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An Empirical Development of Critical Value Factors for System Quality and Information Quality in Business Intelligence Systems Implementations

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by

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A dissertation submitted in partial fulfillment of the requirements
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We hereby certify that this dissertation, submitted by Paul Dooley, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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Business intelligence (BI) systems have been widely recognized as a leading technology for many years. However, despite the high priority and importance placed on BI, there has been a significant lack of BI system implementation (BISI) success. BI systems are not considered to be conventional information systems (IS) and often rely on the integration of a complex information infrastructure. Consequently, the degree of information quality (IQ) and system quality (SQ) have not met expectations for BISI success.

This study was designed to determine how an organization may gain benefits in the context of BISI by uncovering the antecedents and critical value factors (CVFs) of SQ and IQ necessary to derive greater BISI success. In phase one, a list of BISI SQ and IQ characteristics were collected through literature discovery and an open-ended questionnaire delivered to a group of BI user experts. The collected items were grouped and categorized based on their similarities. In phase two of the study 257 survey responses were collected from BI users to measure the level of importance, i.e. value, they placed on SQ and IQ characteristics. Exploratory factor analysis (EFA) via principal component analysis (PCA) was then used to uncover the CVFs of SQ and IQ that influence BISI success. Two highly reliable CVFs for SQ of BISI with a cumulative variance of nearly 62% and three highly reliable CVFs for IQ of BISI with a cumulative variance of over 75% were subsequently identified. In phase three of the study, an extended conceptual model for IS success was validated to assess the uncovered CVFs of SQ and IQ, as well as their influence on the constructs of perceived SQ of BISI and perceived IQ of BISI. Employing partial least squares (PLS), a subset of structural equation modeling (SEM), the research model was then used to assess the dimensions of perceived SQ of BISI and perceived IQ of BISI as antecedents of the constructs of perceived user systems satisfaction and perceived user information satisfaction from BISI. The crossover effects of perceived user systems and information satisfaction from BISI were also analyzed. The results identified two SQ CVFs of BISI (integration flexibility SQ and reliability SQ) that demonstrated a significant positive impact on perceived SQ for BISI as well as three IQ CVFs of BISI (representation IQ, intrinsic IQ, and accessibility IQ) that had a significant positive impact on perceived IQ of BISI. The constructs of perceived user systems satisfaction and perceived user information satisfaction from BISI had explained variances of R^2 = .576 and .589 respectively. Additionally, 12 items of SQ for BISI and 14 items of IQ for BISI were identified as possessing high reliability.

This study makes two important contributions to the IS body of knowledge. First, it investigated the universal set of antecedents of SQ and IQ to establish the CVFs of IQ (integration flexibility SQ and reliability SQ) as well as the CVFs of IQ (representation IQ, intrinsic IQ, and accessibility IQ) for BISI success. Second, this study evaluated the crossover effects of system and information satisfaction in BISI success highlighting the importance that BI users place on the need to distinguish between the BI system, the IQ of the output produced, and the influence of IQ on perceived user system satisfaction from BISI. This study benefits stakeholders by focusing on what is important to BISI success and identifies those areas that are most likely to lead to better use of scarce resources while providing the greatest benefits.

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Chapter 1

Introduction

Background

Organizations have generally remained data-rich and information-poor in spite of large and increasing investments in information technology (IT) (Forte, 1994; Williams & Williams, 2007). Business intelligence (BI) systems, however, have the potential to deliver meaningful information in a timely, accurate, and complete manner to facilitate improved decision-making (Yeoh & Koronios, 2010). According to Williams and Williams (2007) "Business intelligence systems combine products, technology, and methods to organize key information that management needs to improve profit and performance" (p. 2). BI systems aid decision making by providing a means by which information can easily and quickly be analyzed and converted into knowledge. However, as evidence and research have shown, information does not always reflect a high degree of quality or satisfy the intended need, which creates challenges during the utilization process and delays in decision making. Furthermore, since the impact of BI systems on organizational performance is long-term and indirect, it is difficult to measure the immediate benefits of such systems (Popovic, Coelho, & Jaklic, 2009; Watson, Goodhue, & Wixom, 2002).

The consequences of ineffective decisions and operational inefficiencies, which are created as a result of poor IQ, negatively impact the organization (Marshall & de la Harpe, 2009). The benefits of BI system implementation (BISI), therefore, rely on the ability of the organization using BI to provide quality information. This study tested a

model for information system (IS) success to help understand how an organization can gain benefits in the context of BISI by understanding the SQ and IQ necessary to derive BISI success.

Problem Statement

The research problem that this study addressed is the preponderance of failed BI system projects, promulgated by a lack of attention to SQ and IQ in BISI (Arnott & Prevan, 2008; Jourdan, Kelly, & Marshall, 2008). DeLone and McLean (1992) defined SQ as "the desired characteristics of the information system itself which produces the information" (p. 62). In a subsequent study, DeLone and McLean (2003) stated that SQ was "measured in terms of ease-of-use, functionality, reliability, flexibility, data quality, portability, integration, and importance" (p. 13). DeLone and McLean (1992) defined IQ as the "quality of the information that a system produces" (p. 64). DeLone and McLean (2003) also stated that IQ was "measured in terms of accuracy, timeliness, completeness, relevance, and consistency" (p. 15). Nelson, Todd, and Wixom (2005) defined IQ as "the output of an IS" and defined SQ as the "information processing system required to produce the output" (p. 199). Moreover, Golfarelli, Rizzi, and Cella (2004) related SQ and IQ to BI by expressing BI as a process through which data are converted into information and then into knowledge via the use of various technologies.

Evidence from research showed that only 20% of users having access to BI tools used them on a regular basis (Clark, Jones, & Armstrong, 2007). Meanwhile, according to Yeoh and Koronios (2010), spending on BI systems has comprised one of the largest and fastest growing areas of IT expenditures. In spite of these investments, only 24% of 513

companies surveyed in a study conducted by Howson (2008), considered their BI implementations to be very successful.

Pre-implementation activities for BI projects, particularly addressing SQ and IQ requirements are of paramount importance to BISI success (Howson, 2008; Marshall & de la Harpe, 2009; Negash & Gray, 2008; Power, 2008; Watson et al., 2002). Moreover, there has been a growing body of research that seeks to determine the role of SQ and IQ in IS success (DeLone & McLean, 2003; Petter & McLean, 2009). However, very little attention has been given in the literature to addressing the role of SQ and IQ in the success of BISI (Arnott & Prevan, 2008; Ryu, Park, & Park, 2006; Nelson et al., 2005). Furthermore, little attention has been given to the user's perceived value of SQ and IQ characteristics that have an impact on BISI success (Nelson et al., 2005; Popovic et al., 2009). In their study, Wixom and Watson (2001) investigated the SQ and IQ factors that affected BI success in a data warehouse environment and acknowledged that there were important factors associated with data quality that were not included in their research. Furthermore, Nelson et al. (2005) acknowledged the importance of identifying the appropriate SQ and IQ factors for BI success and stated that "some factors are more important than others in the data warehousing context and it is not clear if these results will be stable across technologies or applications" (p.220). Moreover, few empirical studies have sought to uncover SQ and IQ characteristics that are of value to users of BI systems, as measured by user satisfaction from BISI (Nelson et al., 2005).

The relationships between the constructs of user perceived value (level of importance) and user satisfaction in the context of understanding the SQ and IQ necessary for BISI success have received little attention in the literature. Research has also been limited to

studies that rely only on specific SQ and IQ factors for BI that are based on prior research, not on the universal set of antecedents for SQ and IQ that had been subjected to empirical analysis (Nelson et al., 2005). Thus, in the context of emerging technologies such as BI, it is important to be focused on objectives and decisions that are of value, often requiring the exposure of underlying or hidden values that allow researchers and practitioners to be proactive and hence create more alternatives instead of being limited by available choices (Dhillon, Bardacino, & Hackney, 2002; Keeney, 1999). Furthermore, according to Sheng, Siau, and Nah (2010), it is important to elicit and organize values in "developing constructs in relatively new and under-studied areas" (p. 40).

