Customer satisfaction with cellular network performance:

Issues and analysis

by

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A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Industrial Education and Technology

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Ames, Iowa

2005

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This research evaluated key drivers of satisfaction with cellular network performance and quantified the relative order of importance for each of the drivers. The study also validated an existing survey instrument, and explored an expanded conceptual framework that draws on service and product quality literature to suggest additional issues and attributes to investigate in future efforts to understand and model perception of cellular network quality. Additional attributes explored were expectation, level of use, other service features, and personality.

The body of published research is generally based on tracking studies that utilize univariate data analysis such as top-box and proportions (Power and Associates, 2003). The literature review in this study reaffirmed several key network attributes commonly surveyed in satisfaction surveys (network availability, coverage, drop calls, and call quality), and also determined the relative impact of each of the variables on satisfaction with network performance.

With respect to descriptive statistics, there are lots more males than female, and there are considerable differences in size and number of account sizes and types. However, descriptive results showed call quality with highest satisfaction level, followed by network availability, drop calls and coverage with mean satisfaction values of 3.68, 3.38, 3.26, and 3.02 respectively. Box-Cox transformation of the dependent variable improved the linearity of the regression model by a modest value of .6% in total variation. Multiple regression analysis was applied to examine the effects of each independent variable on network satisfaction and rank relative order of importance. Together, the independent variables explained approximately 37% of the variation in the dependent variable. With outliers

removed, the model explained nearly 45.3% of total variation in network satisfaction. "Network availability" emerged as the most highly correlated predictor to network satisfaction, followed by "coverage" and "call quality" with regression beta values of .435, .174 and .125 respectively.

Lastly, the normality assumption of regression was met in which the residuals were normally distributed and constant variance (homoscedastic) over sets of values of the independent variables. However, studentized vs. predicted Y plot revealed a slight deviation from linearity of datapoints. Multicollinearity was also assessed and did not appear to be a problem.

CHAPTER 1. INTRODUCTION

Statement of the Problem

Today, wireless technology businesses are faced with the challenging task to discern critical aspects of network improvement. The challenge lies in identifying and prioritizing network improvements in such a manner as to obtain the maximum impact on satisfaction with network performance and, ultimately, on customer satisfaction to provide best return on investment. According to the Wireless Network Quality Assessment study conducted by Power and Associates (2003):

> ...the level of switching intent among cellular users increases proportionally as the number of network quality problems experienced increases. ... It is apparent that providing clear and uninterrupted calls is a top priority for wireless carriers, and it is reflected in their capital spending on network upgrades and improvement. (p. 2)

The problem addressed in this study was the relative impact of key network attributes on customer satisfaction with overall network quality.

Background of the Study

Due to the hyper-competitive environment of the cellular industry, the need for reliable wireless customer satisfaction research is essential to the survival of any wireless carrier. Acquiring and retaining wireless customers are becoming more difficult as markets become saturated with wireless providers and competitive rate plans. Customer satisfaction management (CSM) research is one of the fastest-growing segments of the marketing research industry as a whole. However, CSM research work in the wireless industry remains primarily confidential and exclusive within a few private marketing firms and is not publicly available at a reasonable cost. In addition, there is a paucity of network performance research in public or academic settings that present a comprehensive research design including multivariate analysis work and only top-box or tracking of satisfaction studies have been published.

Satisfied customers offer businesses a promise of enhanced revenues and reduced operating costs (Dutka, 1995). Quality experts (Johnson, M., Gustafsson, A., 2000) emphasize three basic strategies for successful quality management: (a) using reference models or benchmarks; (b) setting priorities for quality improvement; and (c) focusing one's resources.

While some anecdotal evidence suggests that more consumers have begun to express dissatisfaction with various aspects of their wireless phone service, more comprehensive nationwide data about the quality of service provided to wireless phone users are not available publicly (Baker and Kim-Sung, 2003). According to research reports published in the wireless industry (Power and Associates, 2003, Harris Interactive, 2003), a number of factors are tracked in satisfaction studies with network performance, such as network capacity, size of coverage, quality of signal, features, phones, and others. However, it is not known to what extent each of these factors impact overall satisfaction. The concrete aspects of network performance are not the only factors affecting customer satisfaction. As research has indicated (Cronin and Taylor 1994, Oliver, 1997), other intangible factors such as attitude and expectation affect perception of product and service quality as well. For this reason it is critical to understand the effects of the tangible and intangible aspects of satisfaction with cellular network before large investments are committed.

Purpose of the Study

The main objective of the study was to reaffirm key drivers of satisfaction with network quality and determine derived relative order of importance. In the literature review, an effort was made to widen the conceptual model to include other key physical and non-physical attributes of cellular network that could prove to be significant to customer satisfaction with network performance. The dimensions that will be referenced in the literature review are based on leading wireless industry research, customer satisfaction research, and commonly recognized engineering attributes. The case study consisted of actual data collected from a random sample of users that were related to network quality in a particular market. By understanding the level of satisfaction and factors affecting satisfaction with network quality, the results could be applied to provide guidance to management. The findings could possibly aid management to prioritize capital spending accordingly to yield maximum return on investment (i.e., improved customer satisfaction).

Importance of the Study

Industry-wide, billions of dollars are spent each year to improve cellular networks. "With an increasingly competitive environment and changing industry landscape, carriers that offer superior network quality will increase their likelihood of attracting new customers and retain more of their existing base," (Power and Associates, 2003). In general, carriers have a concern about whether there is substantive evidence that when capital is spent on improving network attributes, the resulting improved network correlates with a higher satisfaction score.

Research Questions

The following research questions guided this study:

1. What aspects of the network performance are sources of customer satisfaction or dissatisfaction?
2. What are the key drivers of customer satisfaction with network quality?
3. What is the hierarchy of derived importance of network performance significant attributes?

Assumptions of the Study

The following assumptions were made in this study:

1. During data collection, the instrument was assumed to have been used by professional interviewers and adequate time was allowed for conducting, collecting, and compiling the results.
2. The samples are assumed to be random within this particular market and the sampling methodology was appropriate.

Delimitations of the Study

Delimitations describe the populations to which generalizations may be safely made. The following were delimitations:

1. The generalizability of the study is limited to the subject sample, which is drawn from one market. The company under review provides digital wireless communications (cellular) services in markets throughout the United States. However, the data analysis is based primarily on customers located in one state and only certain variables related to network performance are reviewed and analyzed.

2. Findings from this study are valid for this service provider.
3. Network satisfaction attributes covered in the existing instrument do not constitute a comprehensive network satisfaction construct.

Organization of the Study

Chapter 1, Introduction, presents the statement of the problem, provides a brief literature review about the topic; discusses the research purposes, importance, and questions; and states the study's assumptions, delimitations, and definitions of terms. Chapter 2 presents the Literature Review. The background theories and service literature are discussed, an overview of cellular network performance is provided, and a network performance dimensional model is introduced. Chapter 3, Methodology, presents and provides an explanation of the measurement model, states the questions, identifies the study design, and methodology. The results and findings are presented in Chapter 4. Finally, Chapter 5 discusses the analysis results and their implications, states the limitations regarding interpretation of the results, and suggests future research topics.

Definition of Terms

For the purposes of this study, the following definitions were used:

Benchmarking – Comparison of measurements based on a set variables across several service providers.

Carriers: Cellular service providers.

Cell site: The location where wireless antenna and network communications equipment are placed.

Churn: The number of customers who terminate their service.

Disconfirmation paradigm: is the judgment of perceived service when compared to expectation.

ESMR: Enhanced Specialized Mobile Radio.

Expanding coverage: Adding transmitter sites to expand coverage footprint.

Handoff: The process when a wireless network automatically switches a mobile call to an adjacent cell site with a stronger signal.

Holes or dead spots: Areas within core coverage with no cellular signals.

Interconnect: Regular cellular calls.

Network performance: Relates to the quality of coverage which includes holes, drop calls, system busies, system outages, and in-building coverage.

Network: Cellular network that consists of a network of transmitters.

Outage: Complete loss of signal where there expected to have a signal.

PCS: Personal Communication Systems.

Product: Cellular phones or handsets.

Service: Cellular, two-way, messaging and Internet services provided by the carrier via handset.

Short Messaging Service (SMS): Enables users to send and receive short text messages (usually about 160 characters) on wireless handsets. SMS is available in all advanced wireless networks and in many "second generation" networks.

System busy: User receives a busy signal when setting up a call.

Top-box: the percentage score of all satisfied customers.

Voice quality: Clarity of verbal communication.

Wireless: General term for using radio-frequency spectrum for transmitting and receiving voice, data and video communications signals.

CHAPTER 2. LITERATURE REVIEW

Introduction

Early studies of customer satisfaction focused only on quality and a more explicit customer satisfaction approach did not begin until the 1980s (Johnson and Gustafsson, A., 2000). Most businesses perceived they understood all there was to know about customer satisfaction and how to keep their customers happy. Eventually, with increasing competition, the recession in the 1990s and the shrinking of global markets, businesses were compelled to take a serious look at customer satisfaction surveys, especially as these surveys became increasingly more sophisticated. As emphasis on customer satisfaction programs became strong, designing programs to understand customers better became an important goal for businesses. Examples of such programs have included: Total Quality Management (TQM), Customer Satisfaction, Relationship Marketing, and Value propositions (Myers, 1999).

It would be challenging to determine the percentage of U.S. businesses firms that have formal customer satisfaction programs in place. Generally, medium-sized or larger companies would have the resources to staff such a program. The results of a survey conducted by Mentzer, Bienstock, and Kahn (1993) of 124 business firms, largely between $100 million and $10 billion in gross sales where 63% had more than 1,000 employees, showed that more than 80% of the companies used their own staff employees to establish CSM (Customer Satisfaction Management) programs. As for the type of CSM program followed, the survey by Mentzer et al. (1993) revealed that more than 45% did not know which model they used, approximately 20% used a gap model, and approximately 15% used an attitude model (Myers, 1999) and the remaining 20% did not use any CSM models.

The demand for wireless telecommunications has grown rapidly, driven by the increased availability of services, technological advancements, regulatory changes, increased competition, and lower prices. According to the Cellular Telecommunications and Internet Association (CTIA) (2004), the number of wireless subscribers in the U.S. has increased from approximately 200,000 in June 30, 1985 to over 97 million by June 30, 2000, which reflects a penetration rate of 35.2%. Currently, there are more than 168.8 million U.S. wireless subscribers (CTIA, 2004).

The use of cell phones has increased so rapidly that wireless networks are becoming overloaded, resulting in a growing number of customer complaints about the quality of the service provided. The problems in cell phone service are compounded by economics as more customers have been attracted by the decline in cost of service. The percentage of all wireless subscribers who have called customer-service centers at least once in the past year to complain about service or because they had other problems has climbed to 61%, from 53% (15% rate increase) in 2000, according to J.D. Power and Associates (2003), a firm that measures customer satisfaction in many industries and sells the information to the companies being scrutinized. Experts expect complaints to grow as companies add services, contributing to stress on the networks and subscribers' confusion. Thus, wireless companies need to invest more money to accommodate all the new users. The number of satisfaction studies reviewed (Power and Associates, 2003; Harris Interactive, 2003; In-Stat/MDR's wireless panel 2003; Baker, et al., 2003) indicate that carriers are focused on satisfaction in this highly competitive market and have realized that customer satisfaction is a key to survival and that investing strategically is the primary way to gain advantage over the competition.

Measurement systems provide information that is vital to decision-making. In this research, the goal was to move from information to prioritized network spending. While carriers spend billions of dollars yearly to enhance their network, they struggle in strategic decision-making with prioritizing capital expenditures. The need to compromise is necessary to maintain a balance in spending. Network performance enhancements are important to customer satisfaction. Thus, companies must identify performance drivers of satisfaction and prioritize them. This focuses resources and quality improvement efforts that are most likely to have the greatest impact on satisfaction (Allen and Rao, 2000). Therefore, the key driver analysis and importance-performance analysis become essential to reach this goal. This research utilized the results of key driver analysis as the main statistical analysis to establish a relative importance matrix.

Service Quality

Although researchers have studied the concept of service for several decades, there is no consensus about the conceptualization of service quality (Cronin and Taylor, 1994; Oliver, 1997). Various researchers focused on different aspects of service quality. Reeves and Bednar (1994) noted, "there is no universal, parsimonious, or all-encompassing definition or model of quality" (p. 436). The most common definition is the traditional notion that views quality as the customer's perception of service excellence. In other words, quality is defined by the customer's impression of the service provided (Berry, Parasuraman, and Zeithaml, 1988; Parasuraman, Zeithaml, and Berry, 1985). The assumption behind this definition is that customers form the perception of service quality according to the service performance they experience and based on past experiences of service performance. It is, therefore, the customer's perception that categorizes service quality.

The disconfirmation paradigm of customer service models the consumer's process in comparing expectations to a firm's performance (Oliver, 1980). The paradigm refers to satisfaction judgments as positive disconfirmation, and dissatisfaction judgments as negative disconfirmation. The gap theory model of service quality (Zeithaml, Berry, and Parasuraman, 1990) differentiates the gaps between a guest's expectations and perceptions.

According to Parasuraman et al. (1985), "service quality, as perceived by customers, can be defined as the extent of discrepancy between customer's expectations or desires and their perceptions" (p. 19). Parasuraman et al. (1985) found that customers assessed service quality through five dimensions: tangibles, reliability, responsiveness, assurance and empathy. They developed the original 22-item "SERVQUAL" scale comprised of questions intended to assess five specific dimensions (tangibles, reliability, responsiveness, assurance, and empathy). The SERVQUAL instrument utilizes a gap (or difference) score analysis methodology, wherein the user's expectations for service quality are assessed at the same time as the user's perception of the actual system performance. The difference between these two scores (performance minus expectation) is used as the basis of analysis.

