MODELING THE EFFECTS OF A SERVICE GUARANTEE ON PERCEIVED SERVICE QUALITY USING ALTERNATING CONDITIONAL EXPECTATIONS (ACE)

Chee-Chuong Sum*
Department of Decision Sciences
NUS Business School
National University of Singapore
BIZ 1 Bldg, 1 Business Link
Singapore 117951
Phone: (65)-6874-3182
Fax: (65)-6779-2621
email: bizsumcc@nus.edu.sg

Yang-Sang Lee
c/o Department of Decision Sciences
NUS Business School
National University of Singapore
BIZ 1 Bldg, 1 Business Link
Singapore 117951

Julie M Hays
Graduate School of Business
University of St Thomas
Minneapolis, MN
USA
email: jmhays@stthomas.edu

Arthur V Hill
Operations and Management Science Department
Curtis L. Carlson School of Management
University of Minnesota
Minneapolis, MN
USA
email: ahill@csom.umn.edu

August 10, 2002

* Correspondence author
MODELING THE EFFECTS OF A SERVICE GUARANTEE ON PERCEIVED SERVICE QUALITY USING ALTERNATING CONDITIONAL EXPECTATIONS (ACE)

ABSTRACT

This paper addresses the dearth of empirical research on the relationship between service guarantee and perceived service quality (PSQ). In particular, we examine the moderating effects of a service guarantee on PSQ. While a recent study provided empirical evidence that service quality is affected by service guarantee and employee variables such as employee motivation/vision and learning through service failure, the nature and form of the relationships between these variables remain unclear. Knowledge of these relationships can assist service managers to allocate resources more judiciously, avoid pitfalls, and establish more realistic expectations. Data was obtained from employees and customers of a multinational hotel chain that has implemented a service guarantee program in 89 of its hotels in America and Canada. As the employee variables could affect performance in a non-linear fashion, we relaxed the assumption of model linearity by using the Alternating Conditional Expectations (ACE) algorithm to arrive at a better-fitting, non-linear regression model for PSQ. Our findings indicate the existence of significant non-linear relationships between PSQ and its determinant variables. The ACE model also revealed that service guarantee interacts with the employee variables to affect PSQ in a non-linear fashion. The non-linear relationships present new insights into the management of service guarantees and PSQ. Explanations and managerial implications of our results are presented and discussed.

Subject Areas: service quality, service guarantee, ACE, non-linear regression
INTRODUCTION

To cope with maturing markets, stiffer competition and increasing customer expectations, many service organizations are forced to adopt proactive strategies to become more customer-driven and offer higher service quality. Service quality is now regarded by many service organizations as one key means to achieve competitive advantage (Hart, Schlesinger & Maher, 1992; Zeithaml, Parasuraman & Berry, 1990).

Customer perception of superior service quality has been found to increase customer satisfaction (Oh & Parks, 1997; Cronin & Taylor, 1992; Anderson & Sullivan, 1990), market share and profitability (Capon, Farley & Hoenig, 1990; Phillips, Chang & Buzzell, 1983). In turn, customer satisfaction leads to increased customer loyalty/retention and positive economic outcomes for the organization (Fornell et al., 1996; Ittner & Laraker, 1996; Anderson, Fornell & Lehmann, 1994; Johnson & Fornell, 1991).

A popular tool for marketing and achieving higher service quality is the service guarantee (Harvey, 1998; Ettorre, 1994; Hart, 1988). While product guarantees (warranties) have existed since the nineteenth century, the concept of service guarantees is relatively new. A service guarantee is a promise by a company to compensate the customer in some way if the defined level of service delivered is not duly met. The intangibility and unpredictability of services generally cause consumers to perceive a higher risk associated with a service (Parasuraman, Zeithaml & Berry, 1985; Guseman, 1981). With a good service guarantee, such perception can be reduced credibly by promising a minimum level of service quality that a customer can expect from the service encounter (Barsky, 1995; Maher, 1991; Rose, 1990).

A service guarantee can force organizations to focus on the needs of customers and re-engineer their processes to support the guarantee (Ettorre, 1994). By punishing the organization for service below the expected quality level, a service guarantee forces the firm to uncover the
roots of service delivery problems and improve service quality (Maher, 1991). Berry (1995) proclaims that a well-conceived service guarantee can impact the operations and culture of the organization.

Implementation of a service guarantee program, however, incurs high financial costs that could make or break an organization (Wirtz, 1998; Hart, 1993; Maher, 1991). Successful implementation of a service guarantee would require managerial emphasis and proper allocation of resources on key determinant variables.

A large base of anecdotal evidence is available to suggest that service guarantees improve business performance. Examples include British Airways, L. L. Bean, Domino’s Pizza, Citibank (Hart, 1988), Colorado Bank (Browning, 1989), Embassy Suites and Harrah’s Casinos (Rose, 1990), Hampton Inns (Rust et al., 1992), Delta Dental Plan, JWS Technologies and Marriott Hotels (Hart, 1993) and Radisson Hotels (Hays and Hill, 2001b; Swanson et al., 1999; Hill et al., 1998).

Still, research on service guarantee suffered from several shortcomings. First, prior research has focused on recommending criteria in the design of service guarantees, stating the benefits of guarantees and documenting success stories. Though these studies have advanced the service literature, they remained anecdotal and case study based, and did not provide a comprehensive analysis of the relationship between service guarantee and service quality. Secondly, existing literature has little rigorous and methodical empirical research that relates service guarantee and service quality.

Thirdly, while the literature has established that employee variables (e.g., employee motivation and vision, learning) are key determinants of service quality, and that service guarantee affects these employee variables, the manner in which service guarantee interacts with the employees variables to impact service quality has not been adequately investigated. The
effects of employee variables on service quality and organizational performance are well documented (e.g., Lovelock, 1994; Farber & Wycoff, 1991; Collier, 1994; Hostage, 1975; Parasuraman et al., 1988; Locke & Latham, 1984; Bowen & Lawler, 1992; Marquardt & Reynolds, 1994; Fornell, 1976). Separately, studies such as Rust (1992), Hill, Geurs, Hays, Johnson and Swanson (1998), Wirtz (1998), Hays & Hill (2001b), Cahill & Warshawky (1995), Lewis (1993) and Maher (1991) have established that implementation of a service guarantee affects employee and human attitudes and behavior. While these studies collectively suggest that a service guarantee could interact with employee variables to affect service quality, the nature and form of these interactions and relationships have not been modeled and examined closely.

Fourthly, modeling studies relating service guarantee, service quality and employee variables have typically assumed linear relationships. However, related literature on learning and motivation has suggested that employee variables affect performance in a non-linear fashion. For example, learning is non-linear (Ang, Quek, Teo & Liu, 1999; Argote, Beckman and Epple, 1990; Baloff, 1971, Yelle, 1979; Givon & Horsky, 1990; Little, 1979). Similarly, the literature on motivation has also suggested non-linear performance-motivation relationships where performance first increases with motivation but then could decrease at high levels of motivation (Vroom, 1964; McClelland, 1951; Birch, 1945; Patrick, 1934; Yerkes & Dodson, 1908). The relationship between the employee variables and service quality could therefore also be non-linear. Relaxing the linearity constraint could yield models that portray the relationship more accurately, and provide a better understanding on how the employee variables affect service quality.

To date, Hays and Hill (2001b) represents one of the most comprehensive empirical studies to test the effects of a service guarantee on employee motivation/vision, organizational learning and service quality. They established that a service guarantee affects perceived service
quality positively through its effect on employee motivation/vision. While employee motivation/vision was also found to mediate the effect of learning through service failure on service quality, the form of the relationships and interactions between service guarantee, service quality, and employee motivation/vision and learning was not examined. In a separate study, Hays and Hill (2001a) found that higher levels of employee motivation/vision and service learning affect service quality positively. The study did not include the impact of a service guarantee. Knowledge of the characteristics of the moderating effects of service guarantee on the employee variables in influencing service quality is valuable to service managers in identifying key areas for resource deployment, avoiding potential pitfalls, and setting realistic implementation expectations for the organization.