SQ and IQ have been found to be significant predictors of user satisfaction in IS (DeLone & McLean, 2003; Iivari, 2005). However, according to Bokhari (2005), "the measurement of user satisfaction with an IS has remained a prime concern of researchers" (p. 327). Kim (1989) also stated that research in user satisfaction often does not specifically take into account the perspective of SQ and IQ. Furthermore, there are few studies that empirically investigated the relationship between SQ, IQ, and user satisfaction (DeLone & McLean, 2003; Iivari, 2005; Qian & Bock, 2005; Urbach, Smolnik, & Riempp, 2009). According to Iivari (2005), if the match between user requirements and their interpretation are correct, "increased user satisfaction should be positively associated with task performance" (p. 13). Research has also shown that SQ and IQ are significant determinants of overall user satisfaction (DeLone and McLean, 1992; Rai et al., 2002; Seddon and Kiew, 1994). In a study of a financial accounting system Iivari (2005) found that user satisfaction predicts task performance and individual

impact. Furthermore, according to Thompson, Teo, and Wong (1998), individual impacts in the decision support system environment were positively related to organizational impacts and were, therefore, represented as net benefits. Moreover, Gatian (1994), in a study of 39 organizations found that there was a close relationship between user satisfaction, decision performance, and user efficiency. However, researchers had also recognized the complicated nature of establishing the dependent variable in IS success (DeLone & McLean, 2003; Iivari, 2005; Seddon, 1997). According to Seddon "in the long run, it is people's observations of the outcomes of use and the impacts that determine their satisfaction with the system" (p. 243). It is, therefore, necessary to strengthen the underlying theory of the DeLone and McLean (2003) model with emphasis on the user satisfaction construct (Iivari, 2005). For the purpose of this study, it is assumed that user satisfaction may be a reasonably good surrogate for net benefits if measures are confined to decision performance (Iivari, 2005). Furthermore, in the context of this study, the BISI was considered effective when users perceived the characteristics of SQ and IQ to be highly important and were highly satisfied with these same characteristics. Thus, this study uncovered the SQ and IQ characteristics that are of value in BISI as measured by user satisfaction.

Dissertation Goal

The main goal of this research study was to validate empirically a model for IS success that investigated user satisfaction in the context of BISI by uncovering the critical value factors (CVFs) of SQ and IQ necessary to derive BISI success. Based on cognitive value theory, value refers to the individual's perceived level of importance (Rockeach, 1969). The concept of value is often referenced in various fields of social research but

mainly in the context of economic value, thereby neglecting the applications of user perceived cognitive value (Levy, 2006). According to Levy (2008), "several scholars have suggested that although it is important to investigate the nature of attitudes and opinions, it is more fundamental to investigate the nature of value since attitudes and opinions can often change based on experience, while value remains relatively stable over time" (p.161). In their study of User Information Satisfaction (UIS), Bailey and Pearson (1983) suggested that "satisfaction in a given situation is the sum of one's feelings or attitude toward a variety of characteristics affecting the situation" (p.531). For each IS characteristic Bailey and Pearson (1983) measured the value (or level of importance) of the characteristic using a scale featuring the semantic differential pair, important to unimportant (Levy, 2003). However, in a follow up study, Ives, Olsen, and Baroudi (1983) proceeded to simplify the measurement of user satisfaction for the purpose of shortening the administration of the survey by omitting the measure of level of importance. The omission of the level of importance measure was criticized by researchers based on the claim that, in some instances, these measures provided a deeper understanding of satisfaction with the IS (Etezandi-Amoli & Farhoomand, 1991; Levy, 2003; Sethi & King, 1999). According to Wang and Strong (1996), the determination of SQ and IQ characteristics could not be theoretically determined or intuitively selected by researchers. An empirical approach to the analysis of data quality which involves asking data consumers what characteristics they found important could reveal antecedents that researchers have not considered. This study, therefore, empirically captured SQ and IQ characteristics of BISI by asking users what was important to them.

IS success has also been assessed using the Critical Success Factor (CSF) methodology (Boynton & Zmud, 1984; Yeoh, 2010). CSFs represent the specific managerial and organizational areas that must be given special and continuous attention to attain and maintain desired performance (Boynton & Zmud, 1984). According to Boynton and Zmud (1984), the CSF methodology is a "procedure that attempts to make explicit those few key areas that dictate managerial or organizational success" (p. 17). The CSF methodology, however, has limited capacity to accommodate complexity and may produce models that do not accurately represent the actual environment (Boynton & Zmud, 1984). Therefore, although human interaction was found to be necessary to uncover and assess CSFs, there were concerns regarding the use of the CSF methodology in performing a complex and thorough cognitive assessment of BISI factors that were important to users. Thus, this study used value theory as the basis for investigating the cognitive value (or level of importance) of characteristics to users in the context of SQ and IQ for BISI. Moreover, this study used value theory as the basis to assess user satisfaction in the context of BISI by uncovering the critical value factors (CVFs) of SQ and IQ necessary to derive BISI success.

Although extensive research has been undertaken in the effects of user satisfaction on IS implementation success, the relationship between users perceived value (level of importance) and satisfaction in the context of BISI is lacking. Wixon and Watson (2001) stated that future research should "examine exactly how the dimensions of success interrelate" (p. 35). Nelson et al. (2005) studied the antecedents of SQ and IQ in the context of data warehousing by surveying users on their experiences with report-based, query-based, and analytical BI tools. The Nelson et al. (2005) research model addressed a

gap in the literature involving confusion in differentiating between SQ and IQ factors in the context of user satisfaction when using BI analytical tools in a data warehouse environment. Their model studied factors of SQ and IQ identified in the literature and their relationships with the constructs of system satisfaction and information satisfaction. The results of the Nelson et al. (2005) study suggested that "crossover or interaction effects may exist between the two constructs" (p. 207). They found that while the crossover effect of SQ on information satisfaction was significant within the context of BI analytics, the path leading from IQ to information satisfaction in the same context was surprisingly not significant. They concluded that future research was necessary to understand the characteristics of BI that led to the user perception that IQ did not strongly influence information satisfaction. Nelson et al. (2005) expressed concern regarding this finding and offered the explanation that, from the user's perspective, it may be difficult to differentiate the BI system from the output it produces, leading to potential over-reliance on the system for IQ while ignoring the responsibility for user interaction with the interface and the generation of output. This concern was also echoed by Iivari (2005) from his findings that perceived SQ emerged as more significant than perceived IQ for IS success and suggested that empirical testing of the DeLone and McLean (2003) model should be extended to cover a wider variety of systems.

According to Nelson et al. (2005) further research would be necessary to empirically study the crossover effects of SQ and IQ in the context of BI and recommended that the universal set of characteristics deemed important for SQ and IQ should be tested. Nelson et al. (2005) pointed to integration SQ as a factor that had a particular crossover affect with IQ that should be studied further. Furthermore, data integration, in the context of BI

covers a wide spectrum of methods for facilitating the distribution of information among multiple sources and targets, often involving information flowing from multiple technology platforms including operational systems, data warehouses, and on line analytical systems (OLAP). This information must be delivered to different members of the BI user community within the proper context. Thus, in the context of establishing BISI success measures, it should be borne in mind that since data values appear in many contexts, formats, and frameworks, improving IQ becomes extremely complicated and researchers should determine the level and importance of constructs by observing information consumers and thereafter establishing the acceptability criteria of their defined expectations (Loshin, 2013).