According to Cronin and Taylor (1992, 1994), SERVQUAL is paradigmatically flawed because of its ill-judged adoption of this disconfirmation model. "Perceived quality" or SERVPERF, they claim, "is best conceptualized as an attitude". They criticized Parasuraman et al. (1985) for their hesitancy to define perceived service quality (SQ) in attitudinal terms; even though Parasuraman et al. had earlier claimed that SQ was "similar in many ways to an attitude," (p. 41-50). Cronin and Taylor observed:

> Researchers have attempted to differentiate service quality from consumer satisfaction, even while using the disconfirmation format to measure perceptions of service quality… this approach is not consistent with the

> differentiation expressed between these constructs in the satisfaction and attitude literatures. (p. 55-68)

Cronin and Taylor (1994) suggested that customers have expectations towards a performed service, but that expectations do not form consumers' perceptions of service quality (p.57). They suggested that perceived performance is the most appropriate measure of service quality and that the performance minus expectations construct is an inappropriate basis for the measurement of service quality (Cronin and Taylor, 1994, p. 125).

The emerging literature seems to support the performance-based paradigm over the disconfirmation-based paradigm; however, a common focus by researchers has been defining service quality dimensions. A study by Brown, Churchill, and Peter (1993) concluded that the performance-only element of SERVQUAL (referred to as SERVPERF) performs about as well as SERVQUAL itself (p. 134).

When one considers the role of expectations in the construction of satisfaction, the extent to which a service fulfills a person's desires may play a role in shaping his or her feelings of satisfaction because of the impact of disconfirmation of expectations on satisfaction (Spreng, MacKenzie and Olshavsky 1996). Failure to consider the extent to which a service fulfills a person's desires has led to logical inconsistencies, such as predicting that a customer who expects and receives poor performance will be satisfied (Spreng et al., 1996).

Gronroos (1984) used a two-dimensional model to study service quality: (1) technical quality that is based on the outcome of the service performance; and (2) functional quality that is based on the perception of how the service is delivered. McDougall and Levesque

(1994) added a third dimension—physical environment to Gronroos' (1984) model and proposed a three-factor model of service quality.

Dabholkar, et al. (1996) proposed a hierarchical model that suggests service quality is a multi-level and multi-dimensional construct. This model includes consumers' overall perception of service quality, a dimension level that consists of physical aspects, reliability, personal interaction, problem solving, and policy, and a sub-dimension level that recognizes the multifaceted nature of the service quality dimensions. Dabholkar et al. determined that quality of service is directly influenced by the perceptions of performance levels. In addition, customers' personal characteristics are important in assessing value, but not quality.

Chia-Ming, et al. (2002) summarized that Brady (1997) developed a hierarchical and multidimensional model of perceived service quality by combining the hierarchical models by Dabholkar et al. (1996) and McDougall and Levesque (1994). There are three dimensions in Brady's model: (1) interaction quality; (2) outcome quality; and (3) physical environment quality. Each dimension consists of three corresponding subdimensions: (1) interaction quality—attitude, behavior, and expertise; (2) outcome quality—waiting time, tangibles and valence; and (3) physical environment quality—ambient conditions, design, and social factors. This hierarchical and multidimensional approach is perceived to better explain the complexity of human perceptions than the conceptualizations currently offered in the literature (Brady, 1997; Dabholkar et al., 1996). The empirical test of this model purports that the model is psychometrically sound. According to Blodgett (1993), "...a customer arrives at an overall judgment of the service transaction based on perceptions regarding the people (interactional justice), the product (distributive justice), and the process (procedural justice). These three interplay to determine a service assessment or a satisfaction judgment based on justice" (p. 100-110).

Review of the literature on personality and individual differences illustrates the importance of the trait-factor on predicting reactions to jobs (Robertson, Lewis, and Bardzil, 1999). Personality traits may be interpreted as individual pre-dispositions to behave in certain ways and are initially established through factor analysis of lexical descriptors i.e., measures of personality traits (Schneider and Hough, 1995). In a study of effects of personality on customers' assessment of quality of service, Robertson et al. (1999) determined that associations between personality type and judgment might be predictive. Research has also shown that a significant percentage of the variance in satisfaction may be explained by one or more enduring personality characteristics (e.g., positive and negative affectivity), although the majority of variance is still explained by situational factors (Robertson et al., 1999).

On the other hand, in a literature review of service quality models, Chia-Ming, et al. (2002) concluded that perception of service quality is a controversial subject and no consensus was reached on how to conceptualize or operationalize the construct:

> SERVQUAL, which applies the traditional disconfirmatory model, was the first effort to operationalize service quality. Although it made great contribution to the field of service quality, it is insufficient because of its inherent weakness. More recent models, hierarchical multidimensional model synthesize prior approaches and represent the complexity of the construct of service quality perception. (Brady, et al, 1997)

Another area of importance in customer service is the possibility of change of expectations over time. Customer expectations are pre-trial beliefs about a product (Olson and Dover, 1979). In the literature on service quality and customer service, they serve as reference points against which subsequent service/product performances are compared and from which judgments on satisfaction or quality are made. Expectations can be resistant to change (Oliver, 1980). In addition, "After several disconfirmations, expectations may eventually coincide with post trial beliefs so that further disconfirmations are not possible" (Olson and Dover, 1979, p. 187). The rate at which consumers adjust their expectations to meet perceived product performance can be affected by the variability of a product's performance, the ease with which it can be evaluated, the degree of involvement with the product, the completeness and accuracy of information that forms expectations, and the precision with which a product's level of performance is recalled. Adjustments to expectations are likely to be swift when the product is easily evaluated, but slow when a product is complicated and has many attributes. Level of use is another aspect of satisfaction found in market research literature related to customer service. Satisfaction with a product/service is a construct that requires experience and use of a product or service (Oliver, 1997). Individuals who pay for a product/service but do not use this product/service should not be expected to have the type of [dis] satisfaction that a product/service user (the consumer) will have. Designing customer satisfaction surveys must be done from customer's viewpoint. The value of using consumer observations and assessments as indicators of wireless service quality depends significantly on how individual consumers use their service. In this regard, consumers who use their cell phones to make numerous calls regularly are likely to have a better insight regarding the quality of their service than are those who make few or no calls but carry a cell phone in case of an emergency (Baker and Kim-Sung, 2003).

In summary, the various general models used in service and product satisfaction research offer insight to the complexity of customer satisfaction constructs. Thus, models should be implemented strategically. The expectations, performance, and disconfirmation constructs have been studied across a range of products and found to successfully explain and predict consumer satisfaction. Studies commonly referred to as "uses and gratifications" research (Palmgreen, and Rayburn 1979), have employed the expectation-disconfirmation model. Researchers in the area of uses and gratifications have had results similar to market and consumer researchers. Others have found that product performance routinely emerges as among the greatest or the only significant predictor of satisfaction (Burgoon, M. and Burgoon, J.K. (1979). In studies of multi-attribute products and services, performance is often treated as a uni-dimensional construct, measured either as a single attribute or by using a summated index of performance and relating it to overall satisfaction, (Jacobs, 1999).

Cellular Network Performance

The ability to make quality phone calls is an essential part of the connection between a company and its customers, and it should reflect the quality efforts by the company. Cellular radio can be regarded as the earliest form of wireless "personal communications". Cell radio enables the subscriber to place and receive telephone calls over a wire-line telephone network wherever cellular coverage is provided. The distinguishing feature of cellular systems compared to previous mobile radio systems is the use of many base stations with relatively small coverage radii or coverage footprint.

Based on a study entitled *Wireless network quality assessment*, J.D. Power and Associates (2003) concluded that: "Carriers that offer superior network quality will increase their likelihood of attracting new customers and retain more of their existing base" (p. 2). The large and growing number of wireless subscribers suggests the public finds use and value in having a wireless phone. The questions to be asked are: (1) What is the value of the actual service subscribers receive? and (2) Are subscribers satisfied with the quality of their service?

Carriers play a key role in shaping perception and satisfaction of network quality, and identifying critical attributes of network performance. The main aim of radio network planning is to provide a cost-effective solution for the radio network in terms of coverage, capacity and quality. Network Management System monitors, among others, amount of traffic and blocking, resource availability and access, receiver level and quality (Mishra, 2004). If one looks at past and current engineering practices in the industry regarding network performance, wireless carriers have an arsenal of tools and devote significant resources to optimize cellular networks. Wireless carriers use these tools for measuring and optimizing signal quality, a practice often called benchmarking. Benchmarking tools are not only a means of rectifying specific network problems and ensuring ongoing quality, but also provide documentation of competitive advantage over similar wireless services. Kobielus and Woessner (1998) predicted that high quality audio performance from wireless systems will become a competitive necessity, something that subscribers will take for granted, which is clearly indicated by J.D. Power and Associates (2003) study. Operators who fail to deliver acceptable audio quality performance, as measured by audio quality and other metrics, will rapidly lose customers to any of several competitors, among them traditional cellular carriers or the new breed of PCS, ESMR, wireless local loop (WLL) and mobile satellite service (MSS) providers. In other words, wireless operators must increasingly focus on quality and subscriber- perceptions of quality. They should concentrate their efforts on areas of competitive weakness, such as call quality due to signal strength and interference. Quality-related systems test, measurement and optimization activities will grow in importance.

Network optimization practices in the industry focus on maintaining high-level quality service. Since the inception of wireless communication, carriers have adopted many optimization techniques and have used various types of test equipment to measure and optimize signal quality and call processing. Historically, cellular network design and management are based on several key goals: (a) use of frequency spectrum; (b) allocation of base stations; (c) efficient use of voice and data channels; (d) power of transmission; (e) placement of cellular sites; and (f) quality of coverage. Construction of new sites is often designed to provide more capacity in a congested area, expand footprint, and improve quality of the network. For voice services, the number of available channels defines the system capacity that provides the capability to simultaneously serve subscribers per area at some predetermined level of signal quality or quality of service (QoS). Data services are defined by the throughput at some predefined level of QoS (e.g., time delay, error rate, reliability). Voice mail and text messaging notification are also services and features that are impacted by quality of service. Thus quality of service is a composite metric made up of several call-related factors that contribute directly to end-user satisfaction. Some of the common metrics tracked are: call access, call quality, and call completion.

Other design objectives are area reliability and call hand offs. Area reliability is the percentage of received signal above the threshold. On the other hand, a hand off usually involves transitioning call from one traffic channel to another. If the received signal from all base stations is weak, a poor hand off or dropped call can occur around the cell boundary. Weak signal level causes poor audio quality. Due to various shadowing and terrain effects, the signal level measured on a circle around the base station shows some random fluctuations around the estimated value given by the propagation model. The Intel technology journal, *Q2* (2004), noted that the second-generation of cellular technology (also known as 2G) introduced digital wireless standards that concentrate on improving voice quality, coverage, and capacity. The 2G standards are defined and designed to support voice and low-rate data only. It should be noted that Internet browsing was in its infancy during the definition stage.

In summary, quality and capacity are the foundations of wireless network management, and providing acceptable coverage and capacity are keys to customer satisfaction. However, to make a network affordable, it is currently necessary to allow a certain percentage of calls to fail, also termed Grade Of Service (GOS). Service providers are constantly challenged with keeping a balance between cost and quality. Service providers must find a balance between GOS and low cost. Therefore, multi-variate research analysis in this area has not been investigated adequately as most published studies have been focused on tracking top-box scores and tracking proportions of satisfied customers in certain areas (Power and Associates, 2003, Harris Interactive, 2003).

Network Performance Dimensional Framework

Interaction between a company and a cellular customer is generally through the network. Thus, the "moment of truth" i.e. customer's interaction with service, between a company and a customer is the perception of network quality during usage. If a company intends to satisfy its customers, it needs to ask: What makes customers satisfied with a company and its products and services? The absence of these aspects of human interaction through which quality can be delivered to customers will have to be compensated for by better performance based on other quality factors or by excellent performance on "new" specific quality factors.

Regarding customer satisfaction with network quality, public research work has been very limited. The methodologies followed in cellular satisfaction studies by consulting firms are highly confidential; thus, not much research design work has been shared with the general public. Consulting firms hired by cellular providers usually share results but not research methodology. Company knowledge is the first source of information about critical performance attributes; however, customer satisfaction must extend beyond the company and to the customer (Johnson and Gustafsson, 2000. For this reason, exploratory qualitative studies are the first step in defining critical performance attributes. As exemplified by carrier practices and revealed in the research, issues of call quality, capacity, and coverage are a few of the foundational measures of wireless network management. Therefore, providing an acceptable level of performance for these measures will most likely be the key to customer's satisfaction.

J.D. Power and Associates (2003) conducted a landmark study on carrier performance and published part of their findings which provided a detailed account of problems customers experience with their wireless calls across a number of dimensions. The study employed a network quality index (NQI) based on seven customer-reported problem areas that impacted overall carrier performance: (1) dropped/disconnected calls (32%); (2) static/interference (29%); (3) voice distortion (14%); (4) no connection on first try (12%); (5) echoes (8%); (6) no immediate voice mail notification (4%); and (7) no immediate text message notification (1%). The company polled 16,800 wireless telephone customers on cell-phone problems. They found that these problems have a large impact on customer satisfaction and carried the most weight in wireless companies' final network quality scores. The study also indicated that the level of switching intent increases proportionally as the number of network quality problems experienced increases.