Our study aims to investigate the form of the relationship between perceived service quality (PSQ) and its determinant employee variables in relation to implementation of a service guarantee. We define PSQ to comprise three elements: repeat customer visit, customer recommendation, and overall satisfaction (as in Hays and Hill, 2001b). Specifically, the objectives of our study are:

1. To investigate the impact of service guarantee on PSQ;
2. To relax the model linearity assumption so as to identify a potentially more accurate relationship between PSQ and its determinant employee variables (i.e., employee motivation, employee vision and learning through service failures);
3. To examine how service guarantee interacts with the employee variables to affect PSQ.

Besides contributing to the service guarantee and service quality literature, our study is among the first to examine the moderating effects of a service guarantee. Our study is also novel in attempting to identify an alternative, non-linear relationship between employee variables,
service guarantee and service quality. We employed the Alternating Conditional Expectations (ACE) technique (Breiman & Friedman, 1985) to relax the assumption of model linearity. By generating non-restrictive transformations for both the dependent and independent variables, ACE develops regression models that can provide much better model fits compared to models produced by standard linear techniques such as Ordinary Least Squares. The ACE transformations can reveal new information and insights on the relationship between the independent and dependent variables. A write-up on ACE and its workings can be found in the Appendix.

ACE has been employed in previous research involving soil-water diffusivity (De Veaux & Steele, 1989), engine exhaust emissions (Rodriguez, 1985), stress corrosion (Easton et al., 1984), seismic (Brillinger & Preisler, 1984), Material Requirement Planning (Sum et al., 1995, 1999) and Information Systems Planning (Ang et al., 1999).

BACKGROUND

Hart, Schlesinger & Maher (1992) defines a service guarantee as a statement explaining the service customers can expect (the promise) and what the company will do if it fails to deliver (the payout). A guarantee can be explicit or implicit, specific or total in coverage and conditional or unconditional. However, the mere existence of a service guarantee is unlikely to bestow any benefits on the company. Only well-designed ones will give the desired marketing and operating leverages (Barsky, 1995; Maher, 1991). A successful service guarantee is a declaration of trust in customers, and has to be unconditional, easy to understand and communicate, meaningful, credible, and easy to invoke and collect on (Hart, 1993; Marvin, 1992; Hart, 1988).

A service guarantee has great marketing appeal (Hays et al., 1999; Hill et al., 1998; Maher, 1991). It explicitly proclaims the reliability of the organization’s high service quality and
encourages potential customers to try the service. Generally, customers’ perceived risk associated with the service encounter increases due to its unpredictable nature (Parasuraman, Zeithaml & Berry, 1985; Guseman, 1981). A good service guarantee, by managing customer expectations, can reduce such perceptions by credibly promising high service quality (Wirtz, 1998; Cahill & Warshawky, 1995; Czepiel, Solomon & Surprenant, 1985). Even if the service fails to perform, the guarantee offers compensation for the service failure. Naturally, these unique characteristics will attract both potential and existing customers, therefore boosting brand loyalty and enhancing positive word of mouth among customers (Hays et al., 1999; Hill et al., 1998; Hart, 1988). While attracting new customers, a guarantee can keep dissatisfied ones through customer retention and recovery. Service failure and the inability to recover can lead directly to customer exit with the customer even more likely to engage in negative word-of-mouth activities (Keaveney et al., 1995; Blodgett, Wakefield & Barnes, 1995; Singh, 1990; Richins, 1983).

Conversely, a service guarantee could have no effect on the marketing strength of the firm (Hays and Hill, 2001a). If the original standards of service are poor, implementing a service guarantee may prove to be a disastrous move. Customer expectations cannot be fulfilled and payouts are incurred from the inability to fulfill the guarantee. In addition, customers might be suspicious and doubtful of the organization’s quality performance as they view the presence of a service guarantee as an acknowledgement of lingering problems and persistent failures (Wirtz, 1998; Tucci & Talaga, 1997).

A service guarantee incurs cost (Wirtz, 1998; Firnstahl et al., 1989; Hart, 1988). Aside from the direct costs of design and implementation of the guarantee, indirect costs also arise from the guarantee’s impact on operations and service quality. The operational impacts of a service guarantee on the company are many. A guarantee can ceaselessly drive, motivate and bind
employees in the vision to offer superior service that exceeds customer satisfaction through organizational learning and service recovery processes.

An effective service guarantee sets clear standards of performance for customers to expect and to which employees adhere (Al, 1993; Rose, 1990; Hart, 1988). It communicates to workers the level of service the organization intends to offer to its customers, as well as provides a clear and strong task identity (Cahill & Warshawky, 1995). It mandates that every decision and employee must focus on the customers. This can provide a difficult and challenging goal for employees to strive toward. As the organization’s reputation and bottom-line are at risk, employees have no choice but to become committed to improving service quality. Thus, a service guarantee can positively influence the motivation and vision of employees.

On the other hand, employees working under a service guarantee program may find it increasingly difficult to meet to organizational and customer expectations given their limited training and skills. A service guarantee may even have a demotivating effect on employees from the constant flow of negative feedback and service guarantee invocations (Wirtz, 1998; Al, 1993; Lewis, 1993). Furthermore, some frontline service employees are lowly compensated and tend to be minimally educated. As such, these employees may not have the abilities to deal with the demands arising from the service guarantee.

Organizations can learn through service failure and customer complaints. Due to the intangible nature of services, a service guarantee can be an effective complaint-management tool that provides important feedback on service failure, resulting in organizational learning (Hays and Hill, 2001b; Hill et al., 1998; Fornell, 1976). As the guarantee encourages and even rewards customer complaints, specific actionable and constructive information on the sources of service failure can be acquired and shared among employees. This can increase the organization’s
understanding of customer expectations and facilitate quality improvements and better control over the organization (Hart, 1988).

Customer perceptions of superior quality have been found to relate to increased customer satisfaction that, in turn, leads to increased customer retention and positive economic outcomes for the organization (Fornell et al., 1996; Ittner & Larcker, 1996; Cronin & Taylor, 1992; Oliver & DeSarbo, 1988; Parasuraman, Zeithaml & Berry, 1985, 1988). Several studies have observed a strong link between customer satisfaction and loyalty (Jones & Sasser, 1995; Boulding et al., 1993; La Barbera & Mazursky, 1983; Bearden & Teel, 1983). Rust et al. (1992) proclaimed that quality and customer satisfaction are closely linked and affect customer retention, market share and profitability directly.

Past research has provided a large base of anecdotal evidence on the benefits, design and criteria of service guarantees (e.g., Hays et al., 2000; Swanson et al., 1999; Hill et al., 1998; Hart, 1988, 1993; Rust et al., 1992; Rose, 1990; Browning, 1989). However, few studies have attempted to develop comprehensive service guarantee models.

Wirtz (1998) proposed a model to show the impacts of a well-designed guarantee on operations, service quality, customer behavior and business performance. The model was developed based on the service guarantees literature and insights obtained from an exploratory study with four firms (a paint company, a pest control firm, a pizza restaurant and an automotive center). Structural interviews were conducted with the firms' marketing managers and frontline employees. Propositions were advanced when the findings of the four case studies and the literature were in substantial agreement. “Substantial agreement” was defined as when no case study contradicted the proposition and at least two cases supported it. The model has not been validated empirically.
Hays and Hill (2001b) developed a model to depict how service guarantees affect service quality and, ultimately, a firm's business performance. Hays and Hill (2001b) argued that a strong service guarantee improves customer satisfaction, service quality and customer loyalty through three intervening variables: Marketing Communications Impact, Employee Motivation and Vision and Organizational Service Learning. The study focused on the effects of a service guarantee on employee motivation, vision and learning through service failure and its subsequent influence on customer satisfaction. The model was empirically validated using data from a multinational hotel chain that had implemented a service guarantee program. The results suggested that a service guarantee had a significant, positive effect on both customer satisfaction/loyalty and employee motivation/vision. Learning through service failure was found to affect customer satisfaction/loyalty positively through its impact on employee motivation/vision. Employee motivation/vision was found to mediate the effect of learning through service failure on customer satisfaction/loyalty, as well as the effect of a service guarantee on customer satisfaction/loyalty.

