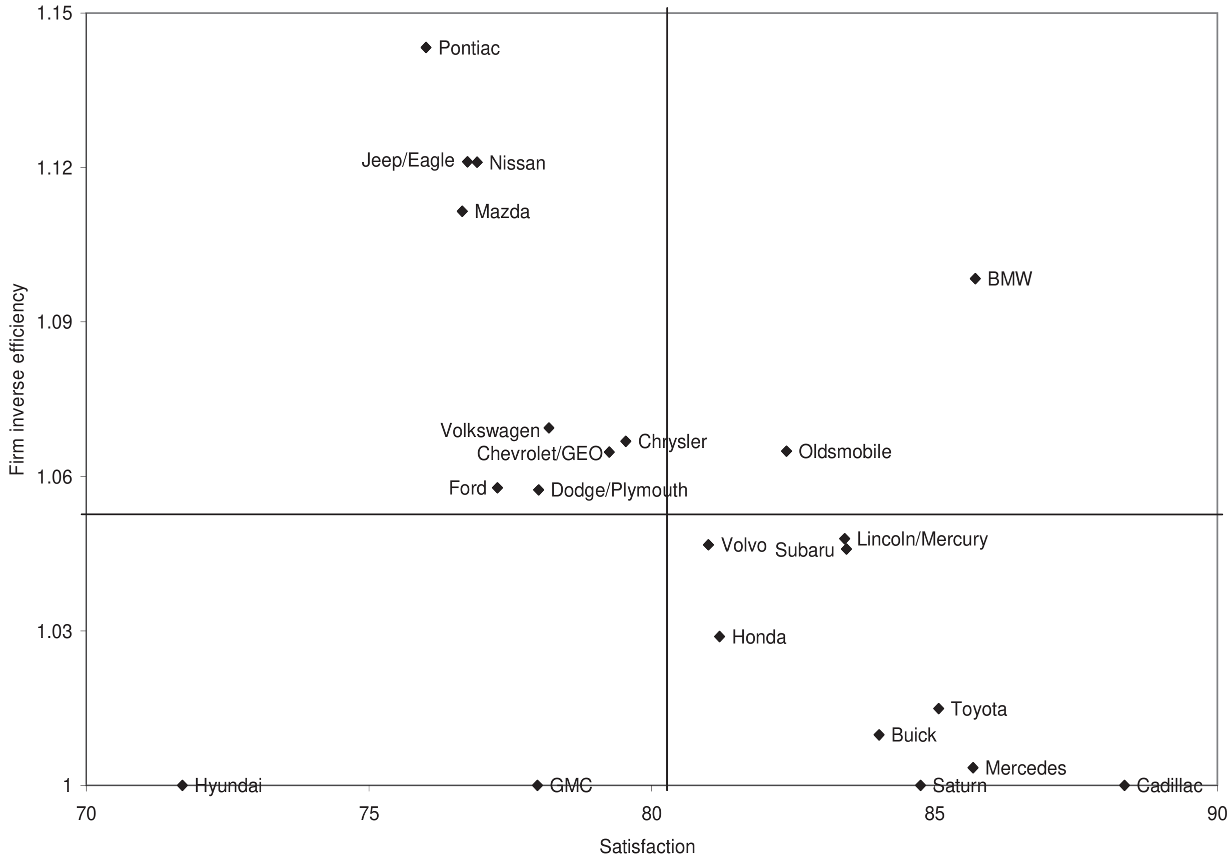

Fig. 3. Perceptual map of firm-level inverse efficiency versus customer satisfaction