According to a recent survey by In-Stat/MDR's wireless panel (2003), the top four drivers of customer satisfaction include: (1) service price; (2) good geographic coverage in the user's area of interest; (3) network quality/reliability; and (4) customer service. A wireless carrier's customer satisfaction can be judged based on each of these attributes, as well as on an overall basis. In-Stat/MDR also created its own scores by which to judge providers' performance.

In June of 2003, the AARP (American Association of Retired Persons) conducted a nationwide survey (Baker, et al.) to measure consumers' interest in, awareness and understanding of, and satisfaction with wireless telephone service and service providers. A nationally representative sample of 3,037 adults participated in the survey. The sample was designed to represent the continental U.S. adult population living in households that had a cell phone. The survey also enabled comparisons between wireless telephone users and non-users in three different age groups: 18-49, 50-64, and 65 and older. In their summary/conclusions section, it was reported, unsurprisingly, that consumers who use their wireless service more frequently are generally in a better position to assess service quality. In this regard, the findings from this survey suggest that the most frequent users of cell phone service are less likely to report being "very satisfied" with their service and more likely to say they have experienced difficulties in making or receiving calls. When asked why they remain with their current provider, more than half of the most frequent users of cell phone service said they either wanted to avoid paying an early termination fee or that they did not want to give up their current cell phone number. This finding suggests that cellular users experience with other cellular companies is somewhat limited which makes it challenging to compare the network quality of this provider to other service providers and, thus, set realistic expectations. However beginning November 17th, 2004, users are able to keep their phone numbers when they change cell companies and market data is already showing some carriers maintaining a positive port-in to port-out ratio against other competitors with a churn rate ranging between 1.5-3.3 % (Pappalardo, 2004).

Another study conducted by the School of Information Management and Systems at University of California, Berkeley (Day, Hsueh, Liggett, and Ren, 2001) concluded that the overwhelming top three reasons consumers selected a provider were: (1) the coverage area associated with the service; (2) cost of the service plan; and (3) number of minutes included in the service plan. Another factor that could be related to satisfaction is impact of regular vs. infrequent use of a service.

Studies referenced below illustrate that system availability, coverage, frequency of dropped calls, and call quality are key to network reliability and have emerged as important factors in retaining and acquiring customers. Therefore, how does one define a network performance construct? From the perspective of today's wireless phone user, network quality is based on, among others, three factors: (1) access reliability (or blockage rate); (2) completeness of coverage; and (3) audio quality (Power and Associates, 2003, In-Stat/MDR's wireless panel 2003, Baker et al., 2003). These attributes seem to be key and cellular carriers monitor network performance by measuring parameters that directly affect these characteristics.

Based on the key parameters used by carriers for network optimizations, leading marketing firms research in the cellular industry (i.e. J.D. Power, Harris, and others), and based on previously reviewed research studies, it is posited that a network performance dimensional model should combine attributes from aforementioned sources which can be summarized into four key dimensions or benefits: 1) call quality, 2) coverage, 3) system availability, and 4) drop calls. However, each of these dimensions can be further defined by one or more sub-attributes. Therefore, a list of physical network attributes comprised in this research attempted to cover all relevant categories of the network (i.e., benefits from both carrier's and consumer's perspectives. Figure 1 illustrates the dimensional framework of the model proposed in this study:

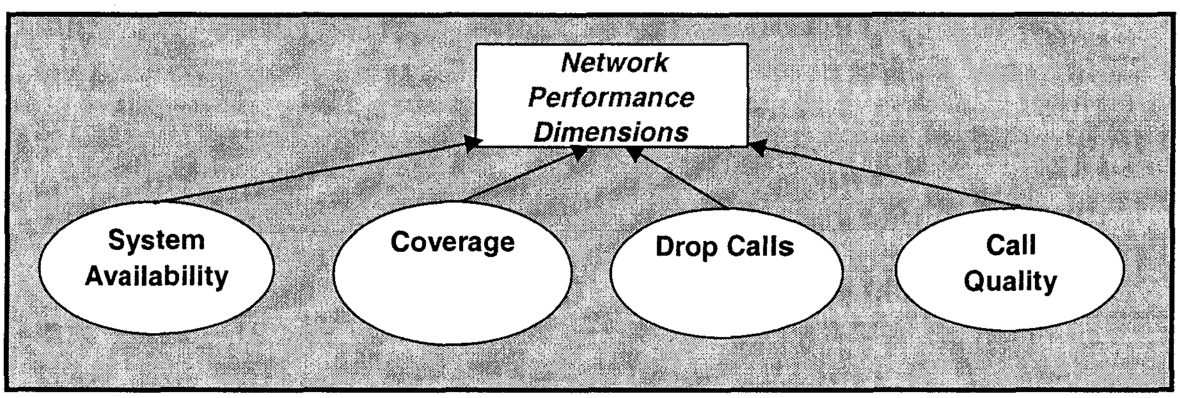

Figure 2.1. Network performance dimensional model

In the context of network quality as it relates to SERVQUAL, reliability is the only dimension that applies directly. Reliability is the ability to perform the promised service dependably and accurately. Two of the aspects in the reliability dimension are "doing what is promised", and "doing it at the promised time." The following is a description of the "reliability" dimension in SERVQUAL and network attributes adopted:

Dimension 1: System availability is the ability to access the network in a timely fashion. Timely network access is a crucial component to reliability. Thus, when someone needs to make a call promptly, getting access to the network and setting up a call becomes a critical factor in determining satisfaction with reliability. According to J.D. Power and Associates (2003), no connection on first try, ranked (12%). A number of reasons could cause failure in access, to name the major ones:

- *Outage* occurs if there is a power or other outages to the site that could affect its operation causing a loss of signal in the serving area
- *System busy* is a condition in the network that would cause a denial or a delay in making phone calls.

Dimension 2: Coverage is the extent of the space in which a customer could use the service. It is a convenience that many customers find key to their satisfaction. Several studies mentioned in this research revealed that size of coverage is one of the main factors customers use in selecting a provider. Coverage consists of several types:

- Local coverage which is primarily the coverage for the local calling area
- National coverage which is the coverage the provider provides outside of the local area

- In-building coverage which is coverage inside buildings and facilities such airports, malls, and densely inhabited urban areas.
- Holes and dead spots are areas within the local coverage area that can also be important in evaluating satisfaction with coverage.

Dimension 3: Dropped calls usually occur because of a loss of signal or system processing error, which would ultimately cause an abrupt loss of service. Power and Associates (2003) found that, among customers, dropped/disconnected calls rated 32% in importance in seven customer-reported problem areas.

Dimension 4: The quality aspect of the call is the main interaction between a customer and an organization. As explained previously, there are a number of causes for poor call quality and, regardless of the reason, the impact on customer satisfaction is negative. There are a great number of customers who abandoned their provider because they were frustrated with the quality of calls. According to Power and Associates (2003), three of seven call quality related areas ranked a total of 51% in terms of importance in seven customer-reported problem areas. The remaining two of the seven areas ranked as follows no immediate voice mail notification (4%); and no immediate text message notification (1%). Therefore, the need to have high quality call is paramount.

Case Study – A Theoretical Perspective

In theory, a researcher defines the hypothetical constructs by specifying the dimensions of each (Bollen, 1989). Before the theory can be tested empirically, a set of observable indicators must be defined for each dimension of each construct. There must be clear rules of correspondence between the indicators and the constructs, such that each construct and dimension is distinct (Costner, 1969). The current research is a case study that is based on a particular group of customers of a particular cellular provider. "When and why would one want to do case studies on a topic?" is a question asked by Yin (1994) to explain research strategies and selection. According to Yin, research strategies are not hierarchical (i.e., exploratory should only be used in the investigative phase of a research, and surveys are only appropriate for the descriptive phase, and that experiments are the only way of doing exploratory or causal inquiries). Yin argued that a more appropriate view is a pluralistic one in which each strategy can be used for all three purposes: exploratory, descriptive, or explanatory.

The next question is, which strategy to use and why? Yin (1994) lifted the boundaries of case study strategies and provided a general guideline on when to use a strategy based on the type of research question to be presented. A survey strategy is favored when the question is "what", "who", or "where" and when the research goal is to describe a phenomenon and to be predictive about certain outcomes.

The current study is a typical example of a survey study wherein there is little control over the events, whereas the focus is to understand what drives customer's satisfaction and what variables affect customer satisfaction scores. This approach supports an exploratory type of a case study as suggested by Yin (1994). A rigorous method of research must be followed in case study research. The highest level of knowledge is causal, which includes correlational knowledge. Single-subject designs cannot produce causal knowledge with complete certainty; they can only be approximated. Causal knowledge also contains correlational and descriptive knowledge. Correlational knowledge also includes descriptive knowledge. Hence, the major argument for the use of single-subject designs is that they can provide different levels of knowledge that practitioners can use in making decisions about assessment, treatment implementation, and treatment evaluation (Tripodi, 1994). The argument by Tripodi illustrates the importance of understanding the limitation of single-subject studies and the level of knowledge one can obtain from analysis.

CHAPTER 3. METHODOLOGY

This chapter identifies the methods and procedures used in achieving the objectives of the study. Transforming raw data into an understandable form is the main goal of any data analysis. Secondary research from an existing proprietary survey instrument was used which provided the measurement of the level of satisfaction with network performance within the studied organization. The following main topics are addressed in the methodology: Survey Instrument Review; Variables of the Study; Measurement Scales; Research Design; Statistical Analysis Data Considerations; Population and Sampling; Confidence Intervals; Sampling Adequacy; and Validity and Instrument Reliability.

The model in the current research is a multi-dimensional construct model that is based on wireless industry practices and research. All dimensions in the model correspond to questions in the existing survey currently used by the company of interest. Each of these attributes is considered as an independent variable. The four dimensions listed in the model include: system availability, coverage, dropped calls, and call quality. The model did not take into consideration the sub-attributes with in each dimension discussed previously. The purpose in the current research was to attempt to validate key dimensions of network performance. Another influence that has been ignored is the human psychological factor. This is a non-network based dimension, which includes personality. Other attributes such as knowledge of technology, service area, and voicemail notification should be considered. Further research will be required to investigate the effects of these attributes. It was perceived that some of the dimensions and aspects, which have been defined for general service environments, are also important in wireless service. In addition to the five dimensions defined by Parasuraman et al. (1985), empirical evidence might reveal more explicit dimensions in addition to those shown in the preliminary research conduced in this area by J.D. Power and Associates (2003).

Survey Instrument Review

The survey data was obtained using simple questions regarding satisfaction in four areas: system availability, coverage, dropped calls and call quality. All questions used the phrase "how satisfied are you with" for each of the four areas. A list of questions is provided in Appendix (A). The questionnaire was used by the company consulting firm at periodic time intervals to secure evaluations from the company's customers. The survey is comprehensive and covers a wide range of issues. However, the scope of the research was limited to only those questions that are related to network performance. The network performance attributes recalled are attributes that fall into the four dimensions previously identified. It is essential that the measurement system use attributes that are important to customers. In addition, having a survey instrument that better captures the customer's perception of the company makes the data easier to analyze (Johnson and Gustafsson, 2000). The survey questions were based on customer perception and management input as to the relevant network attributes. The key dimensions in this research included the majority of attributes typically analyzed in cellular studies. Other network attributes, such as voicemail notifications and messaging, that have been addressed in other surveys are not considered in this research due to a lack of data.

The survey was administered via a telephone, which is considered ideal for collecting data in a controlled and directed manner. The majority of quantitative marketing research is conducted via telephone survey. Typically, telephone surveys are structured interviews that are short in duration. Telephone surveys are popular because the questionnaires are mediated by professional interviewers instead of using self-administration by the respondents. Survey results are quantitative and projectable onto the target population under study.

A consulting firm employed by the company developed the survey instrument used during the data collection phase however a secondary survey is provided in Appendix A, which is based on four common attributes of network performance. The survey is given monthly to a sample of randomly selected customers. This study analyzes responses from 855 customers collected over a period of time. The phone interview generally takes 10 to15 minutes depending on each customer's answers. Customers in the study were geographically located throughout the state and served by various cell transmitter sites. To better understand users' perceptions of satisfaction with network performance, the instrument is focused on network quality attributes.

Variables of the Study

The concrete attributes of network performance and satisfaction applied in the analysis were:

Dependent Variable:

1. Satisfaction with network performance (DV)

Independent Variables:

1. System availability (IV1)
2. Coverage (IV2)
3. Dropped Calls (IV3)
4. Call Quality (IV4)

Other variables used in the descriptive analysis to understand customer demographics were:

5. Number of units (Nunits) – This is
6. Account type (AccType)
7. Gender (Gender)

Values for demographic variables Nunits and AccType were categorized to simplify data analysis and interpretation. In order to keep proprietary data confidential, account type and size categories will be coded in the following manner:

Nunits – choices for number of units in the account i.e. number of phones each account has:

size 1 = x units
size 2 = size1+y units
size 3 = size2+y units
size 4 = size 3 + y units
size 5 = size 4+y units

Choices for demographic variable account type were coded into 6 different groups or categories depending on the type of account whether it is a personal (Group A) or business. In addition, the business category is divided into four sub-groups depending on the type of business such as blue collar, white collar, and others.

AccType – account type choices:

1- Group A
2- Group B
3- Group C
4- Group D
5- Group E
6- Other

Measurement Scales

The study used a survey comprising structured scale items. Scale items measured are based on the standard four-point Likert scale ranging from "strongly agree" to "strongly disagree". The scale is anchored at the end points 1 and 4, with each scale point reflecting an increase in intensity of the attitude to the question. There are no absolute rules in this regard and each response is dependent on the respondent's cognitive process. It has been noted that a fully anchored five-point scale leads the subject towards an ordinal-level response (Allen and Rao, 2000). Using a Likert scale is consistent with past behavioral and services marketing research methodologies (Zeithaml et al., 1990). Most, if not all, scales in customer satisfaction yield interval data (Allen and Rao, 2000).