RESEARCH HYPOTHESES

We hypothesize that service guarantee affects PSQ and that service guarantee moderates the relationship between PSQ and its employee variables (employee motivation, vision, learning from failure). In other words, we hypothesize that significant interaction effects exist between service guarantee and the employee variables in affecting PSQ. The concept of statistical interaction is closely tied to the notion of moderated relationship (Jaccard et al., 1990). For example, the ability to learn from service failure is important in recovering customers successfully. However, it is reasonable to expect that the rate of learning is different with and without a service guarantee. When a service guarantee is absent, one could expect that the
learning process of the employees to be not as focused compared to when a service guarantee is present to specify clear performance standards and failure compensation so that employees can prioritize and concentrate better on specific areas of learning. Similarly, one would expect PSQ to be affected differently by employee motivation in an environment with and without a service guarantee. The first hypothesis is as follows:

Hypothesis 1: Significant differences in the relationship between PSQ and its determinant employee variables exist in the presence of a service guarantee.

Our second hypothesis is based on the notion that the employee variables do not necessarily correlate with PSQ in a linear fashion. For instance, Ang, Quek, Teo & Liu (1999) found that human factors, such as nurturing a culture of communications of goals and conflict resolution within an organization, has a non-linear impact on operational performance. Increasing learning and motivation also appears to have a non-linear effect on performance (Vroom, 1964; Argote et al., 1990; Yelle, 1979; Givon & Horsky, 1990; Little, 1979). Hence, the second research hypothesis is as follows:

Hypothesis 2: Significant underlying non-linearities exist between PSQ and its determinant employee variables.

Hypotheses 1 and 2 can be tested via the following regression equation:

$$g(PSQ) = f_1(x_1) + f_2(x_2) + ... f_n(x_n) + h_{12}(x_1x_2) + h_{13}(x_1x_3) + ... h_{1n}(x_1x_n) + \varepsilon$$  \hspace{1cm} (1)

where $x_1$ is a categorical variable indicating the presence/absence of a service guarantee, $x_2, x_3, ..., x_n$ are the employee variables, and $g$, $f$ and $h$ are generalized functions associated with
PSQ, main effects and interaction effects respectively. The functions $g$, $f$ and $h$ could be linear or non-linear and are graphically generated by ACE as transformation plots. Examples of graphical ACE transformations can be found in Figure A3 in the Appendix.

**METHODOLOGY**

In this section, we discuss the data collection process and operationalization of the research variables.

**Data Collection**

Data was obtained from a multinational hotel chain that has implemented a service guarantee program in 89 of its hotels in America and Canada. The hotel chain is a subsidiary of one of America’s largest privately owned corporations and a world leader in the hotel industry with more than 418 hotels in 35 countries. In 1999, the corporation had total sales of more than US$31.4 billion. These hotels represented a wide spectrum of hotel types, locations and sizes. A comprehensive training program complete with specially developed training manuals and videotapes accompanied the service guarantee program. Managers and frontline staff in every hotel were required to participate in the training program before the service guarantee program was implemented.

**Independent (Determinant) Variables**

Questionnaires concerning perceptions of employee motivation/vision and learning through service failure were sent to each hotel’s management and frontline staff prior to the implementation of the service guarantee as well as after the service guarantee had been in place for a month in the period from April 1998 to March 1999. The constructs of employee motivation/vision and learning through service failure were measured with the survey instrument
developed by Hays and Hill (2001ab). The instrument was developed from a consolidation of service literature (eg., Oldham, 1996; Price, 1972; Lawler & Hall, 1970; Kanfer, 1990; Campbell & Pritchard, 1976; Mellander, 1993; Huber, 1991; Nevis et al., 1995; Schneider et al., 1996) and rigorously validated by academics and practitioners (see Hays and Hill (2001a) for details).

The dimensions of the motivation/vision and learning through service failure constructs were operationalized by the twenty items in Table 1. The questions were randomized in the actual survey. Of the twenty questions/statements in the survey, two were worded negatively and the rest positively according to recommended procedures for scale development (Churchill, 1979). Respondents were asked to rank on a 7-point Likert scale with anchors, “1” for “strongly disagree” and “7” for “strongly agree”.

The unit of observation for both the employee motivation/vision construct and learning through service failure construct was the hotel employee/staff as an informant. A staff could be either from management or frontline operations. Management and frontline staff were given the same set of 20 questions in Table 1. The management staff surveyed included the hotel general manager, food and beverage manager, restaurant manager, guest services manager, operations manager, human resources manager, training manager, and front office manager. Frontline staff are employees in direct contact with customers and include receptionists, concierges, desk clerks, frontdesk clerk, cashier, switchboard operator, bellman, and housekeeping personnel.

A total of 1,621 employee responses was received. Responses from each hotel were separated into management and frontline responses to facilitate more precise analysis and interpretation. The number of frontline staff for a hotel before and after the service guarantee implementation ranged from 1 to 18 with an average of 6 responses. The corresponding number of management staff ranged from 1 to 26 with an average of 8 responses. Frontline and management staff responses for each hotel were averaged respectively to form units of hotel
response both before and after implementation of the service guarantee. For purposes of analysis, each unit of hotel response had to have both management and frontline responses. Hotels without either management or frontline responses were dropped. Eighty observations was obtained.

As responses from management and frontline staff were separated for analysis, we had a total of 40 independent variables. A factor analysis was conducted to reduce the number of variables to a parsimonious and smaller set before ACE analysis (Sum et al., 1995; Ang et al., 1999; Hays and Hill, 2001ab). Several tests were conducted on the suitability of the data for factor analysis (Hair et al., 1998; Hays and Hill, 2001ab). Firstly, a visual inspection of the anti-image correlation matrix revealed that all anti-image correlations were less than 0.30. The anti-image correlation matrix is the negative value of the partial correlation. Larger partial or anti-image correlations are indicative of a data matrix that is not suitable for factor analysis. Secondly, the use of the Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) suggested that it was “meritorious” at 0.865. The MSA (Kaiser, 1970) provides a measure of the extent to which the variables belong together and are thus appropriate for factor analysis. Another test for appropriateness was the Bartlett’s test of sphericity, a statistical test for the presence of correlation among the variables. It was found to be significant at $p < 0.0001$. Hence, the items met the fundamental requirements for factor analysis (Hair et al., 1998).

Factor analysis (principal component method with varimax rotation and selection of factors with eigenvalues greater than one) was then performed. Table 2 displays the results of the factor analysis. Some of the 40 variables were dropped because the item-total correlation was
less than 0.5 or the inter-item correlation was less than 0.3. The variables in Table 2 accounted for 75.43% of the variance in the sample. Factor loadings for all items were at least above 0.60 and were considered significant. The Cronbach alpha values were all above 0.70 and indicate that the factors were reliable (Nunnally, 1978).

Table 2 shows that the items within every factor were associated with the same staff type. For instance, all the items making up the MLRS factor pertained to responses from management staff, and hence MLRS represents management staff’s perspective of learning and the recovery structure. Similarly, the FVL factor comprises all frontline items/responses, and thus depicts frontline staff’s vision and ability to learn through failure.

Dependent Variable (Perceived Service Quality (PSQ))

The concepts of service quality, customer satisfaction, and customer loyalty/retention are closely related and difficult to separate (Hays and Hill, 2001ab). However, the fundamental goal for an organization is still customer retention or customer loyalty (Evans & Lindsay, 1996; Fay 1994; Gerson, 1993). Customer loyalty/retention is the willingness of customers to repurchase from a particular organization. Jones & Sasser (1995) argued that only completely satisfied customers are loyal customers. They also asserted that “levels of satisfaction ... are a good indicator of the level of quality ... that they (customers) are receiving.” Hays and Hill (2001a) asserted that intent to repurchase and willingness to recommend are measures of service quality.