Business users often use BI to analyze, extract, and manipulate data for the purpose of providing recommendations to senior management. Although, to a large degree BI systems rely on well-defined methods, architectures, and techniques, business users often rely on insight and intuition related to the use of data. Their ability to integrate and analyze sources of information for the purposes of drawing inferences is of paramount importance and value to a successful BISI (Loshin, 2013). However, while BI tools make the business user more self-sufficient by providing innovative ways to analyze data as data volumes increase, a plan is required to ensure that IQ transformation activities such as information integration, aggregation, summarization, and derivation are performed properly (Loshin, 2013; Moss, 2010). In their exploratory study of data quality, Wang and Strong (1996) recognized the need to ask data consumers what characteristics of IQ they found important in order to assess if information was “fit for use” in the context of the specified task. Wang and Strong (1996) found, for instance, that the format and

meaning of data were generally addressed by syntax in database systems but acknowledged that research is required to explore the area of context interchange among heterogeneous sources and the relationship to the representational IQ factor. According to Loshin (2013), data integration in particular "is not limited to extracting data sets from internal sources and loading them into a data warehouse, but focuses on effectively facilitating the delivery of information to the right places within the appropriate time" (p. 340). Moreover, in support of the issues with differentiating the integration construct in the context of BISI, Popovic, Hackney, Coelho, and Jacklic (2012) stated that "while IS success has been well researched, our understanding of how BI systems dimensions are interrelated is limited" (p. 729). In their study of 181 organizations, Popovic et al. (2012) measured the data integration construct for analytical decisions by measuring how available data are integrated and whether the data from different data sources are mutually consistent. They found that data integration is considered a key factor contributing to the success of BISI but issues faced with supporting large amounts of data from disparate heterogeneous sources and the provision of analytical capabilities (e.g. query generation, on-line analytical processing (OLAP), reporting, and data mining) created a complex environment for the analysis of data (Popovic et al., 2012).

Wang and Strong (1996) introduced a framework that measured representational data quality and found that data consumers could not always interpret and understand data correctly. As a result, information understanding, interpretability, consistency, and conciseness were regarded as important characteristics of representational IQ that should be assessed. Moreover, in the context of BISI, Loshin (2013) identified contexts and formats as important characteristics of BISI success. In their study of data quality, Wang

and Strong (1996) assessed characteristics associated with ease of operation which included items that addressed the ease with which data are joined, changed, updated, downloaded/uploaded, used for multiple purposes, manipulated, aggregated, reproduced, integrated, and customized. According to Wang and Strong (1996), many of these characteristics were not considered highly important in the context of their study which assessed an accounting IS. However, according to Loshin (2013), these characteristics are highly important to BISI and were, therefore, assessed in this study within the context of BISI success.

Wang and Strong (1996) found that data consumers also recognized the importance of accessibility for their information needs and, therefore, viewed accessibility IQ as an important IQ construct. However, Nelson et al. (2005) considered accessibility to be a construct of SQ with the understanding that accessibility was "the degree to which a system and the information it contains can be accessed with relatively low effort" (p. 206). Wang and Strong (1996) acknowledged the differences in the treatment of the accessibility construct in the literature and stated that regardless of its treatment in research models, accessibility must be considered in IS success research.

In recognition of the uniqueness of BI as an IS and the call for further research in the crossover effects of constructs in BISI, this study attempted to identify the universal set of antecedents necessary to uncover the CVFs of SQ and IQ for BISI success. The CVFs for SQ and IQ and their interaction were studied in the context of BISI while applying the BI SQ and IQ research model based on the DeLone and McLean (2003) model for IS success which included the constructs of SQ, IQ, and user satisfaction. This study used only those DeLone and McLean IS success constructs that are relevant to the

investigation of the influence of the CVFs for SQ and IQ on user satisfaction of BISI (Prybutok, Zhang, & Ryan). Moreover, this study was built on the concepts of DeLone and McLean (2003) which identified SQ and IQ as the key initial constructs for IS success. Extending those notions, Nelson et al. (2005) derived a model that identified, integrated, and assessed the dimensions of SQ and IQ as antecedents of the constructs of perceived user systems satisfaction and perceived user information satisfaction in their model titled "Determinants of information and system quality" (p. 208). The Nelson et al. (2005) extended model was, therefore, used in this study.

Petter, DeLone, and McLean (2008) argued that "the practical application of the DeLone and McLean model is naturally dependent on the organizational context" (p. 239). Moreover, in applying the model, researchers "must have an understanding of the information system and organization under study to determine the types of measures used in each success dimension" (p. 239). To address this gap in the literature, Marshall and de la Harpe (2009) indicated that further research in IQ is required to determine its usefulness to BI users. Additionally, Marshall and de la Harpe (2009) stated that "A better understanding of the quality of information on which decisions are based is required to fine-tune further research" (p. 13).

The first specific goal of this research, following Keeney's (1992) methodology, was to gather a list of user perceived SQ and IQ characteristics from literature and augment it with input from an expert panel. The second specific goal of this research was to use the SQ and IQ characteristics to uncover the CVFs of SQ and IQ associated with BISI. The third specific goal of this research was to test the impact of the CVFs of SQ on perceived SQ of BISI and the CVFs of IQ on perceived IQ of BISI. The fourth specific goal of this

research was to test the impact of perceived SQ of BISI on perceived user system satisfaction from BISI and perceived SQ of BISI on perceived user information satisfaction from BISI. The impact of perceived IQ of BISI on perceived user information satisfaction and perceived IQ of BISI on perceived user system satisfaction from BISI was also tested using the BI SQ and IQ research model based on the DeLone and McLean (2003) model for IS success as extended by Nelson et al. (2005) in their derived model of determinants of SQ and IQ. Figure 1 presents the research model for this study.

The need for this work was demonstrated by Popovic et al. (2009) as well as Yeoh and Koronios (2010) in their calls for further research to address SQ and IQ issues with BISI. Baars and Kemper (2008) also recognized the importance of SQ and IQ for BISI success and suggested that the integration of unstructured data should be studied. Nelson et al. (2005) recommended that further research should be conducted to understand the characteristics of BI which led to their surprising conclusion that IQ did not strongly influence information satisfaction in BI analytic applications. Vavpotic and Bajec (2009) suggested that system development methodologies (SDM) be tailored for BI system development efforts to accommodate SQ and IQ requirements. Consequently, this study addressed the limited number of research studies in SQ and IQ characteristics that lead to BISI success.