Customer Service Management (CSM) research has revealed that the Likert scale with end points anchors is popular with customer satisfaction researchers. Delvin, Dong, and Brown (1993) compared numerous scales across six criteria: response bias, understanding, discriminating power, ease of administration, ease of use, and credibility. Using this set of criteria, the researchers concluded that either a five-point expectation scale or a four-point requirements scale yielded the best results. Grapentine (1994) was somewhat critical of the assertion by Delvin et al. (1993) that fully anchored expectations and requirements scales were most appropriate for customer satisfaction research. Grapentine (1994) suggested that the expectation scales had questionable validity referring to respondent's expectations changing overtime. Allen and Rao (2000) stated that, "...it seems safe to assume that scales based upon expectations, requirements, or gaps between service experience and service expectations have only modest support in applied and academic circles. In applied settings, the multipoint scale with endpoint anchors appears to be preferred" (p. 45). The two main scales used in the paper were categorical and interval.

Measures designed to collect demographic data about the subjects and descriptive information about type of account and time of survey were also included in the questionnaire. Demographic variables were categorical and include: gender, account type, and account size. The variables were employed in the descriptive study.

Because the questionnaire is the heart of the study, it was important to determine validity and reliability coefficients. Content or face validity and construct validity were established from experts in the field, the literature review, and the questionnaire. The measurement model was tested first, prior to conducting the regression analysis. Then construct validity was further validated through factor analysis. Reliability estimates for these scales are presented as Cronbach's Alphas (CAs). CAs verify reliability by testing the degree to which scaled items represent the phenomenon they are intended to measure (Cronbach, 1951). For the variables that had not been replicated in empirical studies (i.e., customer satisfaction survey), a CA of 0.70 is acceptable (Nunnally, 1978).

Data Screening

Before conducting the analysis, results were coded into a computer data file i.e. a spreadsheet. Numbers were assigned to each of the answers. Since a Likert scale was used in the survey, it was treated as an interval by assigning a value to each of the levels with anchor end points. In this study, the instrument used 4 points, or primary levels, with values ranging from 1 to 4. A total of 530 datasets were completed listwise for the study multivariate variables i.e. dependent and independent variables. Since the difference in regression results for R-squared, when the analyses were run with and without missing values, was less than 1.5 %, records with missing values for all four multivariate variables (IV1-IV4) were eliminated. This caused the sample to decrease in size to 530 from 855. As for demographic variables, datasets found were 687 for "AccType" and 481 for "gender", and 855 for Nunits. The measurement scale for demographics variables is categorical. Another type of scale used is nominal or categorical. The following demographic variables were used: date, total units (Nunits), type of account (AccType), and gender. (See Appendix B for a detailed scale profile). Lastly, in all cases, choice 6, which is "not sure", was neglected in the data analysis and, therefore, eliminated from the data. When the regression analysis was run with choice 6, "not sure", as a 5-point scale, the model results were weakened (new R-squared .315 versus .371). Since there was no evidence as to how "not sure" should be interpreted, the decision made was based to remove choice 6.

Results were checked with and without missing data. The researcher assessed the results of each analysis; if they were markedly different an attempt was made to discern the reason for the difference. An attempt was also made to evaluate which result more closely approximated reality (Tabachnick and Fidell, 1996).

The data were also analyzed for outliers. Outliers can distort the results of a statistical test. There are three fundamental causes of outliers: (1) data entry errors were made by the researcher; (2) the subject is not a member of the population for which the sample is intended; or (3) the subject is simply different from the remainder of the sample (Tabachnick and Fidel, 1996).

Research Design

From company's history, data analysis from survey results collected to date has ranged from proportions or percentage bases to top box score (i.e., calculating percentage of customers who responded favorably or non-favorably to survey questions). Consequently, the monthly-distributed customer report exhibited only percentages of certain answers and did not study the effect of any of the variables surveyed on overall customer satisfaction. Thus, an attempt was made to take the analysis into a higher level by conducting a multivariate analysis to examine the effects of each of the independent variables on overall satisfaction with network performance.

Since customer satisfaction data can be examined in many different ways (Allen and Rao, 2000), an extensive research methodology review was required. Various satisfaction research methodologies were examined to find a statistical method that best applies to the current research. In particular, multiple regression analysis is also suggested.

By examining the predictive effect of each of the variables and their relative importance, the results can be transformed to guide senior management with strategic decisions concerning capital expenditures. This is familiar to researchers engaged in customer satisfaction programs and is known as key driver analysis. Generally, one dependent variable is assumed to be dependent on a set of predictor variables, as shown in Figure 3.1.

Multiple regression is the basis for virtually all key driver analysis (Allen and Rao, 2000). The general purpose of multiple regression is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable. According to Allen and Rao (2000), causality is implied but not established. The nature of the dependence of the outcome variable on the predictor variables is of great interest in applied customer satisfaction research. Thus, multiple regression was the main analysis technique used in the study.

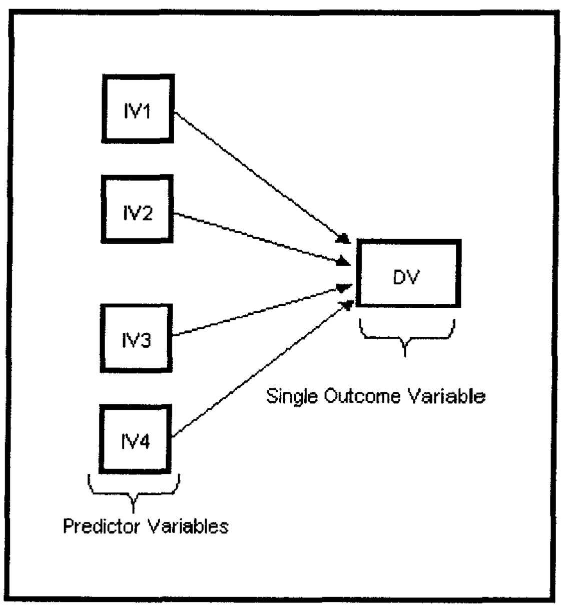

Figure 3.1. Multiple regression analysis

Before applying the design model, the statistical tests most appropriate for measuring data on each type of scale were determined. In summary, the methodology model followed consisted of four main steps:

A. *Coding the data and dealing with missing values*: Cases with unusual or extreme values (i.e., outliers) were also examined. In this study, a total of 855 responses were collected; however, only 530 responses were complete for the multivariate analysis i.e. the dependent and independent variables. Since missing values had no significant impact on the regression results, a decision was made to run the analysis and exclude cases listwise and ignore the 325 records that were missing for the same respondents across these variables. In addition, values for dependent and independent variables were examined and found that all response levels were within expected range except for a few outliers. More details are provided in the results sections. Some records for descriptive variables were missing and, thus, ignored. Frequency distribution tables in the descriptive section revealed the number of missing values.

B. *Descriptive statistics*: These were applied to evaluate summary information about the distribution, variability, and central tendency of each variable. For this purpose, descriptive analyses, including analysis of variance, were adopted. Descriptive analysis provides information on the segmentation of the customer base and their level of satisfaction. This dealt with identifying the characteristics of customer profiles (i.e., demographics) and verifying whether there is a significant difference in network satisfaction among gender, account type and account sizes. One important aspect of the results is the percentage of customers who give an excellent rating to every satisfaction question. These customers are generally the most loyal and recommend service to others. On the other hand, tracking dissatisfied customers is also important. Companies should be very interested in knowing those customers. In each case, the dependent variable is satisfaction with network quality. The descriptive analysis is divided into four key statistics: frequency, proportions, cross-tabs, and analysis of variance. The demographics variables are: gender, AccType and

Nunits. The first statistic to be performed is used to determine the central tendency that is based on the mean, standard deviation, variance, skewness, and kurtosis. The statistic is cross-tabulation. Cross-tabulations are performed to study satisfaction ratings for various sub sets of the population based on the demographics. Included in the cross-tabs statistics is a procedure that provides a variety of tests and measures of association for two-way tables.

C. *Analysis of variance*: The one-way ANOVA procedure was used to test the hypothesis that the means of two or more groups are not significantly different. The intent is to perform group-level statistics for satisfaction and check if there is a significant difference in satisfaction of various groups within gender, account size, and account type. An important first step in the analysis of variance is establishing the validity of assumptions. One assumption of ANOVA is that the variances of the groups are equivalent.

D. Factor analysis: This procedure was used to identify underlying variables, or factors, that explain the pattern of correlations within the set of observed independent variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables (Mertler and Vannatta, 2002). However, the analysis is used to validate that the variables used form the latent factors of the theoretical model and establish that they are orthogonal. In addition, this analysis is used to support construct validity of the instrument as well by showing the negligible inter-correlation among variables.

E. *Multiple regression analysis*: To identify the best combination of predictors of satisfaction with network quality, multiply regression was applied. A few factors account for most of the variation in the dependent variable (DV), and these can be used to predict values in the dependent variable. This multiple regression analysis models the value of the dependent variable (DV) that is based on its relationship to one or more predictors. Before the analysis is run, regression assumptions will be validated. If evidence is weak regarding linear relationship between the dependent variable and the independent variable, an attempt is made to find the appropriate transformation to satisfy linearity. Box-Cox power family transformation is applied to determine if there are non-linear linear relationships (Cook, and Weisberg, 1999). From the regression results, an examination of importance is completed:

- Measuring relative importance of predictor attributes can establish the relative predictive importance of the independent variables (comparing beta weights); and
- Model evaluation and assessment of fit were conducted.

A typical footnote inserted in research using interval techniques with Likert scales regarding regression analysis, which assumes interval data, is:

> .....In a recent review of the literature on this topic, Jaccard and Wan (1996) summarized, "For many statistical tests, rather severe departures (from intervalness) do not seem to affect Type I and Type II errors dramatically" (p. 30).

Statistical Analysis Data Considerations

Multiple regression is a method used for explanation of phenomena and prediction of future events. The key predictor variables are quantitative at the interval level, data for which Pearson correlation coefficients can sensibly be calculated and should be suitable for regression analysis (Mertler and Vannatta, 2002). Since multiple independent variables and one dependent variable are considered, multiple regression analysis capitalizes on this data type. The data should have a bivariate normal distribution for each pair of variables, and observations should be independent. In multiple regression, there are actually two sets of assumptions: assumptions about the raw scale variables, and assumptions about the residuals (Pedhazur, 1982). In addition, there are two approaches to testing assumptions (Tabachnick and Fidell, 1996). The first approach involves the conventional data screening procedures and graphical analysis such as skewness, kurtosis, histograms and bivariate scatter plots. The alternative approach is to examine the residuals' scatter plots. This approach is used to determine predicted values of DV ($\hat{Y}$) and standardized residuals. Examination of these residual scatter plots provides a test of all three of the crucial assumptions (Tabachnick and Fidell, 1996). If the assumptions of linearity, normality, and homoscedasticity are acceptable, the points cluster around the horizontal zero line in a somewhat rectangular pattern.

Following are assumptions for multiple regression, factor, and analysis of variance:

Multiple regression analysis:

- Interval or near-interval data variables.
- For each value of the independent variable, the distribution of the dependent variable must be normal.

- The variance of the distribution of the dependent variable should be constant for all values of the independent variable.
- The relationship between the dependent variable and each independent variable should be linear, and all observations should be independent.
- The error term should be normally distributed with a mean of 0.
- The variance of the error term is constant across cases and independent of the variables in the model. An error term with non-constant variance is said to be heteroscedastic.

Factor analysis:

The factor analysis model specifies that variables be determined by common factors (the factors estimated by the model) and unique factors (which do not overlap between observed variables); the computed estimates are based on the assumption that all unique factors are uncorrelated with each other and with the common factors. The dependent and independent variables are quantitative. Categorical variables, such gender, account type, and account size were recoded to binary (dummy) variables and used for descriptive statistics

Analysis of variance:

The data are a random sample from a normal population; in the population, all cell variances are the same. Analysis of variance is robust to departures from normality, although the data should be symmetric. To check assumptions, homogeneity of variances tests is used.

Population and Sampling

The sampling in this research was statistical sampling, which involves the use of random selection to include the ability to statistically determine the appropriate sample size, and the ability to determine how representative the sample is of the population. Since the objective was to identify critical network performance attributes, all collected data were treated as one sample. Total sample size was considered to be at a maximum of 855 data points for the completed survey questions, however, only 530 records were complete listwise for the regression variables. The population of interest was greater than 50K. The response rate was 62% for the dependent and independent variables. However, for demographics variables gender, AccType, and Nunits, response rates were 56.3%, 80.4%, and 100% respectively.

Confidence Intervals

Probability theory enables researchers to estimate an adequate sample size. Through this principle, one can estimate a sample's accuracy and establish a certain level of confidence of the estimate. Since all samples are estimates, the difference between a sample statistic and the actual population parameter is known as a sampling error (Folz, 1996). In this survey, the sample size was selected to minimize the margin of error, and maximize the level of confidence (95%) while ensuring adequate frequency of occurrence of the variables being considered. In order to meet these criteria, the target sample size was selected using the table provided by Dutka (1994) in the *Customer satisfaction survey* (p. 103). The confidence level was expected to be higher than 95%, with a standard measurement error of 5% or less. One of the variables in the set contained 530 responses list wise, which was higher than the 385 required. A 95% percent level of confidence indicates that an error is likely about one time in 20. The level of confidence and the margin of error were computed for the entire sample and cross-tabulations based on subsets of the sample not achieving the same levels of confidence.