The intent to repurchase is a measure of customer satisfaction and loyalty and perceived service quality (Hays and Hill, 2001a; Hill et al., 1998; Yi, 1990). A customer who intends to return and repurchase is satisfied with the organization’s offerings and perceives the organization
to offer superior service quality. Woodside et al. (1989) used “intention to use the hospital again” to measure patient satisfaction.

Hensley (1999) argued that “if the research is focused on an operation management measure that is available from the organization, then the obvious choice should be to use the measure already developed by the organization.” Similar to Hayes and Hill (2001b), we operationalized the PSQ construct to comprise three items: (1) the likelihood of the customer staying at the hotel again; (2) the likelihood of the customer recommending the hotel to a friend; and (3) the customer’s rating on overall satisfaction of the hotel. Item (1) was measured using an anchored scale with “1” for “definitely would not” and “5” for “definitely would.” Item (2) was measured using an anchored scale with “1-2” for “definitely would not”, “5-6” for “undecided” and “9-10” for “definitely would.” The anchored scale for item (3) was “1-4” for “poor,” “5-7” for “fair” and “8-10” for “excellent.”

The hotel chain provided the PSQ data. The PSQ data was obtained from telephone surveys of a random sampling of hotel guests by the hotel chain in the quarters both prior and after the implementation of the service guarantee in the period from January 1998 to March 1999. The survey was conducted by an independent market research firm. The unit of observation for PSQ was the hotel customer as an informant. The average number of customer responses per hotel is 7. Customers’ quarter responses for each hotel were averaged to form a unit of hotel response in both before and after implementation of the service guarantee.

As in Hays and Hill (2001b), a factor analysis (principal component method with varimax rotation and selection of factors with eigenvalues greater than one) was performed on the 3 items making up the PSQ construct. Table 2 shows the factor analysis results. The Cronbach alpha value of 0.97 suggests that the factor is reliable.
Since the unit of analysis was the hotel, each unit hotel observation of the staff (containing the independent variables) was matched with each unit hotel observation of the customers (containing the dependent variable PSQ) for both before and after implementation of the service guarantee. The observations that could not be matched were discarded, leaving a usable sample of 65 matched observations. The number of missing values was negligible. Scale values were revised for negatively worded statements prior to data analysis.

**ACE ANALYSIS**

The resulting list of dependent and independent variables employed in the ACE analysis is presented in Table 3. Sixteen independent variables were considered for the ACE regression. Ten of the 16 variables were interaction terms (e.g., MLRS-Service guarantee interaction). As these interaction terms are ordinal-categorical variables, ACE requires 2 variables to model each interaction term.

A simple summated variable score for each variable (MLRS, MMV, FVL, FM, FDCD) was formed from the items identified in the factor analysis (Table 2). The scores for the interaction terms were obtained by taking the product of the scores of the two independent variables that make up the interaction term. These summated variable scores were used in the ACE regression.

Following Sum et al. (1995, 1999), the modeling capability of ACE was evaluated by first obtaining the best linear models using the same variables identified. Running all possible regression models resulted in a selection of the top few linear models with the highest adjusted
$R^2$. Using the same variables in the top linear models, ACE generated models that yielded substantially higher $R^2$ and $p$-values than the linear models. In one case, the ACE model improved the $R^2$ and $p$-values by as much as 230 percent and 64 times respectively. This confirmed the superior modeling capability of ACE. Details on using ACE can be found in Sum et al. (1995), Ang et al. (1999), Fox & Long (1990) and Breiman & Friedman (1985).

RESULTS AND DISCUSSION

Table 4 shows the final ACE regression model and its corresponding $R^2$, adjusted $R^2$ and $p$-values. The variable $p$-values suggest that all variables are statistically significant at the 5% level. Figure 1 shows the final analytic (graphical) transformations for the ACE model in Table 4. The five significant variables are MLRS, MMV-with service guarantee, FM-with service guarantee, FDCD-without service guarantee, and service guarantee. The presence of the service guarantee variable suggests that PSQ is affected by service guarantee. The interaction terms in the final ACE model (Table 4) support the first hypothesis that the relationship between PSQ and the employee variables is moderated by a service guarantee. The non-linear plots in Figure 1 also support the second hypothesis that significant underlying non-linearities exist between PSQ and some of the employee variables.

For interpreting the plots in Figure 1, it should be noted that transformed values (Y-axis) of the independent variables are positive correlates of their corresponding observed values of the
dependent variable, PSQ (see section "Interpreting ACE Transformation Plots" in Appendix). This is true because the transformation of the dependent variable (PSQ) is an increasing function (Figure 1a). Thus, the transformed axis (Y-axis) of the individual independent transformation plots can be interpreted as if it is the corresponding axis of the observed dependent variable, PSQ (Ang et al., 1999; Sum et al., 1995).

To illustrate, in Figure 1c, the transformed axis (Y-axis) can be taken to represent PSQ. So the plot in Figure 1c can be interpreted that as the independent variable, MMV-with service guarantee, increases, PSQ will initially decrease and then increase.

**Management Learning & Recovery Structure (MLRS)**

MLRS refers to the extent that management staff learns from service failures and devises a recovery structure of processes, measures and systems to help employees perform service recovery. A higher MLRS suggests that management staff attains greater learning and the existence of a more elaborate structure of recovery mechanisms. The transformed plot (Figure 1b) suggests that, in general, PSQ increases as MLRS is enhanced.

An explanation for the upward trend is that enhancing the recovery structure upon learning by management staff allows frontline staff and employees to recover service failure more easily and successfully. Greater learning by management staff leads to the design of more effective recovery measures. The increased availability of recovery measures enables frontline staff and employees to choose suitable recovery actions to resolve complaints expeditiously. A recovery structure can also facilitate collection, integration, tracking, and disseminating of customer complaints and feedback. This could allow for better analysis and identification of critical failure points and weaknesses in the current service recovery system.
A more comprehensive recovery structure can present more options and alternatives to cater to different types of failures, resulting in higher PSQ. The insight for this can be drawn from Kelley et al. (1993), who examined the effectiveness of various recovery measures used by retailers to improve customer retention. These measures require different levels of recovery structure complexity for execution. The 456 respondents gave effectiveness scores of 96%, 86%, 81% and 77% (out of 100% for maximum effectiveness) to the measures of correction, discount, refund and apology, respectively, thus suggesting that the more effective measures (such as correction) are those that require a more elaborate recovery structure for implementation.

Service recovery efforts are likely to leave a lasting impact on customers due to the heightened circumstances and attention arising from a service failure (Spreng et al., 1995). The recovery process is likely to be the last experience the customer had with the organization resulting in a recency effect. Thus, when the customer contemplates a service provider for the next transaction, the effectiveness of the service recovery effort may have a greater influence on intentions than the original service failure (Spreng et al., 1995). As the ability to recover is related on the availability of recovery mechanisms, it is no surprise that increasing the recovery structure results in higher PSQ. As proclaimed in Hart (1990), “To err is human; to recover divine.”

Our result that PSQ requires a matching service recovery process concurs with Spreng et al. (1995), Jones et al. (1995), Halstead & Page (1992), Bitner, Booms & Tetreault (1990), and Hart et al. (1990). Gilly (1987) also found that complainers who are satisfied with the recovery response have higher repurchase intentions than those who are satisfied and did not complain. The statistical significance of MLRS also suggests that management staff being leaders of the organization play a key role in actively learning through failures and translating their learning experience into the creation of an effective and practical recovery structure.
Figure 1b also shows that while PSQ increases with increased MLRS, the incremental impact of MLRS on PSQ appears to taper off a bit towards high MLRS. This suggests that after some point, improving the recovery structure through management learning produces relatively lower benefits to PSQ. The reason could be that as the recovery structure grows in size and complexity, this could lead to an over-proliferation of measures and options available to support service recovery. Now employees could have a few too many recovery options to choose from in the event of a service breakdown. Faced with an increasing number of recovery possibilities, different employees could subjectively select different recovery actions, resulting in some loss in recovery consistency and effectiveness. Furthermore, if recovery actions span different departments, the rippling effects of employees’ subjective assessments of the seriousness of the failure are magnified, thus leading to higher inconsistency in customer recovery and treatment.