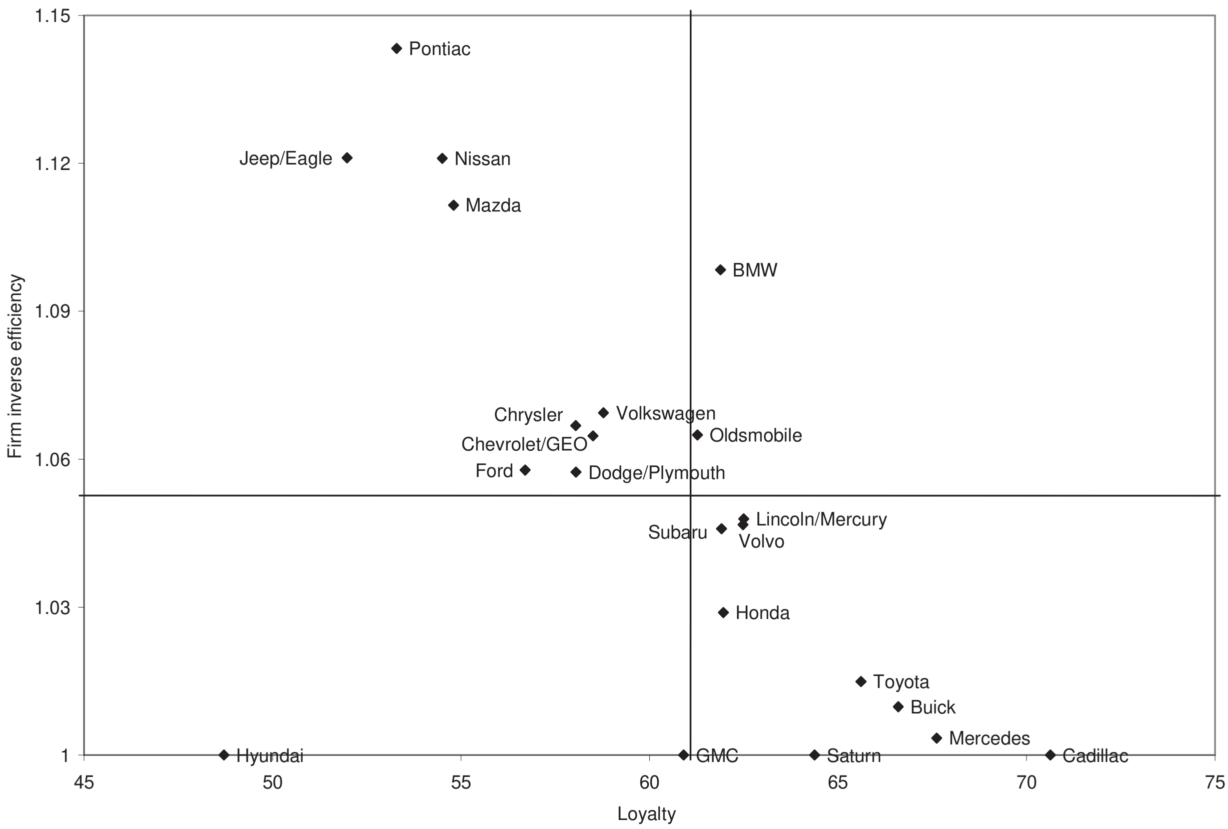

Fig. 4. Perceptual map of firm-level inverse efficiency versus loyalty

Managerial implications

Our Network DEA model may allow managers to allocate resources across the stages of the customer satisfaction process so as to better utilize the resources at their disposal. Managers can also complement such an analysis with internal profitability measures to decide whether or not to allocate additional resources to satisfaction and if so, where. Current thinking has focused almost solely on increasing customer satisfaction or loyalty levels without much thought for the resources being utilized in achieving such levels (Hauser et al., 1994). This could be one of the reasons for the conflicting findings on whether or not satisfaction or loyalty leads to higher levels of profitability (Klein and Einstein, 2003). Efficiency analyses such as ours have the potential to increase profitability by pointing to areas in which current resources can be more efficiently utilized.

But there are practical issues to be considered as well. To be able to implement this approach, managers need detailed data on all stages of the customer satisfaction, meaning that they will need to put into place a customer satisfaction process similar to the one described in Fornell (2001). This may prove to be both expensive and time consuming for managers in smaller firms.

Limitations and future research

It is important to remember that our analysis does not indicate why a certain firm is efficient or inefficient, nor does it provide us with specific actionable guidelines to improve efficiency. For example, our research may indicate that for a given level of customer satisfaction, the firm could have achieved a higher level of loyalty and a lower level of complaints. However, this alone cannot tell managers how to choose from the several possible alternative choices they may have to achieve these levels of outputs. An understanding of the context of a process is necessary to help managers make such decisions.

An important extension of our research would be to link the efficiency analysis of the customer satisfaction process with a firm's effectiveness in creating profits and long-term value. It would be useful to see if the efficient firms are the ones that are effective as well. Also, are there any stages of the customer satisfaction process where efficiency is more crucial to a firm being more effective than others?

Recognizing that time effects such as lags and persistence play an important role in the customer satisfaction process, it may be useful to extend the Network DEA methodology to incorporate such effects using multi-period data. Finally, another important area for future research is to apply the Network DEA model to other industries and contexts, either using ACSI data or to study related processes like the creation of customer lifetime value and profits (Rust et al., 2002).

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