Sampling Adequacy

The Kaiser-Meyer-Olkin (KMO) statistic is a measure of sampling adequacy. The KMO measure of sampling adequacy met the minimum criteria. The Bartlett sphericity tests the null hypothesis that the variables in the population correlation matrix are uncorrelated. Bartlett's test of sphericity value was less than 0.05 of the significance level, indicating that a factor analysis may also be useful with the data.

Validity and Instrument Reliability

Validity

Validity is established by two methods, content and construct. Content validity in this research began by the premise that designing customer satisfaction surveys must be from the customer's view of the organization. In addition, having a survey instrument that better captures the customer's perception of the company makes the data easier to analyze (Johnson and Gutfassen, 2000). Johnson and Gutfassen stressed the effectiveness of the Critical Incident Technique (CIT) in identifying critical attributes when designing customer satisfaction surveys. The list of concrete attributes they cited regarding cellular customer surveys included: cell phone design, product functionality, innovation, prices, quality of service, and branding. These attributes are covered in the survey used in the current research, which validated the comprehensiveness and appropriateness of the instrument used. This technique revealed that reception quality, reliability and network support were key attributes in the product functionality benefit category. These data were collected from the CIT perspective. In addition, attributes used in the survey are network metrics that RF engineers with most cellular providers consider most important to evaluating network performance and trends on regular basis. These attributes are also present in the surveys of the two leading marketing firms in the wireless industry (Power and Harris Interactive), which establish content validity by content experts.

Construct validity was evaluated with a factor analysis of network performance scores to determine whether we were accurately testing the four dimensions intended by the originator of the instrument (i.e., call quality, reliability, coverage, availability). Factor analysis has been widely used, especially in the behavioral sciences, to assess the construct validity of a test or a scale. The rotated component matrix helps to determine what the components represent. Since the dependent variable is expressed in terms of multiple items of an instrument, factor analysis is used for construct validation.

Instrument Reliability

The reliability analysis procedure calculated a number of commonly used measures of scale reliability and also provides information about the relationships between individual items in the scale (see Appendix D). Intraclass correlation coefficients can be used to compute interrater reliability estimates. Reliability estimates for these scales are presented as Cronbach's Alphas (CAs). CAs verify reliability by testing the degree to which scaled items represent the phenomenon they are intended to measure (Cronbach, 1951).

CHAPTER 4. RESULTS AND DISCUSSION

This research evaluated key drivers of satisfaction with cellular network performance and quantified the relative order of importance for each of the drivers. This chapter reports the results and findings gained through analysis of data obtained by administering the customer satisfaction survey by the company vendor. This chapter is organized into six sections: Descriptive Statistics; Analysis of Variance; Results of Instrument Validity and Reliability; Multiple Regression Analysis Results; Model Assessment and Implications; and Summary

Descriptive Statistics

Descriptive statistics were analyzed for level of satisfaction across gender, account type, and account size.

Gender

One of the collected customer data variables from respondents was gender. Table 4.1 shows the actual statistics for gender in the study's demographics. To keep descriptive analysis results confidential, only the 530 completed datasets used for regression analysis were considered, of which only 273 descriptive records were useable. A total of 257 values were missing from the data (48.5%). Of these useable records, 181 (66%) were from male respondents and 92 (34%) were from female respondents. The data clearly show the majority of users were male.

Table 4.1. Results of frequency statistics for gender (n-530)

		Frequency	Percent	Valid percent
Valid	Male	181	34.2	66.3
	Female	92	17.4	33.7
	Total	273	51.5	100.0
Missing	System	257	48.5	
Total		530	100.0	

A summary of users' satisfaction level is provided next. The summary is based on gender and shows the proportions of customers who are satisfied and those who are dissatisfied within the gender type and across genders. Table 4.2 indicates that nearly 82% of male respondents were either satisfied or very satisfied with the service as opposed to only 18% who were either dissatisfied or very dissatisfied. The 82% percent score of all satisfied male customers is sometimes referred to as top-box score. Females showed an 89.2% of top-box network satisfaction.

Table 4.2. Results of proportion statistics for the dependent variable and gender

% within gender		Satisfaction with network performance (%)				Total (%)
		Very dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Very satisfied	
Gender	Male	3.9	14.4	44.8	37.0	100.0
	Female	1.1	9.8	44.6	44.6	100.0
Total		2.9	12.8	44.7	39.6	100.0

One-way analysis of variance was produced using SPSS (see reference). Based on significance test level of p=.05, Table 4.3 indicated no significant difference exists between satisfaction of males and females (p=. 074). Levene's test for homogeneity of variance (p=.616) suggests that the difference in variance in satisfaction between males and females is statistically insignificant (i.e., assumption of equal variance between males and females is fulfilled). This test is not dependent on the assumption of normality. The overall ANOVA results showed no significance difference between males and females, however, top-box score were higher for females, suggests that females are slightly more satisfied than their male counter parts.

Table 4.3. Results of one-way ANOVA for the dependent variable and gender

Levene statistic	df1	df2	Sig.
.251	1	271	.616

	Sum of squares	df	Mean square	F	Sig.
Between groups	1.909	1	1.909	3.210	.074
Within groups	161.190	271	.595		
Total	163.099	272			

Account type

The second demographic variable of the customer data collected was account type. Table 4.4 shows the actual statistics for account type in the study's demographics. For confidentiality reasons, only 530 responses were analyzed. Of the 444 useable surveys that were collected, 103 were from Group A respondents constituting 19.4% of the sample, 68 were from Group B (12.8%), 100 from Group C (18.9%), 104 from Group D (19.6%), 43 from Group E (8.9%), and 26 responses were from "other" (4.9%). The three largest accounts based on size were: group A, group B, and group C, constituting nearly 70% of sample size. A total of 86 data points were missing from the data (16.2%) Table 4.4.

Table 4.4 Results of frequency statistics for account type (n=530)

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Group A	103	19.4	23.2	23.2
	Group B	68	12.8	15.3	38.5
	Group C	100	18.9	22.5	61.0
	Group D	104	19.6	23.4	84.5
	Group E	43	8.1	9.7	94.1
	Other	26	4.9	5.9	100.0
	Total	444	83.8	100.0	
Missing	System	86	16.2		
Total		530	100.0		

Table 4.5 presents a summary of users' satisfaction levels. The summary is based on type of business users are engaged versus level of satisfaction and dissatisfaction. Table 4.5 shows the proportions of customers who are satisfied and those who are dissatisfied within account type.

Table 4.5. Results of proportion statistics for the dependent variable and account type

% Account Type		Satisfaction with network performance (%)				Total (%)
		Very dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Very satisfied	
Account Type	Group A	3.9%	17.5%	47.6%	31.1%	100.0
	Group B	2.9%	8.8%	51.5%	36.8%	100.0
	Group C	1.0%	14.0%	48.0%	37.0%	100.0
	Group D	2.9%	7.7%	47.1%	42.3%	100.0
	Group E	4.7%	9.3%	37.2%	48.8%	100.0
	Other	3.8%	15.4%	42.3%	38.5%	100.0
Total		2.9%	12.2%	46.8%	38.1%	100.0

Table 4.5 reveals "Group D" segment ranged highest with nearly 89.4% top-box score and "Group A" lowest at 78.8%. Users from the "Group D" segment had the lowest dissatisfied proportions rating of 21% as opposed to "Group A" at 10.5%.

Levene's test for homogeneity of variance with a p value of .834 suggests that the difference in variance in satisfaction between groups is statistically non-significant (i.e., assumption of equal group variance is fulfilled). The one-way analysis was produced using SPSS (see reference). Table 4.6 indicates a non-significant difference exists between network satisfaction of various account types (p=. 316). This test is not dependent on the assumption of normality.

Table 4.6. Results of one-way ANOVA for the dependent variable and account type

Levene statistic	df1	df2	Sig.		
.421	5	438	.834		
	Sum of squares	df	Mean square	F	Sig.
Between groups	3.428	5	.686	1.183	.316
Within groups	253.732	438	.579		
Total	257.160	443			

Account size

The third and last demographic variable of the customer data collected was account size. Table 4.7 indicates the actual statistics for account size in the study's demographics. Of the 528 useable surveys that were collected, 459 were from account size 1 constituting the majority of categories (86.6%) of the sample, 52 were from account size 2 (9.8%), 9 were from account size 3 (1.7%), 2 were from account size 4, and 6 were from account size 5.

Table 4.7. Results of frequency statistics for account size (n=530)

		Frequency	Percent	Valid percent	Cumulative percent
Valid	size 1	459	86.6	86.9	86.9
	size 2	52	9.8	9.8	96.8
	size 3	9	1.7	1.7	98.5
	size 4	2	.4	.4	98.0
	size 5	6	1.1	1.1	100.0
	Total	528	99.6	100.0	
Missing	System	2	.6		
Total		530	100.0		

Table 4.8 provides a summary of users satisfaction levels. The summary is based on size of account versus level of satisfaction and dissatisfaction. Table 4.8 reveals that accounts sizes 3 or higher are 100 % satisfied customers, while accounts of less than 3 show a lower satisfaction rate. Smaller accounts such as size 1 and 2 have a comparable dissatisfaction rate of almost 15 %.

Table 4.8. Results of proportion statistics for the dependent variable and account size

% within NUNITS		Satisfaction with network performance (%)				Total (%)
		Very dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Very satisfied	
NUNITS	size 1	3.1	11.5	44.9	40.5	100.0
	size 2	1.9	13.5	46.2	38.5	100.0
	size 3			88.9	11.1	100.0
	size 4				100.0	100.0
	size 5			50.0	50.0	100.0
Total		2.8	11.4	45.6	40.2	100.0

Levene's test for homogeneity of variance with a p value of .014 suggests that the difference in variance in satisfaction between groups is statistically significant (i.e., the Levene's statistic rejects the null hypothesis that the group variances are equal). Table 4.9 indicates the ANOVA is robust to this violation when the groups are of equal or near equal size; however, group size varies significantly from 2 (40 units or less) to 459 (less than 30 units). Therefore, the ANOVA analysis cannot be retained due to the large difference in sample sizes.

Table 4.9. Results of one-way ANOVA for the dependent variable and for account size

Levene statistic	df1	df2	Sig.
3/149	4	523	.014

	Sum of squares	df	Mean square	F	Sig.
Between groups	1.768	4	.442	.765	.548
Within groups	302.042	523	.578		
Total	303.811	527			

Estimates for Construct Validity and Instrument Reliability Sampling Adequacy

Construct validity and instrument reliability were assessed. The results are presented in the following subsections.

Construct validity

Factor analysis has been widely used, especially in the behavioral sciences, to assess the construct validity of a test or a scale. Construct validity for the customer satisfaction survey used in this study was established by evaluating separate principle component factor analysis for the five survey items. An analysis of the scree plot suggests a very strong single factor for each of the items used. A "varimax" was used subsequent to the principle-components factor analysis to confirm the validity of the survey.

The rotated component matrix helps to determine what the components represent (Table 4.10). The first component is most highly correlated with call quality (IV4). The second component is highly correlated to coverage (IV2). The third component is highly correlated to dropped calls (IV3). Lastly, the fourth component is highly correlated to system availability. Clearly, four distinct factors emerge from the analysis where each of the variables comprises its dimension.

Table 4.10. Construct validity principal component analysis results

	Component			
	1	2	3	4
IV1				.957
IV2		.973		
IV3			.968	
IV4	.931			

Extraction method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Note: Rotation converged in 5 iterations.

Kaiser's measure of sampling adequacy (MSA), as discussed in Chapter 3, is a measure of whether the distribution of data is adequate for conducting factor analysis (Kaiser, 1970). As shown in Table 4.11, values greater than .7 can be considered to be "middling" (Kaiser and Rice, 1974, p. 112). The Bartlett's test of sphericity value is less than 0.05 of the significance level, which indicates that a factor analysis may also be useful with the data.

Table 4.11. Results of the Kaiser-Meyer-Olkin measure of sampling and Bartlett's test of sphericity

Kaiser-Meyer-Olkin measure of sampling adequacy		
Bartlett's test of sphericity	Approximate Chi-square	486.655
	df	10
	Sig.	.000

Instrument reliability

The reliability analysis procedure calculated a number of commonly used measures of scale reliability and also provides information about the relationships between individual items in the scale (see Appendix D). Intraclass correlation coefficients can be used to compute interrater reliability estimates. Reliability estimates for these scales are presented as Cronbach's Alphas (CAs). CAs verify reliability by testing the degree to which scaled items represent the phenomenon they are intended to measure (Cronbach, 1951) (Table 4.12).

Table 4.12. Statistics and reliability estimates for main study scales

Reliability Analysis – Scale (alpha)

1. DV
2. IV1
3. IV2
4. IV3
5. IV4

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	16.4358	6.7378	2.5957	5

Reliability Coefficients
N of Cases = 530.0 N of Items = 5
Alpha = .7138

As shown in Table, 4.12, an actual value of .7138 was obtained, which is desired for judging a scale reliable. Cronbach Alpha is based on the average correlation of items (if items are standardized) or average covariance (when they are not). The standardized coefficient is the value obtained if all the items were standardized. When the items have fairly different variances, the two alphas are expected to differ.