Management Motivation & Vision (MMV)-With Service Guarantee

Management motivation and vision (MMV) represents the extent that management staff aspires to provide high service quality and understands the service priorities needed to achieve superior service quality. The transformation plot (Figure 1c) suggests that when MMV increases in the presence of a service guarantee, PSQ first decreases and then increases.

Management staff is primarily responsible for the formulation and communication of service priorities to frontline staff as well as the design of recovery measures for resolving customer complaints. When management staff is lowly committed to offering service quality, and as their motivation is increased, they might begin to feel for the first time that they are responsible and accountable for customer satisfaction. However, due to the lack of knowledge on service quality, they might have developed only a superficial understanding of the connection between service quality and customer satisfaction. More important, they might not fully realize
the service priorities associated with the service guarantee. Lacking experience in service recovery, management staff might therefore be communicating wrong and unclear service priorities to the frontline staff. Their translation of the service guarantee into performance standards and recovery measures could also be flawed, leading to poor recovery by frontline staff. This could result in a dip in PSQ as customer expectations arising from the service guarantee cannot be fulfilled. In addition, customers might perceive relatively greater unfairness, staff insincerity, and inconsistency in service quality and recovery compared to when there was no service guarantee, and when these staff were not motivated and simply indifferent to customer complaints.

According to Bitner et al. (1990), the perceived inappropriateness and/or inadequate response of employees to failures may represent a “double deviation” from role expectations that customers hold for providers, causing greater negative evaluation of the service. Here, the first “deviation” represents the initial service breakdown and the second the inability to recover the failure satisfactorily. These effects are more pronounced when a service guarantee is present. In due time, customers are driven away as they become less tolerant of the inept recovery efforts after the initial service failure (Hill, 1994). The overall impact is a decrease in PSQ.

As noted by Harvey (1998) and Parasuraman (1985), delivering service quality involves a chain of events that must take place from the time a need is detected to its eventual satisfaction. There are five major links in this chain that can be broken resulting in non-quality. Two of the links could be broken in the above context that could lead to poorer PSQ. The first is the inability of management staff to translate the design (service guarantee) into appropriate service standards and requirements. This could arise from the initial low level of management motivation and insufficient understanding and communication of service priorities to frontline staff by management. When management staff are lowly motivated, they tend to be
unappreciative of concepts of service quality and recovery, and have difficulty in defining priorities and what needs to be done to provide high service quality. The second area is the inability to recover the failure effectively. This can be attributed to the poor translation of the service guarantee into performance standards and recovery measures by management staff.

The turning point in Figure 1c suggests that after a certain threshold of motivation and vision, management staff are able to value service quality, and use their understanding to formulate proper service priorities and recovery standards from the service guarantee. As MLRS is increased, PSQ increases because of more effective failure recovery and fulfillment of the service guarantee.

**Frontline Motivation (FM)-With Service Guarantee**

The transformation plot (Figure 1d) indicates that, in the presence of a service guarantee, as motivation among frontline staff is increased, PSQ stays unchanged and then increases. In other words, a relatively high level of frontline motivation is required before PSQ increases.

A probable interpretation is that when frontline staff are lowly motivated, and as their desire to provide high service quality is increased, their surge in enthusiasm might not be matched by their knowledge of how to provide high service quality. Since their motivation was low to begin with, these frontline staff might not have deeply internalized and understood the value of service quality. Furthermore, their lack of experience in service recovery might prevent them from making any significant positive impact on customer satisfaction. Even with a service guarantee and performance standards, customers might not register any improvement in PSQ despite a noticeable increase in the frontline staff’s desire to provide superior service quality.

However, after a certain level of motivation, frontline staff might begin to move beyond superficial appreciation of service quality. They began to internalize the value of superior
service recovery on customer satisfaction. Through their direct contact and interaction with customers, highly motivated frontline staff could begin to improve service recovery by learning from mistakes and making constructive efforts to coordinate their recovery efforts. Over time, frontline staff could learn from each other’s recovery experiences and improve recovery performance. The courtesy, empathy and responsiveness of frontline staff could all combine to influence customers’ quality perceptions (Parasuraman et al., 1988). According to Bowen and Lawler (1992), motivated staff who have a clear vision (arising form the presence of a service guarantee) could provide superior service to customers.

**Frontline Discovery Through Complaint Data (FDCD) -Without Service Guarantee**

Frontline discovery through complaint data (FDCD) refers to the ability of frontline staff to detect service failures through customer complaint data. A higher FDCD implies that frontline staff are better able to identify and understand service failure as a result of collecting more information on customer complaints. The transformation plot (Figure 1e) indicates that, in the absence of a service guarantee, increasing FDCD has a positive, followed by a negative impact, on PSQ.

Complaint data can be assessed in terms of the amount, timeliness, accuracy and relevance of complaint feedback from customers. Collecting feedback from customers makes the organization appear concerned with the needs, expectations and satisfaction of customers. However, the amount of data and feedback elicited from the customers tends to be correlated with customer expectations of the organization. As customers provide more feedback, they tend to develop higher expectations of the organization. This is natural as customers expect to have their feedback incorporated into policies and recovery measures.
When the amount of customer feedback collected is relatively low, this could suggest that only brief comments are solicited. Correspondingly, customer expectations are not high and, as such, frontline staff could accommodate and resolve complaints with its existing recovery structure. As more feedback is collected and as long as the complaints are not too difficult or complex for the existing recovery structure to respond, customers are satisfied that their complaints have been resolved and so PSQ can increase.

However, customer expectations could be raised substantially beyond a certain point when customers are asked to provide more specific details about their unhappiness. Thus, the turning point in Figure 1e could indicate the critical level of customer complaints where increasing customer expectations are barely met by the organization’s recovery measures. As customers get more explicit and detailed about their complaints, frontline staff might not be able to cope with the rising expectations of the complaining customers. Particularly, in the absence of a service guarantee, the complaining customer now is more difficult to appease, as there are no explicitly stated compensation or performance standards to “limit” or frame the expectations of the unhappy customer. Customers would use their own valued opinions about what may be sufficient or adequate compensation for their complaints and unhappiness. To compound the situation, when a service guarantee is not present to stipulate service standards, frontline staff might exercise their own subjective judgement in selecting recovery actions, leading to undesirable variations in recovery practices and perception of inconsistent service quality by the customers. As stated in Parasuraman et al., (1985), creating expectations that cannot be met will result in the breakdown of service delivery. To the customers, the time spent “teaching” the organization about their needs and preferences (through the complaint collection process) is wasted and, thus, not worth the effort. This leads to a loss in PSQ.
Service Guarantee

Figure 1f shows that having a service guarantee increases PSQ. The result in Figure 1f concurs with the widely accepted notion that a service guarantee positively impacts service quality and customer satisfaction (Hays and Hill, 2001a; Hill et al., 1998; Wirtz, 1998; Ettorre, 1994; Hart, 1993; Rust et al., 1992; Maher, 1991; Rose, 1990; Browning, 1989; Firnstahl, 1989; Hart, 1988).

In general, customers are more willing to return to the same organization because a service guarantee lowers the risk of making a purchase (Wirtz, 1998; Firnstahl, 1989; Hart, 1988). A service guarantee clarifies the standards of performance that customers can expect and thereby reduces customers’ concern for uncertainty. Customers could be attracted because the guarantee gives the impression that high service quality is “guaranteed.” Additionally, customers are reassured that even if the service fails, the guarantee can be invoked and the magnitude of any negative consequence reduced (Berry, 1995).