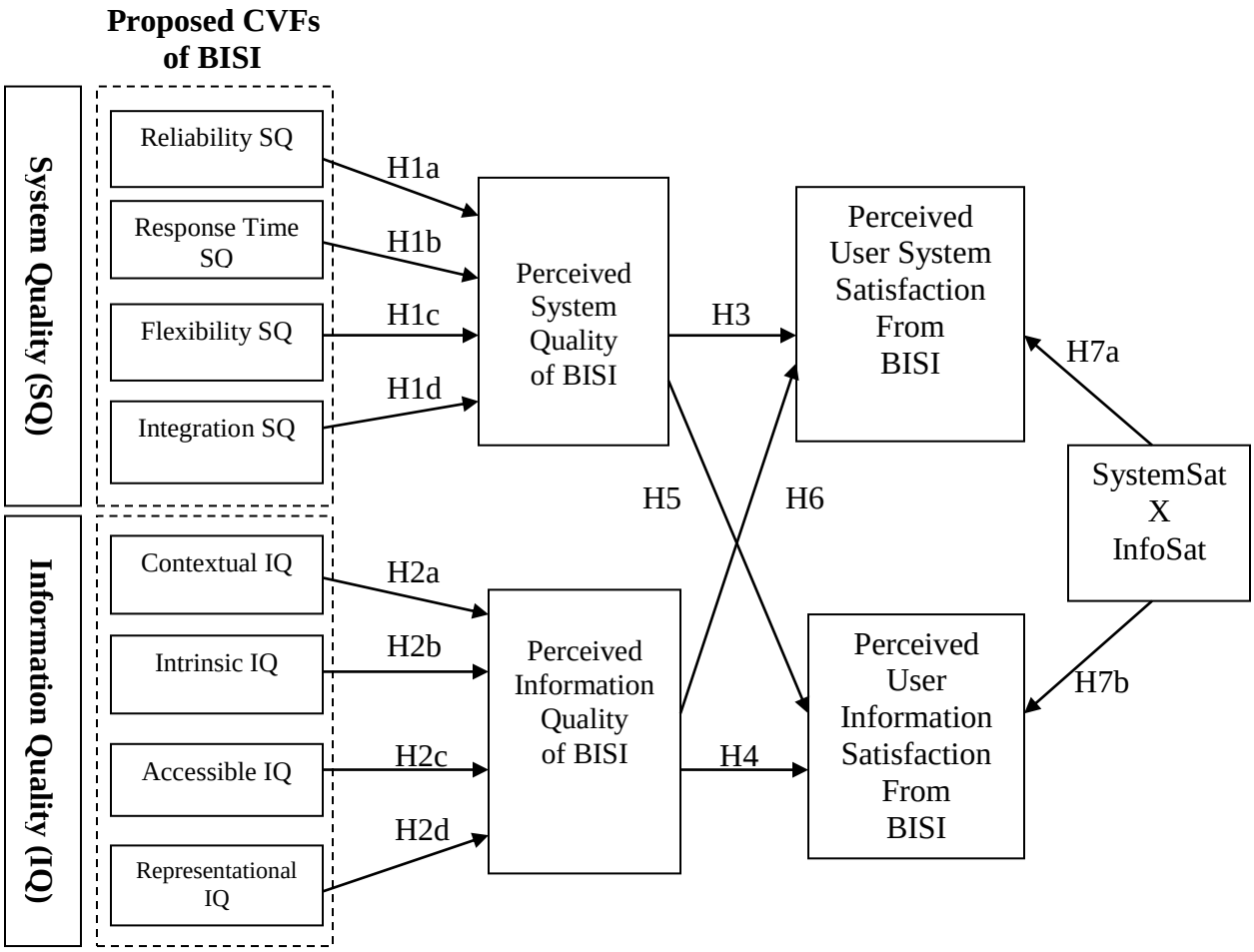


Figure 1. BI SQ and IQ research model based on DeLone and McLean (2003) IS Success Model as extended by Nelson et al. (2005).

Research Questions/Hypotheses

The main research questions that this study has addressed are:

RQ1: What SQ characteristics are valued in BISI by users? What IQ characteristics are valued in BISI by users?

RQ2: What are the CVFs for SQ that users' value in BISI? What are the CVFs for IQ that users' value in BISI?

Stemming from the research questions, this study then addressed the following specific hypotheses:

H1a-d: The CVFs of SQ will have a positive significant impact on perceived SQ of BISI.

H2a-d: The CVFs of IQ will have a positive significant impact on perceived IQ of BISI.

H3: The perceived SQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H4: The perceived IQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H5: The perceived SQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H6: The perceived IQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7a: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7b: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user information satisfaction from BISI.

Relevance and Significance

BI application systems have been rated as a leading technology for the last several years (Luftman & Ben-Zvi, 2010). However, despite the high priority placed on BISI, organizations have found BI systems difficult to implement and there has been a significant lack of implementation success. In particular, organizations have struggled to

ensure that high quality information is provided to and from BI systems (Luftman & Ben-Zvi, 2010). This suggested that organizations have recognized the value of information and the potential opportunities available with BI but are challenged by the lack of success in BISI. Moreover, according to Marshall and de la Harpe (2009), 80% of the time spent in BI support involves investigating and resolving IQ issues which if inadequately addressed, will severely affect organizations through decreased productivity, regulatory problems, and reputational issues.

BISI requires a complex infrastructure and dedicated resources over a lengthy period of time which is often difficult to achieve (Yeoh & Koronios, 2010). Despite these known obstacles there has been little empirical research that addressed the SQ and IQ characteristics valued by users in BISI. The study of BISI is a relatively new area that has been driven primarily by the IT industry and by vendors. As a consequence, the scarce BI research that is available mainly focuses on constructs that affect IS success, often taking only from the literature SQ and IQ characteristics associated with IS success for specific and often unrelated domains.

The relevance of this study is that it represents the first empirical analysis of CVFs that affects SQ and IQ for BISI success. According to Marshall and de la Harpe (2009) "In the context of BI, this means that information should reflect certain characteristics that the information consumer identifies as important in order to be regarded as useful to a decision making process" (p. 3). Moreover, SQ and IQ for BI systems should satisfy the purpose for which they were intended as with any IS implementation (Strong, Lee, & Wang, 2007).

Focusing on objectives that are of value will create more alternatives for SQ and IQ in BISI and, therefore, offers promise as a resolution to the problem of limited available choices. In IS success research, SQ and IQ have played a major role in determining overall IS success. IS success models have shown that SQ and IQ are independent variables that have a strong relationship to user satisfaction with an IS. In BI research, SQ and IQ are regarded as major constructs. Therefore, empirical research to shed more light on what is important in BISI is desirable for BISI success. Establishing the CVFs of SQ and IQ in BISIs provides the SQ and IQ characteristics that are valued by users of BI solutions to improve and maintain SQ, IQ, and their crossover effects in BISI, thereby adding to the Body of Knowledge (BoK).

This study is significant because research in BISI is a relatively new area that has been driven primarily by the IT industry and by vendors. Therefore, empirical research to shed more light on CVFs that influence BISI success is desirable. An understanding of the CVFs of SQ and IQ in BISIs will enable BI stakeholders to optimize their scarce resources and efforts by focusing on those significant factors that are most likely to aid successful system implementation (Yeoh & Koronios, 2010).

Barriers and Issues

The goals of this study have not previously been achieved for several reasons. While the BI market appears vibrant and the importance of BI systems is more widely accepted, few studies have investigated the CVFs that affect BISI success (Yeoh & Koronios, 2010). According to Marshall and de la Harpe (2009), SQ and IQ issues continue to impact BISI and the overall lack of business confidence and believability has led to confusion and ineffective decisions. Furthermore, considerable time has been absorbed in

researching and correcting SQ and IQ issues, thereby impacting productivity and leading to increased costs. An understanding of the CVFs for SQ and IQ in BISI success will enable BI stakeholders to overcome these issues by identifying opportunities to optimize scarce resources and efforts by focusing on those CVFs of SQ and IQ that are most valued in BISI success.

Assumptions, Limitations and Delimitations

The results of this study may be generalized across BI systems implementations in both the private and public sectors. One limitation of this study is that it may not be representative of the entire participant population. Participants in this study were selected on a random basis and their experience levels varied. Another limitation surrounds the lack of consistency in the BI technology used. For example, one participant may have experienced BI using the IBM Cognos tool. Another participant may have experienced BI using systems that were integrated in an ERP system. Another limitation is that the survey instrument was distributed via email to BI system users. This raises the possibility that BI system users may have ignored the invitation based on email overload and the associated lack of time to review and respond to a multitude of messages.

The primary delimitation of this study surrounds the possibility that participants may have varying degrees of exposure to analytical BI systems. While BI systems are associated with decision making, the complexity of the implemented system and the interpretation of its output could require skill levels that may not be consistent among all participants. It is, therefore, assumed for the purposes of this study that participants had, at a minimum, implemented an analytical BI system.

Definition of Terms

Below is a list that defines the terms and acronyms used in this study.

BI – Business Intelligence - Business information and business analysis within the context of key business processes that lead to decisions and actions that result in improved business performance (Williams & Williams, 2007). Also known as business analytics which includes applications, infrastructures, tools, and best practices that enables access and analysis of information to improve and optimize decisions and performance. Business analytics includes BI platforms, corporate performance management suites, advanced analytics, analytical applications and performance management, among other elements of BI (Chandler, 2014).

SQ – System Quality – the information processing system required to produce the output (Nelson et al., 2005)

SQ Characteristics – System Quality Characteristics - the desired characteristics of the information system that produces the information (DeLone and McLean, 1992).

IQ – Information Quality - Information that is valued for a specific purpose or use (Wang & Strong, 1996).

IQ Characteristics – Information Quality Characteristics – Information attributes that are important to individual perceptions of IQ (Arazy & Kopak, 2011).

IS – Information system – An automated system that provides information to a specific audience on particular topics in an organized context (Iivari, 2005).