Multiple Regression Analysis

As pointed out in the methodology in Chapter 3, assumptions about the raw scale variables and the residuals must be validated before interpretation of results. In addition, residuals scatter plots need to be analyzed to test assumptions of residuals. Since the researcher was interested in determining the effect of all the variables, the four variables were entered using SPSS (see reference) in a standard multiple regression. The effect of each IV on the DV variable was assessed as if it had been entered into the equation after all IVs had been entered. Each IV was then evaluated in terms of what it adds to the prediction of the DV as specified by the regression equation (Tabachnick and Fidell, 1996).

Assumptions and limitations

There are three key assumptions of regression analysis that need to be tested before regression model is rendered valid:

1. The relationship between IVs and DV is linear;
2. Errors are not correlated with the IVs; and
3. Errors are normally distributed.
4. Constant variance of the error term

Next, collinearity statistics are conducted to test the level of variable independence. Tolerance is a commonly used measure of collinearity. The tolerance is the percentage of the variance in a given predictor that cannot be explained by the other predictors. A low tolerance value (near 0) indicates extreme collinearity; that is, the given variable is almost a linear combination of the other independent variables. A high value (near 1) indicates that the variable is relatively independent of the other variables. When variables are included that are linearly dependent, they inflate the standard errors, thus weakening the power of the analysis (George and Mallery, 2001).

As stated in the methodology, residual scatter plots can be used for testing these three assumptions. Therefore, residual scatter plots are conducted in lieu of routine procedures. If the assumptions of linearity, normality, and homoscedasticity are tenable, one would expect to see points cluster along horizontal line defined by Ai =0, in a somewhat rectangular shape (Tabachnick and Fidell, 1996).

As noted in the descriptive analysis, due to the nature of the data scale used, when one examines the bivariate scatter-plot of the DV and any of the IV1, IV2, IV3, and IV4, the data points fall into 4 by 4 grid, which is reflective of the 16 possible choices of DV and IV (e.g., 4-level scale each). To illustrate the point, a graph is provided in Figure 4.1.

All independent variables follow the same data distribution when plotted against the dependent variable. Even though data distribution indicates 16 fixed distances with location in the scatterplot, the amount of data points per location varies significantly. There seems to be a large concentration of data points in a somewhat elliptical form to the upper side of a regression line (Figure 4.2).

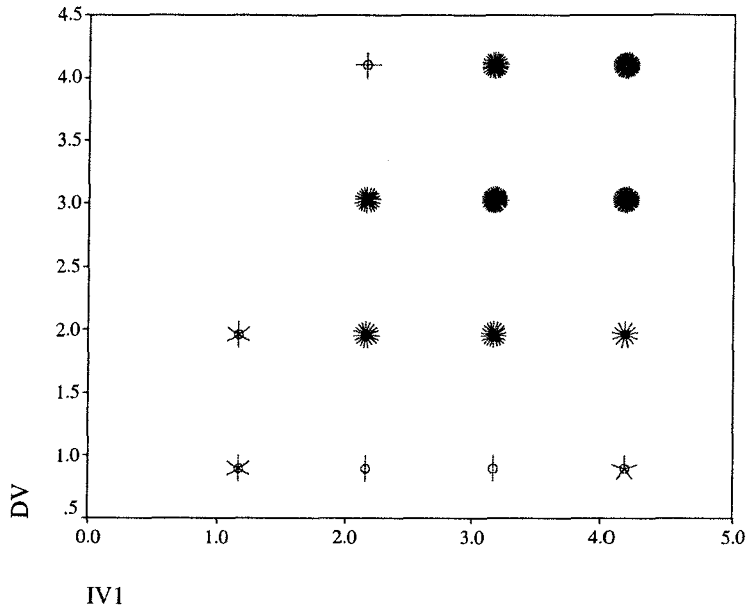

Figure 4.1. Bivariate scatter plot: DV vs. IV1

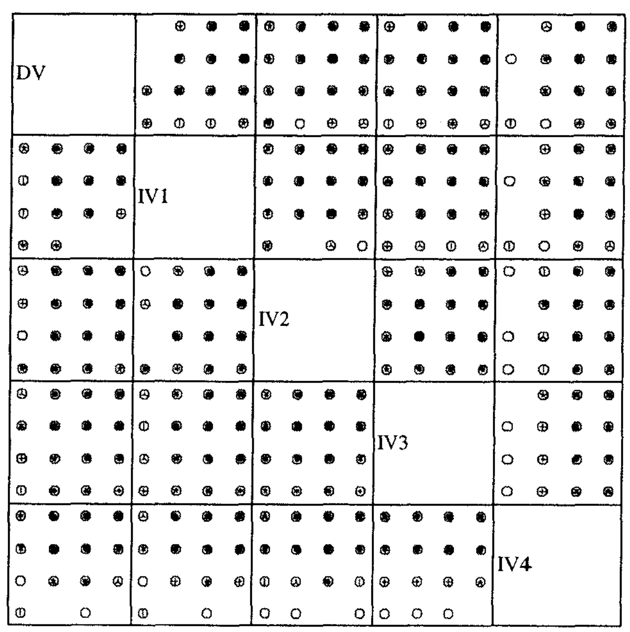

Figure 4.2. Multivariate scatter plot for dependent and independent variables

In Figure 4.1, a “sunflower” scatterplot was created using SPSS (see reference). To create the "sunflowers", a small line, called a pedal, is added to each point on the scatterplot to indicate how many observations each point represents. The scatterplot reveals the distribution of the datapoints above and below these lines as well as the 95% confidence intervals of the regression results. This is a typical distribution with the other three variables. This Likert type scale with 4 possible datapoints in the dependent variable and 4 possible levels in the independent variable forces all the data to fall into these 16 possible locations. Thus, this type of data limits the range of treatments that can be applied for more linear fit.

Several transformations were attempted to optimize linearity, however, none yielded promising results. In order to maximize linearity of the relations, BOX-COX analysis was run to find the optimal transformation. Given the SAS (by SAS Institute Inc., version 9.1) results, all IVs converged to a Lamda value of 2 (see Appendix C). Using a second order term for dependent variable would improve the line fit slightly. Since this optimum transformation, DV^2 was used instead of DV when trying to build the model. Other transformations were considered for the independent variable however with no promising results. Thus, the next step was to proceed in fitting the FULL model.

When referring to residual plots, residual plot of Studentized (e) versus Predicted DV variable (Figure 4.3) is the main plot of concern (see assumption 1). Since the e Note that the only problem is with the possible non-linearity, although a fix may not be possible.

In analyzing Figure 4.3, three regression assumptions are discussed:

Assumption 1: The relationship between IVs and DV is linear. The data points form a straight line; however, the line is sloped and not horizontal around the zero reference line

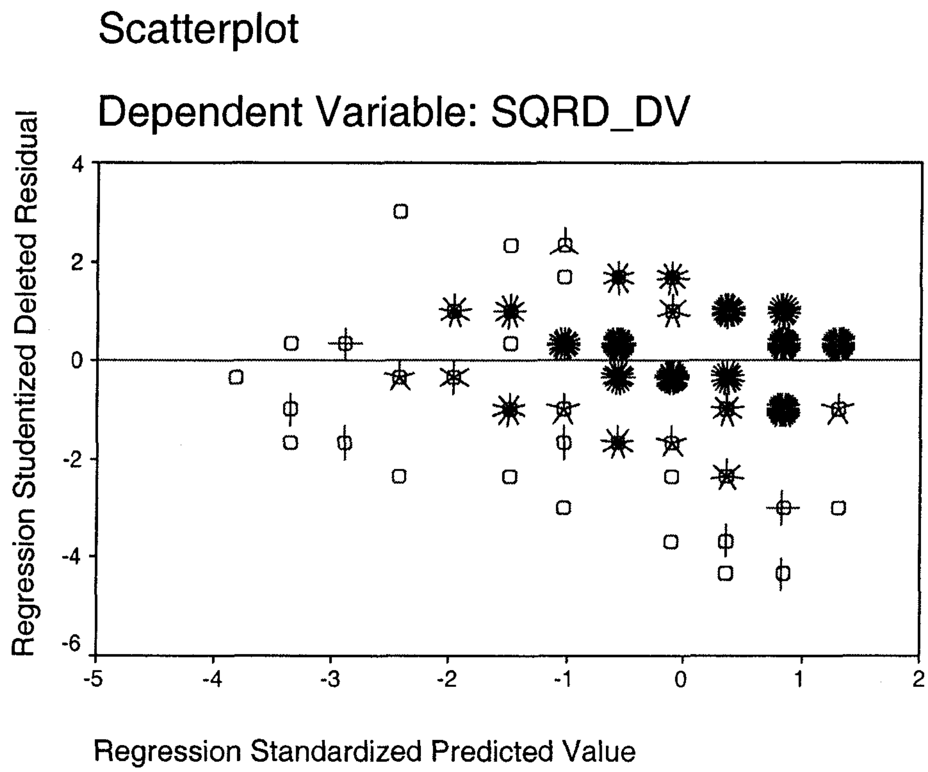

Figure 4.3. Residual plot of Studentized (e) vs. Predicted SQRD_DV variable ê=0. This plot indicates a moderate violation of the linearity assumption. In cases that involve moderate violations of linearity and homoscedasticity, one should be aware that these violations merely weaken the regression analysis, but do not invalidate it (Tabachnick and Fidell, 1996).

Assumption 2: Errors are normally distributed. The scatter data points appear to be dispersed relatively evenly above and below the reference line by ê=0. This type of dispersion suggests a normal distribution of the errors (Tate, 1992). Another method for validating normality of the error term is to examine the Regression Standardized Residual Histogram. In Figure 4.4, the shape of the histogram approximately follows the shape of the normal curve. Therefore, this histogram is acceptably close to the normal curve.

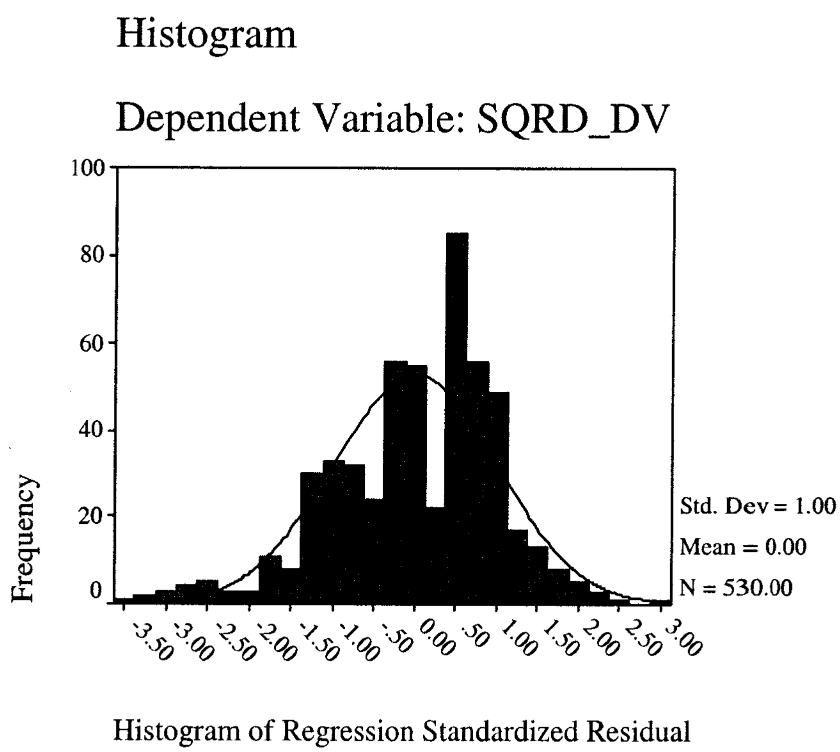

Figure 4.4. Regression standardized residual

Assumption 3: The variance of the residuals across all values of the independent variables is constant. The plot of residuals by the predicted values shows that the variance of the errors decreases with increasing predicted satisfaction level however the width is constant affirming that the assumption of homoscedasticity is not violated. Note that the only problem is with the possible non-linearity, although a fix may not be possible for this type of data. Figure 4.5 also confirms the assumption to be satisfied. Further more, moderate violations of the normality assumption may often be ignored – especially with larger sample sizes – since there are no adverse effects on the analysis (Tate, 1992).

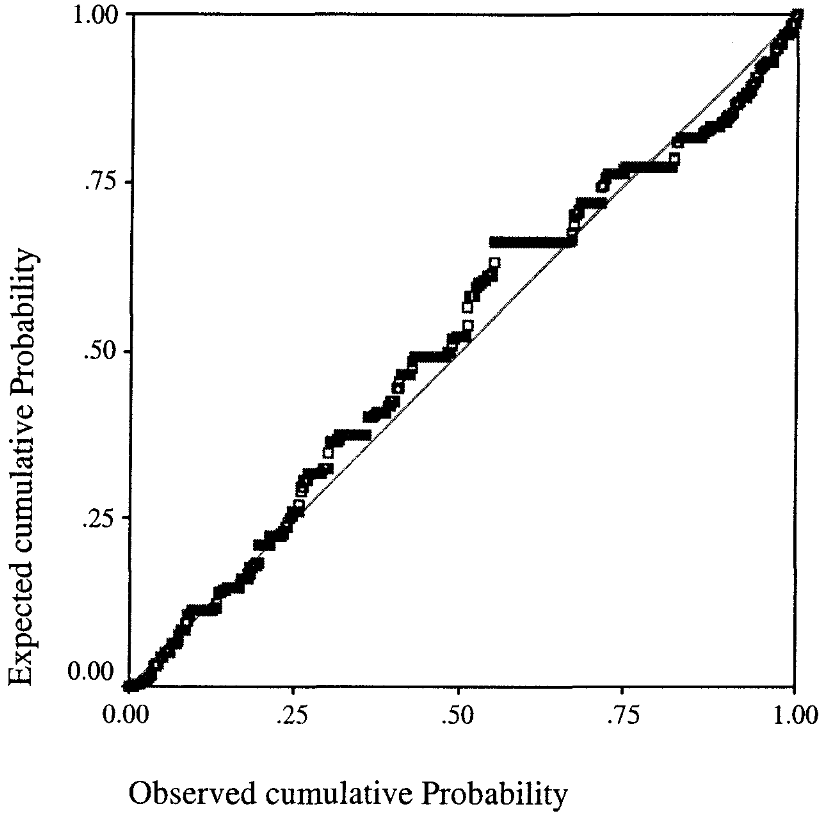

Figure 4.5. Normal P-P plot of regression standardized residual

The P-P plot of the residuals helps to check the assumption of normality of the error term. The P-P plotted residuals follow the 45-degree line very closely. Neither the histogram nor the P-P plot indicates that the normality assumption is violated. The resulting scatterplot appears to be suitable for linear regression, with one possible cause for concern: the linearity between the dependent variable DV and independent variables IV1-IV4.