When a service guarantee is present, dissatisfied customers may be more willing to return because the organization is expected to make amends or pay out the guaranteed compensation. The compensation can go a long way toward stemming the potential loss of critical business resulting from occasional failures. Satisfaction and customer retention can improve when complaints are resolved through successful service recovery and guarantee payouts (Wirtz, 1998; Berry, 1995; Hart, 1993).

MANAGERIAL IMPLICATIONS

A major finding is that while a service guarantee improves PSQ, it has a significant moderating, non-linear effect on other determinants of PSQ. The non-linear effects of a service guarantee
provide key insights and implications for service managers and implementers of service guarantees. The managerial implications are summarized as follows:

**Recovery Structure**

Our finding suggests that learning (through service failure) by management staff has a positive impact on PSQ as managers are responsible for devising the recovery structure based on their knowledge and understanding of service quality and failures. Given varied customer complaints, an elaborate and comprehensive recovery structure offers recovery staff a wide range of mechanisms and measures to resolve customer complaints and improve PSQ.

An imperative for service organizations is to recognize the strong relationship between service recovery and PSQ, and to ensure that management staff takes an active role in learning from service failure so that they can design an effective recovery structure. With or without a service guarantee, service organizations should regard the recovery structure as an integral part of its service quality strategy. A well-designed recovery structure offers staff a wide range of mechanisms and measures to resolve customer complaints. To avoid subjective adoption of recovery measures and undesirable variations in recovery practices arising from an overly extensive recovery structure, service managers must specify and communicate service performance standards clearly to frontline staff. Standard operating procedures should also be enforced to project consistency and reliability of service. A recovery structure with standard operating procedures can result in clearer priorities and guidance for frontline recovery staff. When recovery staff are trained on the proper use of the recovery structure, they become more focused, responsive and successful in resolving customer complaints.

**Motivation**

26
With a service guarantee, the early impact of increasing motivation among lowly motivated staff (both managerial and frontline) can be a drop in PSQ. For these staff, the initial surge in enthusiasm and sense of personal responsibility toward customer satisfaction can lead to overzealousness and confusion over how to appease complaining customers. Lacking internalization of service concepts and experience in service quality, management staff could set inappropriate service priorities for frontline staff. The lack of awareness of service quality could also result in management staff creating an ineffective recovery structure.

The implication is that, when a service guarantee is in place, service organizations of lowly motivated staff would need to adjust their expectations of the initial results of motivation programs. Service managers should also ensure that motivation programs are accompanied by education on practical service recovery. A supporting and matching recovery structure should complement the progressive increase in staff motivation so that staff can translate their enthusiasm into effective recovery actions. Equally important is the communication of clear performance standards and priorities to staff.

**Complaint Data**

The impact of soliciting customer complaints on PSQ is affected by a service guarantee. In the absence of a service guarantee, collecting more detailed complaint data could eventually have an adverse impact on PSQ. The dip could be due to heightened customer expectations (resulting from progressive solicitation of data) that were unmet, especially in the absence of clearly stated compensation for service failure. The managerial implication is that while complaint feedback is important for recovery, service managers cannot ignore the effect of the complaint collection process on customer expectations. Solicitation of feedback inevitably raises customer expectations on recovery standards, and unless compensation policies are communicated (as in a
service guarantee), PSQ can decrease. Managers must exercise caution in soliciting feedback from customers as the organization may not be able to meet the customer needs and expectations. A service guarantee can serve to frame customer expectations on recovery standards.

CONCLUSIONS AND FUTURE RESEARCH

Our study contributes to the better understanding of the complex moderating effects of a service guarantee on PSQ. By removing the constraint of model linearity, our study uncovers a statistically significant non-linear relationship between PSQ and its determinant employee variables. The non-linear ACE plots provide important insights and implications for service quality managers. Our results also provided a basis for the use of non-linear modeling techniques in service quality research.

Future research can proceed to validate our results by examining the impact of a service guarantee in other service industries. Interactions between other determinant variables can also be analyzed for non-linear relationships. The inclusion of interaction effects is meaningful because many determinant variables are inherently related somewhat. Time may be an important factor in assessing the impact of a service guarantee on an organization. Hence, longitudinal studies would also be a promising area.
Table 1: Items in survey instrument.*

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Item Description</th>
</tr>
</thead>
</table>
| **Motivation and Vision**           | **Motivation** (defined as extent to which firm’s employees have a desire to provide high quality service)  
- Our employees always make customer satisfaction their top goal.  
- Our employees go out of their way to listen when customers complain.  
- Our employees feel a strong sense of accountability and ownership for service quality.  
- Customer satisfaction is not very important to my co-workers.  

**Vision** (defined as degree to which management has communicated priorities clearly and firm’s employees have an awareness of the key role service quality plays in firm’s strategy)  
- Our service quality priorities are always clear to our employees.  
- Our employees have a clear understanding of the role that service quality plays in helping our company compete in our market.  
- We have very well defined standards for service quality. |
| **Learning Through Service Failure**| **Discovery** (defined as degree to which a firm is able to detect service failures)  
- When a service problem occurs, we are almost always aware of the problem.  
- Our employees are very aware of customer complaints and why they occur.  
- Customers with a service problem seldom complain to us.  
- Our systems catch all of our customers' complaints.  

**Data** (defined as degree to which a firm collects and communicates information on service failures)  
- We have accurate information on how many complaints we receive.  
- We have accurate information on why our customers complain.  
- Information on customer satisfaction trends is communicated to all of our employees.  

**Improvement** (defines as degree to which a firm uses failure information to improve quality)  
- Collecting customer feedback helps us to regularly improve our service quality.  
- We have improved our service quality over the past year based on customer complaint information.  
- Customer complaint information is used to help us eliminate future service problems.  
- When a customer complains to us, the cause of the problem is found and fixed quickly.  
- Customer complaints at our hotel occur over and over again for the same reasons.  
- Our service quality is improving rapidly. |

* based on Hays and Hill (2001a).
Table 2: Factor analysis.

<table>
<thead>
<tr>
<th>Factor Description</th>
<th>Variable Description</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Service Quality (PSQ)</td>
<td>Willingness to return</td>
<td></td>
</tr>
<tr>
<td><em>(α=.97)</em></td>
<td>Willingness to recommend</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall satisfaction</td>
<td></td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>Our service quality is improving rapidly – <em>(M)</em></td>
<td>0.81</td>
</tr>
<tr>
<td>Learning &amp; Recovery Structure (MLRS)</td>
<td>Our service quality priorities are always clear to our employees – <em>(M)</em></td>
<td>0.80</td>
</tr>
<tr>
<td><em>(α=.94)</em></td>
<td>We have accurate information on how many complaints we receive – <em>(M)</em></td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>We have very well defined standards for service quality – <em>(M)</em></td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>We have improved our service quality over the past year based on customer complaint information – <em>(M)</em></td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Information on customer satisfaction trends is communicated to all of our employees – <em>(M)</em></td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Customer complaints at our hotel occur over and over again for the same reasons – <em>(M)</em></td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>When a customer complains to us, the cause of the problem is found and fixed quickly – <em>(M)</em></td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>Customer satisfaction is not very important to my co-workers – <em>(M)</em></td>
<td>0.61</td>
</tr>
<tr>
<td>Management Motivation &amp; Vision (MMV)</td>
<td>Our employees feel a strong sense of accountability and ownership for service quality – <em>(M)</em></td>
<td>0.83</td>
</tr>
<tr>
<td><em>(α=.93)</em></td>
<td>Our employees have a clear understanding of the role that service quality plays in helping our company compete in our market – <em>(M)</em></td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>Our employees go out of their way to listen when customers complain – <em>(M)</em></td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Our employees always make customer satisfaction their top goal – <em>(M)</em></td>
<td>0.73</td>
</tr>
<tr>
<td>Frontline Vision &amp; Learning through Failure (FVL) <em>(α=.86)</em></td>
<td>We have improved our service quality over the past year based on customer complaint information – <em>(F)</em></td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>We have very well defined standards for service quality – <em>(F)</em></td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Our service quality priorities are always clear to our employees – <em>(F)</em></td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>Information on customer satisfaction trends is communicated to all of our employees – <em>(F)</em></td>
<td>0.71</td>
</tr>
<tr>
<td>Frontline Motivation (FM) <em>(α=.82)</em></td>
<td>Customer satisfaction is not very important to my co-workers – <em>(F)</em></td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Our employees go out of their way to listen when customers complain – <em>(F)</em></td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Our employees always make customers satisfaction their top goal – <em>(F)</em></td>
<td>0.78</td>
</tr>
<tr>
<td>Frontline Discovery through Complaint Data (FCD) <em>(α=.72)</em></td>
<td>Our systems catch all of our customers’ complaints – <em>(F)</em></td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>When a service problem occurs, we are almost aware of the problem – <em>(F)</em></td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>We have accurate information on how many complaints we receive – <em>(F)</em></td>
<td>0.69</td>
</tr>
</tbody>
</table>