IS Success – A multi-level phenomenon comprised of the technical, semantic, and effectiveness levels (DeLone & McLean, 1992).

Net Benefits – Significant success measures that capture the balance of positive and negative impacts concerning different stakeholder groups (DeLone & McLean, 2003; Dinter, Schieder, & Gluchowski, 2011).

User Perceived Value of IS – A combined set of enduring core beliefs that users incorporate to evaluate the importance of characteristics or attributes (Levy, 2009).

IS User Satisfaction – The user's best estimate of the match between the requirements imposed on a system by his or her work and the systems capabilities (Iivari & Ervasti, 1994).

Value – An enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence (Rokeach, 1973).

Summary

This study was created to address the problem of failed BI system projects, promulgated by a lack of attention to SQ and IQ in BISI. This study empirically determined the CVFs of SQ and IQ for BISI success based on the universal set of antecedents perceived as important to users of BI systems. This research is an extension of the work performed by Nelson et al. (2005) which suggested that further research was necessary to empirically study the relationship between SQ and IQ characteristics leading to BI success in analytical systems. Nelson et al. (2005) suggested that future research should explore the relationship of SQ, IQ and perceived user satisfaction in the context of BI analytical systems to address the surprising results of their empirical analysis that indicated that the influence of SQ on user perceived IQ satisfaction was stronger than the influence of IQ on user perceived IQ satisfaction. Nelson et al. (2005) also acknowledged

that some factors in their study of BI systems success were more aligned with data warehousing, contributing to the possibility of instability across technologies and applications that may have altered the strength of relationships in their conceptual model. It was, therefore, necessary to understand what dominant SQ and IQ characteristics are deemed important in BI to guide the design of BI systems and distinguish the system from its output.

The relationship of SQ, IQ and user perceived satisfaction in the context of BISI is often ambiguous, leading to failed implementations. This confusion is often based on high user expectations from BI technologies and thus a lack of focus on IQ responsibilities that consider the restrictiveness of the BI technology. The main goal of this study was to validate empirically a model for IS success that investigated perceived user satisfaction in the context of BISI by uncovering the CVFs of SQ and IQ necessary to derive BISI success. In recognition of the uniqueness of BI as an IS, this study identified the universal set of antecedents necessary to uncover the CVFs of SQ and IQ as well as their interaction effects in the context of BISI success. This study built upon the concepts of the DeLone and McLean (2003) IS success model, as extended by Nelson et al. (2005) to test for BISI success by assessing the characteristics of the constructs of SQ and IQ as antecedents of the constructs of perceived user system satisfaction and perceived user information satisfaction. This study is relevant as it represents the first empirical analysis of CVFs that affects SQ and IQ for BISI success and has uncovered important characteristics for BISI success that will enable BI stakeholders to better optimize scarce resources.

Chapter 2

Review of the Literature

Introduction

In this section, a brief review of the literature provides the foundation for the theories used in this study. The review begins with an examination of BI history and the evolution of BI theory to its current state. The review continues with a focus on the value foundation established by Keeney (1992) and the implication of value theory on IS success discussed in the literature by Dhillon and Torkzadeh (2001), Dhillon et al. (2002), Levy (2008), Nah, Siau, and Sheng (2005), Siau, Nah, and Siau (2004), as well as Sheng, Nah, and Siau (2005). IQ theory is used to provide the theoretical foundation for discussing this construct in successful BISI. The IQ foundation established by Lee, Strong, Kahn, and Wang (2002), to include the four high level categories of the multidimensional IQ construct, provides the basis for factor analysis of CVFs for IQ of BISI. The SQ foundation established by Nelson et al. (2005), that included high level categories of the multidimensional SQ construct provides the basis for factor analysis of CVFs for SQ of BISI. However, for the purpose of this study the high level category of accessibility, identified as a category in both the SQ and IQ constructs, is used as a category of IQ (Lee et al., 2002). IS success theory and specifically the relationship between and synthesis of the constructs of SQ, IQ, and user satisfaction in the context of BISI is then reviewed based on the DeLone and McLean IS success model (2003) as extended by Nelson et al. (2005) in their model titled "Determinants of Information and System Quality" (p. 208).

BI History

BI systems have evolved from the IT portfolio of IS that included Decision Support Systems (DSS), Expert Systems (ES), and Executive Information Systems (EIS) (Frolick & Ariyachandra, 2006; Williams & Williams, 2007). The implementation of a BI system is not a conventional application-based IT project but shares similar characteristics with other enterprise system initiatives such as enterprise resource planning (ERP) systems implementations (Yeoh & Koronios, 2010). Moreover, the term BI, is multifaceted, having process, technology, as well as product origins and perspectives (Williams & Williams, 2007). Some identify BI with infrastructure based projects including ERP, Customer Relationship Management (CRM), and Data Warehouse (DW) systems (Ghazanfari, Rouhani, Jafari, & Taghavifard, 2009; Reid & Catterall, 2005; Watson et al., 2002; Williams & Williams, 2007; Yeoh & Koronios, 2010). Power (2008) argued that the term BI is used inaccurately and is really a data-driven DSS. BI is a powerful tool that aids decision-making processes by providing a means by which information can easily and quickly be analyzed and converted into knowledge. However, as evidence and research have shown, information does not always reflect a high degree of quality or satisfy the intended need, which creates challenges during the utilization process and delays in decision making (Marshall & de la Harpe, 2009). According to Yeoh and Koronios (2010), "implementation of a BI system is not a simple activity entailing merely the purchase of software and hardware; rather it is a complex undertaking requiring appropriate infrastructure and resources over a lengthy period" (p. 23). Thus, the increased rate of adoption of BI systems, the complexities of implementing a contemporary BI system, the scarcity of academic research, and the far-reaching business

implications justify a more focused examination of BI factors as well as the associated contextual issues required for implementing BI systems.

Value Theory

According to Rokeach (1973), a value is "an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (p. 5). Moreover, Keeney (1992) stated that values are what one desires to achieve. As a large number of BI projects are considered to be failures because organizations do not see tangible business value, it is necessary to understand the value factors that are needed to benefit from BI investments (Todd, 2009). According to Saeed and Abdinnour-Helm (2008), "information quality and system integration are two important characteristics of the information system that contribute towards the formation of the overall assessment of the value of the information system but also directly influences certain usage behaviors" (p. 385). Value based exploration techniques have been applied in many research areas such as value-focused assessment of privacy and security (Dhillon & Torkzadeh, 2001; Dhillon et al., 2002), value-focused assessment of trust in mobile commerce (Siau et al., 2004), and assessing the values of mobile applications (Nah et al., 2005; Sheng et al., 2005). Levy (2008), in a study of online learning activities, used CVFs to investigate and uncover issues related to learners' perceived value. Levy (2009) defined user perceived value as a "belief about the level of importance that users hold for IS characteristics" (p. 94). Moreover, user perceived value has been recognized as relevant to the understanding of user satisfaction and user-perceived effectiveness (Bailey & Pearson, 1983; Levy, 2009).

In the context of BISI, CVFs for SQ and IQ have been identified and discovered using a process whereby a number of SQ and IQ characteristics form clusters that provided an understanding of CVFs (Mertler & Vannatta, 2001). This is particularly important in an emerging technology such as BI where it is not a conventional application-based IT project but a complex undertaking (Yeoh & Koronios, 2010). In emerging technologies, such as BI, it is important to expose underlying or hidden values, particularly in understudied IS technologies (Dhillon et al., 2002; Keeney, 1999; Sheng et al., 2010).