The collinearity statistics results shown in Table 4.13 confirm that there are no serious problems with multicollinearity. The large tolerances show that the other predictors

Table 4.13. Regression analysis coefficients summary For the Full SQRD_DV model

Model		Unstandardized coefficients		Standardized coefficients			Collinearity statistics	
		B	Std. Error	beta	t	Sig.	Tolerance	VIF
1	(Constant)	-5.269	1.122		-4.696	.000*		
	System Availability	2.638	.242	.435	10.893	.000*	.750	1.334
	Coverage	.912	.200	.174	4.568	.000*	.826	1.211
	Dropped Calls	.362	.209	.067	1.735	.083	.808	1.238
	Call Quality	.973	.289	.125	3.370	.001*	.876	1.142

Dependent variable: SQRD_DV
* significance at the $p<.05$ level

can explain 13%-20% of the variance in a given predictor. When the tolerances are close to 0, there is high multicolinearity and the standard error of the regression coefficients will be inflated. A variance inflation factor greater than 2 are usually considered problematic, and the highest VIF in the table is 1.334.

There are two steps to illuminate the results. The first is to rank the betas, setting the output with the attributes shown in order of importance as they relate to the dependent variable. The next step is to highlight those betas that are statistically significant. All of the beta significance values are less than 0.05 except for IV3 or "drop call", which is not significant however, due to the importance of dropped calls in customer's experience, one could include the "dropped call" attribute in the model. Thus, any of the remaining predictors would be adequate if included in the model.

The beta weights are the regression (b) coefficients for standardized data. Beta is the average amount the dependent increases when the independent increases one standard deviation and other independent variables are held constant. If an independent variable has a beta weight of .5, this means that when other independents are held constant, the dependent variable will increase by half a standard deviation (.5). The ratio of the beta weights is the ratio of the estimated unique predictive importance of the independents.

In general, multiple regression procedures will estimate a linear equation of the form:

$$y = b_1x_1 + b_2x_2 + \dots + b_nx_n + c.$$

The b's are the regression coefficients, representing the amount the dependent variable y changes when the independent changes 1 unit. However, in this model, the regression is non-linear as we decide to use the squared term of the dependent variable per Box-Cox transformation, the equation is:

$$SQRD\_DV= c+ b_1 1*IV_1 + b_2*IV_2 + b_3*IV_3+b_4*IV_4$$

Now that regression assumptions and collinearity are verified, the next step is to move forward with the regression results using SQRD_DV as the dependent variable even with the non-linearity issue.

Recall that R-squared is the measured variance accounted for in the DV by the predictors. The independent variables, taken together, explain nearly 37% of the variation in the dependent variable, which assessed by the value of R squared (see Table 4.14).

Table 4.14. Regression analysis model summary[b]

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.609[b]	.371	.366	3.58568

[a] Predictors: (Constant), IV4, IV2, IV3, IV1
[b] Dependent variable: SQRD_DV

As shown in Table 4.15, the ANOVA reports a significant F statistic, indicating that using the model is better than guessing the mean. As a whole, the regression does a somewhat good job of modeling satisfaction with network performance however the residual is rather large and there appear to be other variables that the model does not account for.

Table 4.15. Regression analysis ANOVA summary[b]

Model		Sum of squares	df	Mean square	F	Sig
1	Regression	3982.809	4	995.702	77.444	.000*
	Residual	6749.963	525	12.857		
	Total	10732.772	529			

Predictors: (Constant), IV4, IV2, IV3, IV1
Dependent variable: SQRD_DV
* significant at the p<.05 level

The stepwise algorithm was not selected because all variables were of interest. For all variables, satisfaction appeared to be positively affected leading to the conclusion that the higher the satisfaction with of the predictors, the higher the overall satisfaction with network quality. Next, case-wise diagnostics for the cases meeting the selection criterion (outliers above 3 standard deviations) was conducted. As shown in Table 4.16, the cases reflect a large negative residual from what is expected and when removed, SQRD_DV was increased to from .371 to .453.

Table 4.17 presents the correlation matrix to better understand the inter-correlations between products. The correlation between DV and IV1 is .533, which indicates that higher availability results in higher scores of network satisfaction with IV1 having the highest correlation. In addition, the correlation between DV and IV2 is .383, which indicates that larger size of coverage results in higher network satisfaction scores.

Table 4.16. Regression analysis casewise diagnostics

Case number	Std. Residual	SQRD_DV	Predicted value	Residual
224	3.190	16.00	4.5609	11.4393
329	-3.599	1.00	13.9064	-12.9064
432	-3.126	1.00	12.2091	-11.2091
455	-3.345	1.00	12.9948	-11.9948

Table 4.17. Pearson correlation summary

		DV	IV1	IV2	IV3	IV4
DV	Pearson correlation	1	.558*	.383*	.307*	.303*
	Sig. (2-tailed)		.000	.000	.000	.000
	N	530	530	530	530	530
IV1	Pearson correlation	.558*	1	.387*	.372*	.291*
	Sig. (2-tailed)	.000	.000		.000	.000
	N	530	530	530	530	530
IV2	Pearson correlation	.383*	.387*	1	.284*	.183*
	Sig. (2-tailed)	.000	.000	.000		.000
	N	530	530	530	530	530
IV3	Pearson correlation	.307*	.372*	.284*	1	.288*
	Sig. (2-tailed)	.000	.000	.000		.000
	N	530	530	530	530	530
IV4	Pearson correlation	.303*	.291*	.183*	.288*	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	530	530	530	530	530

*Correlation is significant at the 0.01 level (2-tailed)

The same goes for IV4, quality of calls, which indicates a higher network satisfaction. IV3 is not significant in the regression results and, perhaps, this could be attributed to its higher correlations to the other independent variables than IV1, IV2, and IV4. If IV3 were eliminated, a new "REDUCED" model would have the following ANOVA results (Table 4.18).

Table 4.18. Regression analysis model "REDUCED" summary

Model	R	R square	Adjusted R square	Std. Error of the estimate
1	.606[a]	.367	.364	3.59252

[a] Predictors: (Constant), IV4, IV2, IV1
[b] Dependent variable: SQRD_DV

Table 4.19 depicts the ANOVA analysis for reduced model.

sseREDUCED = 6788.65204 and d.f.REDUCED = 526. Therefore, since the F - statistic for performing this test is:

{(sseREDUCED - sseFULL)/(d.f.REDUCED - d.f.FULL)}/{sseFULL/d.f.FULL}

= {(6788.65204 - 6749.96253)/(526 - 525)}/{6749.96253/525}

= 3.0092, which with 1 and 525 d.f. Results are a p-value of 0.0834, which means that there is little, if any, evidence that the REDUCED model does not fit as well as the FULL model. Hence, two borderline criteria indicate to exclude IV3.

Table 4.19. Regression analysis ANOVA "REDUCED" summary[b]

Model		Sum of squares	df	Mean square	F	Sig
1	Regression	3944.120	3	1314.707	101.866	.000[a]
	Residual	6788.652	526	12.906		
	Total	10732.772	529			

[a] Predictors: (Constant), IV4, IV2, IV1
[b] Dependent variable: SQRD_DV

Model Assessment and Implications

Interpretation of multiple regression focuses on determining the adequacy of regression models (Mertler and Vannatta, 2002). In this research, only one dependent variable was analyzed: satisfaction with network performance. The method used for multiple regressions was "enter" where all four independent variables IV1-IV4 were entered into the analysis simultaneously. The regression results indicate an overall model of three predictors that significantly predict network satisfaction. The predictors are: availability, coverage, drop calls and quality of calls, which loaded satisfactorily into the regression model. Predictor IV3 (dropped calls) was not considered significant, with a p value greater than .05. The model accounts for 37.5% of variance in network satisfaction. This indicates that overall network quality is dependent on these factors and its value can be predicted by the values in these factors. The beta values (∃) indicate the value of each factor in the regression equation indicating that network availability (.435) has the most effect on network satisfaction, followed by coverage (.174), and call quality (.125).

Table 4.20 provides a summary of the difference in regression output for different cases considered in the analysis. When only three predictors are considered, the new model's ability to explain network satisfaction compares favorably with that of the previous model (four predictors). Both models explain satisfaction about the same. The change in R-squared is only .4%. Another implication is the transformation of the dependent variable, which makes it more difficult to interpret the results than a straight use of DV. One could run the regression directly without any transformation of DV and produce a comparable R-squared value (Squared R .365).

Table 4.20. Regression models comparisons

Variables	DV transformation	Model R	R squared	Adjusted R square
3 predictors	Squared	0.606	0.367	0.364
4 predictors	Squared	0.609	0.371	0.366
4 predictors	None	0.604	0.365	0.360
4 predictors (no outliers >3std)	None	0.691	0.477	0.473

With no transformation to the dependent variable DV, the results would have enabled a much simpler interpretation than with the dependent variable squared. Since multiple regression is vulnerable to outliers, a special case was conducted by eliminating all outliers outside 3 standard deviations in the standardized residual. When the outliers were removed, R^2-adjusted improved by nearly 8%, resulting in a much better linear fit than with all outliers included. Nevertheless, at this point, there is no strong evidence that any of the outlier cases are invalid data. None of the high order transformation to the dependent variable or transformations to the independent variables has yielded promising results in terms of linear fit. The only measure that produced significant results was the removal of extreme outliers.

CHAPTER 5. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

An introduction, a review of literature, the methodology, and the results and a discussion of the results were presented in the first four chapters of this study. This chapter reviews the problem, purpose, and questions of the study. Then, a summary, conclusions, and recommendations for further research are provided.

The problem addressed by this study is that the impact of determinants of cellular network attributes on overall network satisfaction has not been adequately investigated. The purpose of the study characterized the general dimensions of network performance that are significantly related to satisfaction. In addition, a subsequent purpose was to validate an existing survey and research an expanded framework to help develop a construct to understand the multi-dimensionality of satisfaction with network quality.

Conclusions

The research validated the adequacy of three of the four attributes used in the survey instrument, but dropped calls were not a statistically significant variable in terms of customer satisfaction in this data set. Network availability, coverage, and call quality emerged as clear distinct factors in the network quality construct. The reliability of the instrument was shown to be at an acceptable level. The regression analysis did not produce any severe violation of multivariate assumptions; therefore, the results can be safely interpreted and trusted. In this context, the general purpose of multiple regression is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable. According to Allen and Rao (2000), causality is implied but not established. The results provided strong evidence of the effect of network availability on satisfaction of network satisfaction. Having service when it is needed proves to be the strongest predictor of satisfaction. Although the following is not part of the research, but one would investigate underlying factors causing network availability:

1. System busy – Insufficient capacity could cause a delay of service availability.
2. Outage – Loss of signal due to loss of power or hardware failures.
3. Site maintenance – Routine maintenance of site equipment.

The second significant factor related to customer satisfaction with network was coverage. Size of coverage is also a significant contributor to the effect on satisfaction. In this instance, size of coverage could mean local coverage, national coverage, holes within network or in-building coverage. More investigation would be necessary to learn the specific factors behind coverage. The third and last factor that was found to be significant was call quality. Call quality was found to be significant. Call quality also has direct impact on satisfaction with network. Service and product quality, as discussed in literature review, involves perception and subjective judgment. This perception is affected by expectation, level of use and personality among other factors.