* Cronbach alpha values
Φ = variable associated with response from management staff
(F) = variable associated with response from frontline staff

30
<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Service Quality (PSQ)</td>
<td>The extent to which a customer is willing to patronize the hotel because of high perceived service quality.</td>
<td>Ordinal</td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Learning &amp; Recovery Structure (MLRS)</td>
<td>The extent to which management staff learns from service failures and develops a recovery structure (systems, measures and procedures) to help employees perform service recovery.</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Management Motivation &amp; Vision (MMV)</td>
<td>The extent to which management staff desires to provide high service quality and communicates service priorities clearly to the firm’s employees.</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Frontline Vision &amp; Learning through Failure (FVL)</td>
<td>The extent to which frontline staff understands the service priorities and uses failure information to improve quality.</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Frontline Motivation (FM)</td>
<td>The extent to which frontline staff feels accountable and is motivated to provide high service quality.</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Frontline Discovery through Complaint Data (FDCD)</td>
<td>The extent to which frontline staff is able to detect service failures through collection of complaint information.</td>
<td>Ordinal</td>
</tr>
<tr>
<td>Service Guarantee(SG)</td>
<td>The presence/absence of a service guarantee program.</td>
<td>Categorical</td>
</tr>
<tr>
<td><strong>Interaction Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Learning &amp; Recovery Structure (MLRS) x SG*</td>
<td>The extent to which management staff learns from service failures and develops a recovery structure (systems, measures and procedures) to help employees perform service recovery in the absence/presence of a service guarantee.</td>
<td>Ordinal-Categorical</td>
</tr>
<tr>
<td>Management Motivation &amp; Vision (MMV) x SG</td>
<td>The extent to which management staff desires to provide high service quality and communicates service priorities clearly to the firm’s employees in the absence/presence of a service guarantee.</td>
<td>Ordinal-Categorical</td>
</tr>
<tr>
<td>Frontline Vision &amp; Learning through Failure (FVL) x SG</td>
<td>The extent to which frontline staff understands the service priorities and uses failure information to improve quality in the absence/presence of a service guarantee.</td>
<td>Ordinal-Categorical</td>
</tr>
<tr>
<td>Frontline Motivation (FM) x SG</td>
<td>The extent to which frontline staff feels accountable and is motivated to provide high service quality improve quality in the absence/presence of a service guarantee.</td>
<td>Ordinal-Categorical</td>
</tr>
<tr>
<td>Frontline Discovery through Complaint Data (FDCD) x SG</td>
<td>The extent to which frontline staff is able to detect service failures through collection of complaint information in the absence/presence of a service guarantee.</td>
<td>Ordinal-Categorical</td>
</tr>
</tbody>
</table>

* SG is a binary variable.
* ACE requires 2 variables (eg., MLRS-With service guarantee, MLRS-Without service guarantee) to model each interaction term.
Table 4: Final ACE model.

<table>
<thead>
<tr>
<th>Determinant Variable</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Learning &amp; Recovery Structure (MLRS)</td>
<td>0.6471e-2</td>
</tr>
<tr>
<td>Management Motivation &amp; Vision (MMV)-With Service Guarantee</td>
<td>0.6314e-3</td>
</tr>
<tr>
<td>Frontline Motivation-With Service Guarantee</td>
<td>0.3623e-1</td>
</tr>
<tr>
<td>Frontline Discovery through Complaint Data (FDCD)-Without Service Guarantee</td>
<td>0.4291e-1</td>
</tr>
<tr>
<td>Service Guarantee</td>
<td></td>
</tr>
<tr>
<td>Service Guarantee (SG)</td>
<td>0.1110e-1</td>
</tr>
<tr>
<td>Model p-value</td>
<td>0.3503e-2</td>
</tr>
<tr>
<td>Model Adjusted $R^2$</td>
<td>0.2524</td>
</tr>
<tr>
<td>Model $R^2$</td>
<td>0.3438</td>
</tr>
<tr>
<td>N</td>
<td>65</td>
</tr>
</tbody>
</table>
Figure 1: ACE transformation plots.

(a) Perceived Service Quality

(b) Management Learning & Recovery Structure (MLRS)

(c) Management Motivation & Vision (MMV) – With Service Guarantee
Figure 1: ACE transformation plots (continued).

(d) Frontline Motivation (FM) – With Service Guarantee

(e) Frontline Discovery through Complaint Data (FDCD) – Without Service Guarantee

(f) Service Guarantee
REFERENCES


Collier, D.A., (1994). *The service/quality solution using service management to gain competitive advantage*, Irwin (Richard D.), Milwaukee, WI.


Acknowledgement

This research was partly supported by grants from the National Science Foundation Transformations to Quality Organizations (Grant SBR-9811047), the Juran Center for Leadership in Quality at the University of Minnesota, IMD International and Radisson Hotels Worldwide. The authors also thank the Editor, Associate Editor and reviewers for their helpful comments.
Appendix: Alternating conditional expectation (ACE).

Alternating Conditional Expectation (ACE) estimation is an advanced statistical technique developed by Breiman and Friedman ("Estimating Optimal Transformations for Multiple Regression and Correlation [with discussion]." Journal of the American Statistical Association, vol 80, September 1985) who won the 1985 best JASA Theory and Methods paper award for their work. The ACE algorithm produces the best-fitting additive model by estimating individual optimal smooth transformations for the dependent and independent variables to maximise the correlation between the dependent variable and the variable of the fitted values.

Unlike other empirical methods, the ACE transformations are unambiguously defined and estimated without the use of heuristics, restrictive distributional assumptions, or restriction of the transformation to a particular parametric family. Often, ACE produces models that have a much superior fit compared to those generated using standard regression techniques such as Ordinary Least Squares.

The example below will illustrate the key advantage of ACE over standard regression techniques. This example will also address the interpretation of an ACE model.

ACE Example
This example will demonstrate the effectiveness of ACE by attempting to recover the transformations for individual variables in the following equation used to construct $Y$:

$$Y = \log[3 \sin(1.3A) + \text{abs}(B) + C^2 + (D^3 / 9) + E + 10] - 8 \quad (1)$$

where $A$, $B$, $C$, $D$ and $E$ are independent samples of 100 observations drawn from the Normal distribution with mean 0 and variance 1. Note that relationship (1) above can be re-expressed as:

$$e^8 \exp(Y) = 3 \sin(1.3A) + \text{abs}(B) + C^2 + (D^3 / 9) + E + 10 \quad (2)$$

Thus, if we are simply given the data values for $Y$, $A$, $B$, $C$, $D$ and $E$, without knowledge of functional relationship (1), we might try to plot $Y$ individually against the independent variables $A$, $B$, $C$, $D$ and $E$ so as to gain some insights on the pair-wise relationships, yielding the graphs in Figure A1. Note that the plots in Figure A1 do not suggest any obvious transformation for either the dependent or independent variables.
Ordinary Regression

If we then regress $Y$ on $A$, $B$, $C$, $D$ and $E$ using Ordinary Least Squares (OLS), we will obtain an $R^2$ of 0.637. We might plot the residuals from the regression first against the fit $\hat{Y}$, then separately against the independent variables to see if there might be patterns to suggest possible transformations for the independent variables. The plots are shown in Figure A2. Perhaps only the plots of the residuals versus $A$ and $C$ give any hint that some non-linear component of $A$ or $C$ might help to explain the variation in $Y$.