IQ

The literature has recognized that IQ is a multidimensional construct with specific characteristics to indicate its presence in IS (Lee et al., 2002). These characteristics are often grouped into dimensions or categories, comprising similar characteristics (Arazy & Kapak, 2011). Lee et al. (2002) empirically defined four high level categories for the multidimensional IQ construct, namely intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ. These categories will be used in the context of this study as the proposed CVFs of IQ necessary to derive BISI success. *Intrinsic IQ* was defined by Lee et al. (2002) as "information that has quality in its own right" (p. 135). Moreover, Arazy and Kapak (2011) stated that intrinsic IQ had innate correctness regardless of the context in which it is being used. Drawn from the IS success literature, intrinsic IQ (DeLone & McLean, 1992; Goodhue, 1995; Wand & Wang, 1996; Wang & Strong, 1996) included the characteristics of accuracy, believability, precision, reliability, consistency, and correctness. *Contextual IQ* was defined by Lee et al. (2002) as "the requirement that IQ must be within the context of the task at hand" (p.135). Drawn from the IS success literature, contextual IQ (DeLone & McLean, 1992; Jarke & Vassiliou, 1997; Wand &

Wang, 1996; Wang & Strong, 1996) included the characteristics of relevance, completeness, timeliness, and importance. *Representational IQ* was defined by Lee et al. (2002) as the need for ensuring the proper presentation of information for ease of interpretation and manipulation. Arazy and Kapak (2011) also stated that "representational IQ addresses the degree to which the information being assessed is easy to understand and is presented in a clear manner, which is concise and consistent" (p. 91). Moreover, the IS success literature suggested that representational IQ (DeLone & McLean, 1992; Goodhue, 1995; Loshin, 2013; Wand & Wang, 1996; Wang & Strong, 1996) included the characteristics of understanding, format, conciseness, readability, clarity, compatibility, and meaningfulness. Additional characteristics related to ease of operation included information that is easily joined, changed, updated, downloaded/uploaded, used for multiple purposes, manipulated, aggregated, reproduced, integrated, and customized. *Accessibility IQ* was defined by Lee et al. (2002) as "the importance of computer systems that store and provide secure access to information" (p. 135). In their definition of accessibility, Arazy and Kapak (2011) referred to "the ease with which the information sought is obtained, including the availability of the information and the timeliness of its receipt" (p. 91). Moreover, the IS success literature suggested that accessibility IQ (DeLone & McLean, 1992; Goodhue, 1995; Jarke & Vissiliou, 1997) included the characteristics of availability and security, as well as the ability to use and locate information. Appendix A provides a summary of proposed characteristics of the IQ construct, discovered by a literature review and dimensioned by the proposed IQ framework comprising intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ.

IQ is crucial if a BI system is to be implemented successfully. According to Yeoh and Koronios (2010), a primary purpose of a BI system is to integrate information for advanced analysis so as to improve the decision-making process. IQ related issues that are not discovered until the information is populated and queried within the BI system, will affect the quality of management reports, which in turn will incorrectly influence decision outcomes. In the context of BI, according to Marshall and de la Harpe (2009) "information should be 'fit for use' and satisfy the purpose for which it is intended" (p. 3).

Petter et al. (2008) conducted a literature review to test the currency of the DeLone and McLean (1992, 2003) model of IS success and found that there remained widespread support for the direct relationship between SQ and IS success as well as IQ and IS success. However, Petter et al. (2008) cautioned that "While recent research has provided strong support for SQ and IQ success dimensions in the DeLone and McLean model, more research is needed to explore the relationships that have not been adequately researched" (p. 258). Thus, it has been recognized that in spite of the extensive focus on SQ and IQ in the literature, issues with poor SQ and IQ in BISI continue to contribute to ineffective and delayed decisions as well as duplicate and missing information (Hill, Moss, Sorensom, & Weeks, 2009; Marshall & de la Harpe, 2009; Yeoh & Koronios, 2010). Moreover, the consequences of ineffective decisions and operational inefficiencies, which are created as a result of poor quality information, continue to negatively impact the organization (Marshall & de la Harpe, 2009).

Table 1. Summary of IQ Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Arazy & Kopak, 2011	Theoretical, empirical	270 undergraduate student assessors	Questionnaire	Measures of IQ are often inadequate and greater emphasis should be placed on building assessment criteria that are based on task-expertise and knowledge of the specific domain
DeLone & McLean, 1992	Theoretical	100 studies	Literature review	There are many IS success measures falling into six categories, including IQ, that are interrelated and interdependent
Lee et al., 2002	Theoretical, survey, empirical	261 responses from information consumers and IS professionals in five companies	Questionnaire	IQ can be assessed in organizations according to key dimensions, their measures, and the integration and synthesis of certain components
Marshall & de la Harpe, 2009	Theoretical, empirical	Discussions with eight individuals in the BI and business departments of a retail organization	Literature review followed by interviews	Identified underlying factors that affect IQ in the decision making process in a BI environment
Wang & Strong, 1996	Theoretical, survey, empirical	355 data consumers	Questionnaire	This study provided researchers and practitioners with a theoretical foundation and framework that can assess IQ in specific work contexts

Table 1. Summary of IQ Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Yeoh & Koronios, 2010	Theoretical	Five large organizations	Case study	Concluded that BI systems are different from other infrastructural systems and must consider appropriate differentiating factors

SQ

The literature has aligned the SQ construct with the information processing system necessary to produce the required output (Nelson et al., 2005). According to Nelson et al. (2005), "the dimensions of SQ represent user perceptions of interaction with the system over time" (p. 205). According to Nelson et al. (2005) SQ characteristics are mainly the same with little deviation across different users and can be assessed independent of task, context, or application. In their assessment of the literature which drew on 20 studies, Nelson et al. (2005) suggested that there are five key dimensions to SQ which were accessibility SQ, reliability SQ, flexibility SQ, response time SQ, and integration SQ. With the exception of accessibility SQ, these dimensions of SQ will be used in the context of this study as the proposed CVFs of SQ necessary to derive BISI success. Accessibility SQ was defined by Nelson et al. (2005) as "the degree to which a system and the information it contains can be accessed with relatively low effort" (p. 206). Drawn from the IS success literature, accessibility SQ included the characteristics of retrievable, available, and speed of access. However, for the purpose of this study, accessibility is used as an IQ construct with emphasis placed on access to information. Miller (1996) defined accessibility as the ability to obtain information when needed. A

review of the literature on the effects of information access on BI systems revealed greater efficiency among knowledge workers, enhanced analytical capabilities, and improved timeliness of the input to the decision making process (Popovic et al., 2012). Moreover, according to Popovic et al. (2012), "despite wide recognition that technology mainly influences information access quality with limited possibilities of influencing information content quality, it is believed that through improved interactivity (access quality), knowledge workers do not have information merely delivered but are able to explore it and acquire more relevant information (content quality)" (p. 731).

The proposed CVFs of SQ used in this study include *Reliability SQ* which was defined as the dependability of a system over time as measured by uptime, downtime, or time between failures (Nelson et al., 2005). Wang and Strong (1996) stated that reliability was a key attribute in the study of data quality in the context of accounting systems. Drawn from the IS success literature, reliability SQ included the characteristics of hardware and software downtime, recoverability, validity, and technical quality (Chang & King, 2005; Halloran, Manchester, Moriarity, Riley, Rohrman, & Skramstad, 1978; Miller & Doyle, 1987; Shaw, 2002; Zmud, 1978). According to Nelson et al. (2005), although the reliability SQ construct is often measured objectively with well-established system-related measures, user perceptions may be swayed by the timing of reliability issues and this should be considered in the determination of reliability SQ. *Response time SQ* was defined by Nelson et al. (2005) as "the degree to which a system offers quick (or timely) responses to requests for information or action" (p. 206). Drawn from the IS success literature, response time SQ (Ahituv, 1980; Bailey & Pearson, 1983; Chang & King, 2005; Halloran et al., 1978; Ives et al., 1983) included the characteristics of timeliness

and the suitable frequency of output. *Flexibility SQ* was defined by Halloran et al. (1978) as "the extent to which system features and options lend themselves to accommodating change without modifications to programs" (p. 5). Nelson et al. (2005) suggested that flexibility SQ is more important in systems that perform analytical functions, which are more likely to change over time. Drawn from the IS success literature, flexibility SQ (Chang & King, 2005; Halloran et al., 1978; Miller & Doyle, 1987; Wang & Strong, 1986) included the characteristics of adaptability, extendibility, and expandability. *Integration SQ* was defined by Nelson et al. (2005) as "the degree to which a system facilitates the combination of information from various sources to support business decisions" (p. 206). Systems that facilitate integration must accommodate interdependent tasks and agree on the meaning of the exchanged data among heterogeneous information systems (Goodhue & Thompson, 1995; Sciore, Siegel, & Rosenthal, 1994). Drawn from the IS success literature, integration SQ (Chang & King, 2005; Baily & Pearson, 1983; Miller, 1996; Shaw, 2002; Wang and Strong, 1996) included the characteristics of compatibility and the ability to combine data from a variety of data and data sources.