Contributions of the Research

This study provided strong evidence of the order of importance of network quality attributes. It affirmed that network availability is of greatest importance to cellular phone users. Coverage was also determined to be of considerable importance, along with call quality. The findings should offer valuable information regarding focusing strategic resources to improve customer satisfaction. This study showed that only a few factors contribute to a significant percentage of network satisfaction. Thus, surveys could be customized to focus primarily on significant factors, subsequently reducing the survey time and cost of analysis. In addition, the results of Figure 5.1 below, "Network Performance versus Importance" below, shows satisfaction level for each of the dimensions versus relative derived importance. Once could correlate between satisfaction level in each of the areas to the relative importance of each attribute and distribute capital spending accordingly. The variables examined did not constitute a complete network quality construct but can be used, nevertheless, as a basis for further survey development:

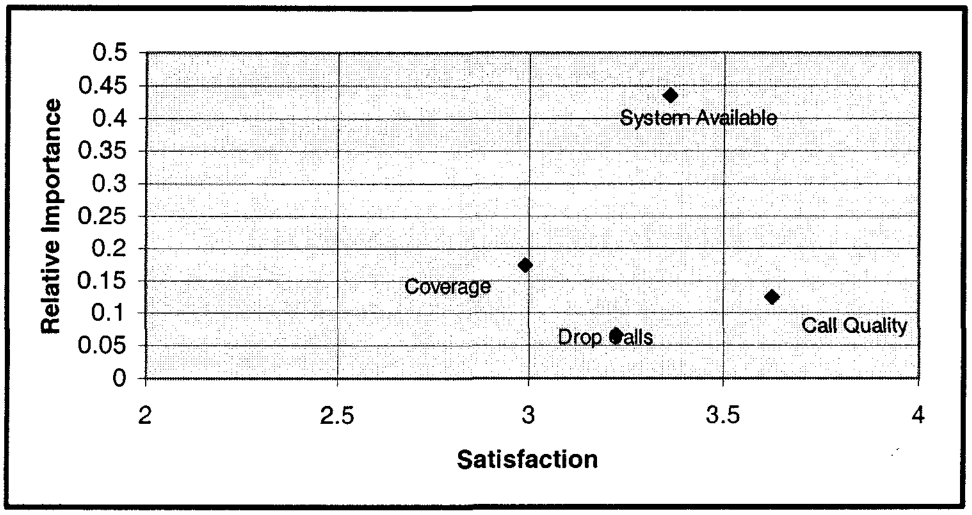

Figure 5.1 Network Performance versus Importance

Limitations of the Study

This research was an investigative study that focused on the main drivers of network satisfaction. It used a data set that was extracted from one carrier in one market and, thus, cannot be generalized to a larger population. The scale utilized was based on a 4-point Likert scale, which limited the dispersion of data. A seven or ten-point scale would have provided more variability; model scale levels would provide a closer approximation of continuous variable. The sample used can also be classified as a convenient sample since it came from one particular market, even though the respondents were randomly selected from within that market. Another limitation is the sampling technique. It is not completely confirmed that samples were randomly selected. This research did not analyze non-network related variables that could influence satisfaction with network experience, such as expectation, attitude, prior experience and service usage.

Suggestions for Future Research

In this study, several network attributes were not examined, such as voicemail and messaging notification, knowledge of technology, expectations, and prior network cellular experience. Future research could be conducted to determine attributes to form a conceptual model by specifying the tangible and intangible attributes of satisfaction that best capture attitude towards network performance as well define its domain. The goal could also be to develop an interdisciplinary conceptual framework that draws on service quality and product literature to suggest issues and attributes to investigate in the effort to understand and model the perceived quality of cellular network. Although network service provided by any cellular carrier does not represent a typical customer service quality domain (i.e., a lack of human interaction), however, it does contain many aspects encountered in service and product quality studies such perception of service, expectations, technical qualities, and other intangible dimensions. The development of a more comprehensive measurement instrument of network performance service quality can be a subsequent effort to be made. It might enable researchers to better understand the measurements used in existing industry surveys and provide a theoretical basis for a survey instrument.

Future models need to be explicit in conceptualizations of satisfaction with network quality. In this study, satisfaction of network quality research assumed that consumers assign different weights to network attributes, and that satisfaction of network performance could influence overall satisfaction with company. In summary, research cited in the study (J.D. Power and Associates, 2003, In-Stat/MDR 2003; Baker et al., 2003; Cronin, and Taylor, 1994; Parasuraman, Zeithaml, and Berry, 1985; Schneider and Hough, 1995) suggests consumer evaluations of performance are based on physical and perceptual attributes together, which are best predictors of satisfaction. Perhaps a more important a performance attribute could be the greater its impact on overall satisfaction. However, this research was only concerned with the effects of four physical attributes and the level of importance of each attribute on network satisfaction. From the models that were discussed in detail in the literature review, one can understand the importance of expectation, perception, desire, knowledge and prior experience in constructing a comprehensive satisfaction construct. Another attribute such as satisfaction with value received for amount paid should be examined as well as the case with the four (case 224, 329, 432, and 455) outliers found in the study where all four respondents thought company service was more expensive than competition. Perhaps, pricing could be another contributor to explain more of the variation with overall network performance satisfaction.

The derivation of attribute importance currently represents the norm in the customer satisfaction research industry. Multiple regression produces parameter estimates have ordinal-level properties. One can make inferences concerning their rank order of covariation with the dependent variable. A beneficial analysis would be to take and expand on the regression analysis results and use a method such as Kruskal (1987) in making ratio-level inferences concerning relative importance.

APPENDIX A. SATISFACTION SURVEY QUESTIONNAIRE

Survey Questions

Satisfaction:

DV- How satisfied are you with the overall performance of the network?
IV1- How satisfied are you with system availability?
IV2- How satisfied are you with coverage?
IV3- How satisfied are you with the number of dropped calls?
IV4- How satisfied are you with the quality of calls?

Choices:

1	Very dissatisfied
2	Somewhat dissatisfied
3	Somewhat satisfied
4	Very satisfied
5	Decline to answer
6	Not sure

Demographics:

Variable name - Variable Description

Nunits - Number of units or phones on the account (sizes are incremented by a factor):

1- size 1
2- size 2
3- size 3
4- size 4
5- size 5

Bustype- Type of business/industry conducted by this organization:

1- Group A
2- Group B
3- Group C
4- Group D
5- Group E
6- other

Gender

1-Male
2-female

APPENDIX B. SURVEY VARIABLES SCALE TYPE

#	Type	Description	Scale Type
1	DV	How satisfied are you with the overall performance of the network ?	Likert
2	IV1	How satisfied are you with system availability?	Likert
3	IV2	How satisfied are you with the size of coverage area?	Likert
4	IV3	How satisfied are you withthe number of cellular dropped calls ?	Likert
5	IV4	How satisfied are you with the quality of calls?	Likert
6	Nunits	Number of units	Categorical
7	AccType	Account type	Categorical
8	Gender	Male 1 Female 2	Categorical

APPENDIX C. BOX-COX (DV) TRANSFORMATION ANALYSES

Transformation Information BoxCox(dv) for IV1
The SAS System 19:43 Sunday, December 19, 2004 33
The TRANSREG Procedure

Lambda	R-Square	Log Like	
-3.00	0.09	-841.693	
-2.75	0.10	-732.361	
-2.50	0.11	-626.220	
-2.25	0.12	-523.747	
-2.00	0.14	-425.490	
-1.75	0.15	-332.062	
-1.50	0.17	-244.125	
-1.25	0.19	-162.355	
-1.00	0.21	-87.390	
-0.75	0.23	-19.767	
-0.50	0.24	40.144	
-0.25	0.26	92.192	
0.00	0.28	136.467	
0.25	0.29	173.290	
0.50	0.30	203.168	
0.75	0.31	226.732	
1.00	0.31	244.672	
1.25	0.31	257.681	
1.50	0.32	266.412	
1.75	0.32	271.459 *	***This tells us we***
2.00 +	0.32	273.343 <	***should use Y squared***
2.25	0.32	272.515 *	***for regression with***
2.50	0.32	269.357	***iv1***
2.75	0.31	264.193	
3.00	0.31	257.293	

< - Best Lambda
* - Confidence Interval
+ - Convenient Lambda

The SAS System 19:43 Sunday, December 19, 2004 34
The TRANSREG Procedure
TRANSREG Univariate Algorithm Iteration History for BoxCox(dv)

Iteration Number	Average Change	Maximum Change	R-Square	Criterion Change	Note
1	0.00000	0.00000	0.31797		Converged

ffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffffff

Algorithm converged.

Transformation Information BoxCox(dv) for IV2

The SAS System 19:43 Sunday, December 19, 2004 35
The TRANSREG Procedure

Lambda	R-Square	Log Like
-3.00	0.05	-854.817
-2.75	0.05	-746.860
-2.50	0.06	-642.373
-2.25	0.06	-541.874
-2.00	0.07	-445.944
-1.75	0.08	-355.218
-1.50	0.08	-270.354
-1.25	0.09	-191.990
-1.00	0.10	-120.688
-0.75	0.11	-56.867
-0.50	0.12	-0.752
-0.25	0.13	47.660
0.00	0.13	88.601
0.25	0.14	122.498
0.50	0.14	149.920
0.75	0.14	171.516
1.00	0.15	187.956
1.25	0.15	199.887
1.50	0.15	207.905
1.75	0.15	212.545 *
2.00 +	0.15	214.267 < ***use Y squared with iv2***
2.25	0.15	213.471 *
2.50	0.15	210.495
2.75	0.14	205.622
3.00	0.14	199.096

< - Best Lambda
* - Confidence Interval
+ - Convenient Lambda

The SAS System 19:43 Sunday, December 19, 2004 36
The TRANSREG Procedure
TRANSREG Univariate Algorithm Iteration History for BoxCox(dv)

Iteration Number	Average Change	Maximum Change	R-Square	Criterion Change	Note
1	0.00000	0.00000	0.14765		Converged

Algorithm converged.

Transformation Information BoxCox(dv) for IV3

The SAS System 19:43 Sunday, December 19, 2004 37
The TRANSREG Procedure

Lambda	R-Square	Log Like
-3.00	0.03	-860.671
-2.75	0.03	-753.241
-2.50	0.03	-649.368
-2.25	0.03	-549.574
-2.00	0.04	-454.442
-1.75	0.04	-364.598
-1.50	0.05	-280.684
-1.25	0.05	-203.307
-1.00	0.06	-132.991
-0.75	0.06	-70.108
-0.50	0.07	-14.837
-0.25	0.08	32.865
0.00	0.08	73.258
0.25	0.08	106.778
0.50	0.09	133.992
0.75	0.09	155.532
1.00	0.09	172.046
1.25	0.10	184.154
1.50	0.10	192.429
1.75	0.10	197.382
2.00 +	0.10	199.455 < ***use Y squared with iv3***
2.25	0.10	199.032 *
2.50	0.10	196.438
2.75	0.10	191.949
3.00	0.10	185.801

< - Best Lambda
* - Confidence Interval
+ - Convenient Lambda

The SAS System 19:43 Sunday, December 19, 2004 38
The TRANSREG Procedure
TRANSREG Univariate Algorithm Iteration History for BoxCox(dv)

Iteration Number	Average Change	Maximum Change	R-Square	Criterion Change	Note
1	0.00000	0.00000	0.09865		Converged

Algorithm converged.

Transformation Information BoxCox(dv) for IV4

The SAS System 19:43 Sunday, December 19, 2004 39
The TRANSREG Procedure

Lambda	R-Square	Log Like
-3.00	0.04	-856.418
-2.75	0.04	-748.956
-2.50	0.05	-645.067
-2.25	0.05	-545.285
-2.00	0.05	-450.201
-1.75	0.06	-360.457
-1.50	0.06	-276.705
-1.25	0.07	-199.567
-1.00	0.07	-129.569
-0.75	0.08	-67.084
-0.50	0.08	-12.281
-0.25	0.08	34.900
0.00	0.09	74.739
0.25	0.09	107.698
0.50	0.09	134.362
0.75	0.09	155.381
1.00	0.09	171.413
1.25	0.09	183.086
1.50	0.09	190.975
1.75	0.09	195.589 *
2.00 +	0.09	197.369 < ***use Y squared with iv4***
2.25	0.09	196.694 *
2.50	0.09	193.885
2.75	0.09	189.213
3.00	0.09	182.910

< - Best Lambda
* - Confidence Interval
+ - Convenient Lambda

The SAS System 19:43 Sunday, December 19, 2004 40
The TRANSREG Procedure
TRANSREG Univariate Algorithm Iteration History for BoxCox(dv)

Iteration Number	Average Change	Maximum Change	R-Square	Criterion Change	Note
1	0.00000	0.00000	0.08650		Converged

Algorithm converged.

APPENDIX D. RELIABILITY ANALYSIS

****** Method 2 (covariance matrix) will be used for this analysis ******

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R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Correlation Matrix

	DV	IV1	IV2	IV3	IV4
DV	1.0000				
IV1	.5578	1.0000			
IV2	.3831	.3869	1.0000		
IV3	.3065	.3721	.2837	1.0000	
IV4	.3029	.2911	.1833	.2881	1.0000

N of Cases = 530.0

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
DV	13.2038	4.3818	.5606	.3646	.6290
IV1	13.0736	4.3519	.5909	.3846	.6172
IV2	13.4453	4.4176	.4376	.2063	.6840
IV3	13.2094	4.5213	.4324	.1961	.6844
IV4	12.8113	5.4313	.3618	.1437	.7056

Reliability Coefficients 5 items

Alpha = .7138 Standardized item alpha = .7163

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ACKNOWLEDGMENTS

I am very grateful to my wife Amy for her unconditional love, understanding, devotion and support. Without her patience, and encouragement, this study could not have been possible. I am also grateful to my major professor, Dr. Dennis Field, for his unwavering support during the course of this paper and throughout my graduate studies. His guidance and passion carried me through the challenging times and enabled me to reach my goal. His dedication and professionalism went above and beyond the job and his eye for detail and valuable suggestions were critical in the completion of this dissertation. Special thanks and appreciation go to my committee members, including Dr. Steve Freeman, for his high professionalism and continuous support from the first day I started my graduate program; Dr. Gary Phye, for the research design and statistics guidance during his class and as a committee member; Dr. Charles Schwab and Dr. Amy Kaleita for their kindness to serve on the committee on a short notice and the valuable feedback they provided during final oral; and the late Professor Dr. Max Wortman for the encouragement and mentoring provided while in his class and as a committee member. I would also like to express my appreciation for all the administrative and professional help I received from the department, especially Kristine Bell and Dr. Freeman and all my colleagues who helped me grow professionally. A special thanks goes to Pat Hahn for helping with the document format. Above all, I humbly acknowledge and thank the lord for all his blessings and the strength he has given me thus far during my graduate studies and throughout my life.