ACE Regression

If we now invoke ACE on the given data set, ACE will provide an output of individual transformations for the variables as shown in Figure A3. ACE’s suggested graphical transformations for the variables are shaped like exponential for $Y$, sine for $A$, absolute-value for $B$, square for $C$, cubic for $D$, and linear for $E$, which are exactly the corresponding functions in relationship (1).
ACE Transformations

**Figure A3**

Note that the transformations do not provide any information on the scales of the transformed variables (e.g., 3 for \( \sin(1.3A) \)) or any shift in the origins for the transformed variables (which would affect the intercept +10). This is because the scaling of an independent variable does not affect the fit of the corresponding regression model, and any translational shift in the origins will be absorbed into the constant term in a regression. We therefore need not be concerned with the markings on the scale for the ordinate (y-) axis in a plot of the suggested ACE transformation for a variable. That is, the origin for the y-axis can be fixed anywhere and the unit of measurement for the y-axis is arbitrary.

In addition, the suggested ACE transformations are constructed such that a larger transformed value for an independent variable will be associated, everything else being equal, with a larger value of the transformed dependent variable. In other words, if we regress the transformed dependent variable on all the transformed independent variables, all parameter coefficients for the independent variables will be positive.

Further, by default ACE ensures that the transformed value of the original observed maximum y value is no smaller than the transformed value of the original observed minimum y value. ACE can also optionally force the transformation of y to be non-decreasing.

Since we are generally fitting a model to the data and because ACE’s suggested transformations (Figure A3) are in graphical form, we would, at this point, need to look for analytic functions that approximate the suggested ACE transformations for transforming the original data. In this example, we would arrive quite easily at analytic functions such as exponential for \( Y \), sine for \( 1.3A \) (the 1.3 would be estimated from the observed x-values at the turning points on the transformation plot for A), absolute-value for \( B \), square for \( C \), cubic for \( D \), and no transformation for \( E \) (Figure A4).

After we have applied these analytic functions to transform the original data, a regression of the transformed \( Y \) on the transformed independent variables will obviously produce an \( R^2 \) of 1, an intercept of \( 10e^{-8} \), and parameter coefficients of \( 3e^{-8}, e^{-8}, e^{-8}, e^{-8}/9 \) and \( e^{-8} \) for the corresponding independent variables. The functional relationship of the model in Figure A4 is thus:

\[
E[\exp(Y)] = 3e^{-8} \sin(1.3A) + e^{-8} \text{abs}(B) + e^{-8}C^2 + e^{-8}(D^3/9) + e^{-8}E + 10e^{-8}
\] (3)
In actuality, the ACE model has an $R^2$ of 0.994 which is short of 1.0 because ACE, being a numerical procedure, is not perfect even on an analytic model. However, note that the $R^2$ of 0.994 is considerably better than 0.637 as obtained using OLS. It is important to note that in theory ACE can not fit worse than ordinary regression, because if no transformation is indeed necessary (i.e., the ordinary regression model is exactly true), then ACE would simply suggest nearly linear transformations for all variables (much like the transformation for $E$ in Figure A3).

Naturally, much like other empirical methods, ACE will generally not do as well as the example here when (1) some independent variables are highly correlated, (2) there is a sizeable error term, (3) some independent variables are omitted or (4) some extra independent variables are present, although this last situation is partially taken care of by a built-in stepwise variables selection procedure. (For the data used in the current example, this selection procedure retains all five independent variables when using ACE, but discards $B$ and $C$ when restricted to OLS.)

**Interpreting ACE Transformation Plots**

To study the effects of the independent variables ($A$, $B$, $C$, $D$, $E$) on the dependent variable ($Y$), we can refer to relationship (3) or the analytic ACE transformation plots (Figure A4). In general, it is easier to interpret the ACE model from the transformation plots because the plots are easier to conceptualise compared to the mathematical expressions of the transformations which can be quite cumbersome.

If we choose to interpret using transformation plots, then a very useful observation to note is that when the transformation for the dependent variable is an increasing function, then the transformed values ($y$-axis) of the individual transformation plots of the independent variables are positive correlates of the observed (i.e., pre-transformed) values for the dependent variable. This observation is true because a higher transformed value for an independent variable has a larger contribution to the transformed value of the dependent variable (because the corresponding parameter estimate for the independent variable is always positive), which in turn maps back onto a higher observed value for the dependent variable (because its transformation is an increasing function).
Similarly, a lower transformed value for an independent variable has a smaller contribution to the transformed value for the dependent variable, which in turn maps inversely onto a lower observed value for the dependent variable.

In our example, the transformation for \( Y \) is an increasing function (i.e., exponential) (Figure A4) and the parameter estimates for \( A, B, C, D, \) and \( E \) are positive (see relationship (3)), hence a higher transformed value for \( B \), say, will result, everything else being equal, in a higher transformed \( Y \) value, which in turn translates back into a higher observed \( Y \) value. In short, a higher transformed \( B \) value will map onto a higher observed \( Y \) value, and vice versa. Therefore, when we want to relate the independent variables \( (A, B, C, D, E) \) to the dependent variable, \( Y \), we can bypass the mapping onto the \( Y \) transformation plot, and simply regard the transformed values of the independent variable plots as positive correlates of the observed \( Y \) values.

In summary, we can, for interpretation purposes, treat a transformed axis (y-axis) of an \( X \)-variable transformation plot as if it were the observed (pre-transformed) axis (x-axis) of \( Y \), provided the ACE transformation for \( Y \) is an increasing function.

So we only need to focus on the individual transformation plots of the independent variables in order to study their effects on the dependent variable, \( Y \). For instance, if we look at the transformation plot for \( A \) (Figure A4), we know that the ACE model suggests that, as the observed \( A \) value increases, the observed \( Y \) value would decrease, then increase, and then decrease again. As for \( B \), its absolute-value transformation suggests that as \( B \) increases, \( Y \) would decrease and then increase (Figure A4).

Generating an ACE Model

The ACE module produces an output of graphical transformations for the dependent and independent variables. ACE will also indicate the adjusted \( R^2 \) and imputed \( p \)-value of the model based on these graphical transformations (all \( p \)-values are really only the computational counterparts of the \( p \)-values in a standard regression model, but they are useful for between-model comparisons as well as for variables selection). As the transformations for this preliminary ACE model are presented in graphical rather than analytic form, analytic functions will then have to be constructed to replace the ACE transformations for transforming the original data (see De Veaux (“Finding Transformations for Regression Using the ACE Algorithm.” Sociological Methods & Research, vol 18, 1989) for examples of analytic function construction).

Ordinary Least Squares regression can then be applied to the transformed data to arrive at the final ACE model. To ensure that the analytic functions represent the graphical ACE transformations adequately, the adjusted \( R^2 \) in the preliminary and the final ACE models must be checked for a close match. The
statistical significance of the variables in the final model are then ascertained, and the model assumptions of constant variance and normality checked.

The construction of analytical functions to represent the graphical ACE transformations is only necessary if it is desirable to present the final model in a parametric form to facilitate formulation of probabilistic statements in estimations, tests, predictions and the like. If the object of modelling is principally to understand relationships or to directly obtain predictions using new data, the graphical solutions can be easily grasped and may naturally be preferred.