Table 2. Summary of SQ Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Chang & King, 2005	Theoretical, survey, empirical	346 responses were received from 120 companies	Questionnaire	Developed measures to assess the performance of the IS function.
DeLone & McLean, 1992	Theoretical	100 studies	Literature review	There are many IS success measures falling into six categories, including SQ, that are interrelated and interdependent
Goodhue & Thompson, 1995	Theoretical, survey, empirical	600 responses from individuals that used 25 different IT systems in 26 different departments in two companies	Questionnaire	Highlighted the importance of the relationship between technology and user tasks and then the impact on user performance
Miller & Doyle, 1987	Theoretical, survey, empirical	276 responses from individuals in 21 financial services firms	Questionnaire	Developed measurements for IS effectiveness and tested hypothesis that established that the overall effectiveness of IS was a function of the correlation between perceived importance and performance of individual attributes

Table 2. Summary of SQ Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Nelson et al., 2005	Theoretical, survey, empirical	450 responses from individuals in four companies and three public sector organizations	Questionnaire	In the context of data warehouse research empirically evaluated the key dimensions of information and system quality to predict the quality of BI system constructs. This study provided researchers and practitioners with a theoretical foundation and framework that assesses BI SQ and IQ and their interrelationships
Popovic et al., 2012	Theoretical, survey, empirical	Data collected from 181 individuals in medium and large organizations in Slovenia	Questionnaire	Linked BIS maturity to information quality, namely content and access quality. Also studied the interrelationships between BIS success dimensions and found that only information content quality is relevant for the use of information while the impact of information access quality is non-significant.

IS Success

The measurement of IS success has been a top concern of researchers and practitioners. Several models have been proposed to define and identify the causes of IS success. However, a universally agreed definition of IS success has not emerged due to differences in the needs of stakeholders who assess IS success in an organization (Urbach et al., 2009). The need for a general but comprehensive definition of IS success was

recognized by DeLone and McLean (1992) in their review of existing definitions of IS success and their associated measures. This led to a multidimensional and interdependent model classified into the six major categories of system quality, information quality, user satisfaction, use, individual benefits, and organizational benefits. Since the publication of the DeLone and McLean (1992) IS success model, many researchers have treated IS success as a multidimensional construct (Urbach et al., 2009). Subsequent to the publication of the original DeLone and McLean (1992) IS success model, many researchers had suggested that it be extended or re-specified to include additional dimensions (Seddon, 1997). As a result, DeLone and McLean (2003) published an updated IS success model to include the addition of service quality and intention to use as constructs. They also collapsed the individual and organizational impact constructs into the parsimonious net benefits construct to measure the positive and negative influence of user satisfaction and use on IS.

According to Urbach et al. (2009) "the majority of studies of IS success use the DeLone and McLean IS success model in combination with other theoretical models as a basis for deriving new research models that are applicable to the specific requirements of the corresponding problem domains" (p. 9). Researchers have argued that certain constructs of the DeLone and McLean model do not significantly correlate with IS effectiveness. For instance, according to Levy et al. (2009), "IS usage has been demonstrated to have mixed results as a predictor of IS effectiveness" (p. 99). Despite some weaknesses, however, the DeLone and McLean (2003) success model has become the dominant model for measuring IS success (Urbach et al., 2009). According to DeLone and McLean (1992), the importance of IS success is imperative and "the evaluation of IS

practice, policies and procedures requires an IS success measure against which various strategies can be tested. Without such a measure, much of IS research is purely speculative" (p. 61). Clark et al. (2007) followed the guidance of the DeLone and McLean IS success models (1992; 2003) to study the underlying threads of commonality with BISI success. Their study suggested that BISI success was theoretically grounded in IS success research. Therefore, this study tested a proposed BI SQ and IQ research model which was based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005). The study specifically tested the influence of SQ and IQ in BISI with user satisfaction from BISI.

Table 3. Summary of IS Success Studies

Study	**Methodology**	**Sample**	**Instrument**	**Main findings or contributions**
Almutairi & Subramanian, 2005	Theoretical, survey, empirical	139 responses from end users and managers from seven organizations in Kuwait	Questionnaire	Used the DeLone & McLean model as the conceptual foundation and found that as IQ and SQ increased, user satisfaction also increased
Clark et al., 2007	Theoretical, empirical	Expert panel	Literature review	BI systems were developed and used without knowledge of the determinants of long term success
DeLone & McLean, 1992; 2003	Theoretical	100 studies	Literature review	There are many IS success measures falling into six categories including IQ, SQ, and user satisfaction that are interrelated and interdependent

Table 3. Summary of IS Success Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Galtian, 1994	Theoretical, survey, empirical	39 organizations	Questionnaire	There is a relationship between user satisfaction, decision performance, and user efficiency
Iivari, 2005	Field study	78 responses from primary users of an accounting system in Finland	Questionnaire	Findings suggested that user satisfaction may be a reasonably good surrogate for individual impact as long as it was confined to work performance
Levy et al., 2009	Theoretical, survey, empirical	192 responses from students using online learning systems	Questionnaire	Proposed taxonomy for IS effectiveness and introduced the user-perceived value methodology for assessing the effectiveness of online learning systems
Petter et al., 2008	Theoretical, survey, empirical	180 papers reviewed for the period 1992-2007	Literature review	Summarized the measures applied to the evaluation of IS success under the DeLone and McLean IS success model
Seddon, 1997	Theoretical,	Not applicable	Literature review	Proposed that the inclusion of variance and process interpretations in the DeLone and McLean IS success model were confusing and thereby required a re-specified model that included service quality

Table 3. Summary of IS Success Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Urbach et al., 2009	Theoretical	In-depth analysis of 28 empirical papers	Literature review	Found that the DeLone and McLean IS success model remained the dominant basis of IS success measurement, often used in combination with other theoretical models

IS User Satisfaction

IS user satisfaction is defined as the extent to which users believe that the IS available to them meets their information requirements at the appropriate point in time (Bailey & Pearson, 1983; Doll & Torkzadeh, 1991; Ives, Olson, & Baroudi, 1983; Kim, 1989). User satisfaction measures are rooted in the work of Bailey and Pearson (1983), Ives, Olsen, and Baraudi (1983), and Doll and Torkzadeh (1988). DeLone and McLean (1992) stated that "the development of the Bailey and Pearson instrument and its derivatives has provided a reliable tool for measuring satisfaction and for making comparisons among studies" (p. 69). The Bailey and Pearson (1983) instrument included 39 items covering a broad spectrum of satisfaction related themes including the means to measure what users' value or find important. Ives et al. (1983) refined and abbreviated the Baily and Pearson (1983) instrument into a short 13-item questionnaire that parsed the measures into three factors, namely quality of output, quality of service, and involvement in the systems development process. According to Gallette (1989), however, the Ives et al. (1983) instrument had eliminated some potentially important items from the 39-item Bailey and Pearson (1983) instrument. Doll and Torkzadeh (1988), in their study measured satisfaction in terms of end-user computing satisfaction (EUCS), specifically associated

with the information product and ease of use, focusing on end-user interaction with a specific application for decision making. In their study of 442 users of computer simulation systems, McHanley and Cronan (1998) determined that the EUCS instrument can be applied to DSS based on computer simulation. In their study of application systems in a power company, Azadeh, Sangari, and Songhori (2009) stated that the Doll and Torkzedeh (1998) instrument is appropriate for measuring user satisfaction and demonstrates acceptable validity and reliability. According to Wixom and Todd (2005), "user satisfaction is typically viewed as an attitude that users have toward an information system" (p. 87). IS user satisfaction is often measured by beliefs about information characteristics (Wixom & Todd, 2005).

According to Urbach et al. (2009), some researchers incorrectly used the term IS effectiveness synonymously with IS success. Others used IS effectiveness to subsume what DeLone and McLean (1992, 2003) label individual impact and organizational impact (DeLone and McLean, 1992) or net benefits (DeLone and McLean, 2003). In the context of this study, the term IS success is used in the sense of DeLone and McLean's (2003) comprehensive understanding but will consider user satisfaction as a surrogate to net benefits to the organization as determined and measured by individuals. Additional research on SQ and IQ in the context of user satisfaction is, therefore, needed to better understand the relationships between success constructs where further research could address the lack of empirical evidence in establishing the strengths of interrelationships across different types of IS (Petter et al., 2008). In addressing the problem of BISI failure, it is, therefore, necessary to consider underlying IS and processes that are not adapted for BI applications. According to Yeoh and Koronios (2010), "poor information quality can

often go unnoticed until cross-systems analysis is conducted" (p. 23). Moreover, according to Saeed and Abdinnour-Helm (2008), "a user will develop a negative perception regarding the value of an information system if he or she makes a decision based on information that turns out to be inaccurate" (p. 378).

Despite the many failures of BISI, few studies have investigated the effects of SQ and IQ and the related cross-systems impacts on BISI success. Nelson et al. (2005) also studied the possibility that more complex relationships may exist between quality and satisfaction in the context of BI success. According to Nelson et al. (2005), the literature suggested that system factors may influence a user's perception of satisfaction with the information provided by the system. Moreover, past confusion in differentiating SQ from IQ factors suggested that crossover or interaction effects may exist between the two constructs. Nelson et al. (2005) studied the determinants of SQ and IQ which included the study of crossover relationships from quality (information and systems) to satisfaction (systems and information) as well as the interaction effect of information satisfaction and systems satisfaction. This study has furthered the research of Nelson et al. (2005) by empirically assessing the universal set of characteristics for SQ and IQ to determine the CVFs for SQ and IQ of BISI for the purpose of exploring what CVFs of BISI lead to BISI success and addresses the user perceived ambiguity between a BI system and its output. Thus, additional research on the effects of perceived SQ and perceived IQ and the related impacts underlying BISI, as measured by perceived user system satisfaction and perceived user information satisfaction, appears to be valuable to the BoK (Clark et al., 2007; Nelson et al., 2005; Popovic et al., 2009; Wixom & Watson, 2001; Yeoh & Koronios, 2010).

Table 4. Summary of IS User Satisfaction Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Bailey & Pearson, 1983	Theoretical, empirical	29 middle managers from eight different companies	Questionnaire	Identified 39 factors measuring satisfaction and their relative level of importance
Doll & Torkzadeh 1988	Empirical	618 end users	Questionnaire	Contrasted traditional and end user computing environments in developing an instrument to measure satisfaction of users who interact with specific applications. Established standards for evaluating end user applications.
Doll & Torkzadeh, 1991	Theoretical	Not applicable	Literature review	Developed end-user computing satisfaction instrument and found that satisfaction should be measured in the context of the appropriate research domain as a dependent or independent variable. Stated that system success in design and implementation activities were measured by end-user satisfaction as a dependent variable.

Table 4. Summary of IS User Satisfaction Studies

Study	Methodology	Sample	Instrument	Main findings or contributions
Ives et al., 1983	Theoretical, survey, empirical	200 responses received from production managers in manufacturing organizations in the U.S.	Questionnaire	Reviewed and suggested measures of information satisfaction. Found that user information satisfaction (UIS) provides a meaningful "surrogate" for IS effectiveness
Iivari, 2005	Field study	78 responses from primary users of an accounting system in Finland	Questionnaire	Findings suggested that user satisfaction may be a reasonably good surrogate for individual impact as long as it is confined to work performance
Kim, 1989	Theoretical	Not applicable	Literature review	Found that research on user satisfaction must consider multiple perspectives regarding user attitudes, IQ, and effectiveness of output to avoid the misapplication of measures

Summary

While much attention has been paid to IQ, SQ, and user satisfaction in IS success literature, little research has focused on the constructs of IS success in the domain of BISI. This may be related to a lack of understanding of BI technologies caused, in part, by the multifaceted nature of BI which combines a nonconventional application-based set of systems with infrastructure related projects (e.g. ERP and CRM) in an analytical user based decision support system context. Various frameworks have been developed for categorizing and measuring IQ, SQ, and user satisfaction leading to IS success. The

framework for IQ developed by Lee et al. (2003), for instance, provided four different categories used to assess IQ in IS. These categories were based on an empirical study of characteristics of a group of conventional IS. Furthermore, Nelson et al. (2005) suggested a framework for the measurement of SQ based on five dimensions of system output. Moreover, Nelson et al. (2005) extended the DeLone and McLean (1992) model of IS success expanding the user satisfaction construct and suggesting that user perceived system satisfaction and user perceived information satisfaction could be considered as dependent variables and as a combined surrogate for user satisfaction.

When considering new or emerging technologies, it is often necessary to uncover hidden attributes that are valued or important to users in their measurement of IS success. Value theory has been established to uncover hidden attributes that users find important to IS success. However, there has been little attention paid to ask the questions regarding what characteristics users find important in BISI. Furthermore, less is known about the CVF's that may lead to IS success in BISI. Value theory and value based exploration techniques have been applied in many research areas and also have been used to assess what is important in emerging and under studied system technology domains such as those related to privacy, security, mobile applications, and online learning systems. Although Nelson et al. (2005) attempted to measure IQ, SQ, and user satisfaction for BI systems in the context of a data warehouse environment, their confirmatory study provided confusing results that included the surprising conclusion that user perceived SQ influenced user perceived information satisfaction more than user perceived IQ influenced information satisfaction. Therefore, Nelson et al. (2005) suggested that future

researchers should study the antecedents of IQ and SQ for BI analytical systems and not rely on those established for conventional systems domains.

This study contributes to the IS field of study by assessing the CVFs of BISI that could lead to greater success of IS systems. This study addresses the confusing results of previous studies that suggested that the system quality of the BI system has greater influence on user satisfaction than the quality of the information. It was, therefore, necessary to identify and align the proper SQ and IQ characteristics with their constructs in the BISI domain, followed by confirmatory factor analysis of the IS success model using the appropriate measurements.

Chapter 3

Methodology

This study used a mixed method approach following the work of Keeney (1999), utilizing both qualitative and quantitative research methods. The study validated empirically a model for IS success that investigated how an organization may gain user satisfaction in the context of BISI by uncovering the CVFs of SQ and IQ necessary to derive BISI success. Hanson, Plano-Clark, Petska, Creswell, and Creswell (2005) stated that quantitative and qualitative data could be complementary when variances are uncovered that would not have been found by a single method. Qualitative research could be used to discover and uncover evidence, while quantitative methods are often used to verify the results, thereby improving the integrity of the findings of the study (Shank, 2006). Additionally, both qualitative and quantitative methods each carry their own capabilities to uncover the underlying meaning of phenomena in research (Straub, 1989).

This study followed the approach of Straub (1989) as depicted in the research method process (Figure 2). The main research questions addressed in this study were:

RQ1: What SQ characteristics are valued in BISI by users? What IQ characteristics are valued in BISI by users?

RQ2: What are the CVFs for SQ that users' value in BISI? What are the CVFs for IQ that users' value in BISI?

Stemming from the research questions, this study then addressed the following specific hypotheses:

H1a-d: The CVFs of SQ will have a positive significant impact on perceived SQ of BISI.

H2a-d: The CVFs of IQ will have a positive significant impact on perceived IQ of BISI.

H3: The perceived SQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H4: The perceived IQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H5: The perceived SQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H6: The perceived IQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7a: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7b: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user information satisfaction from BISI.

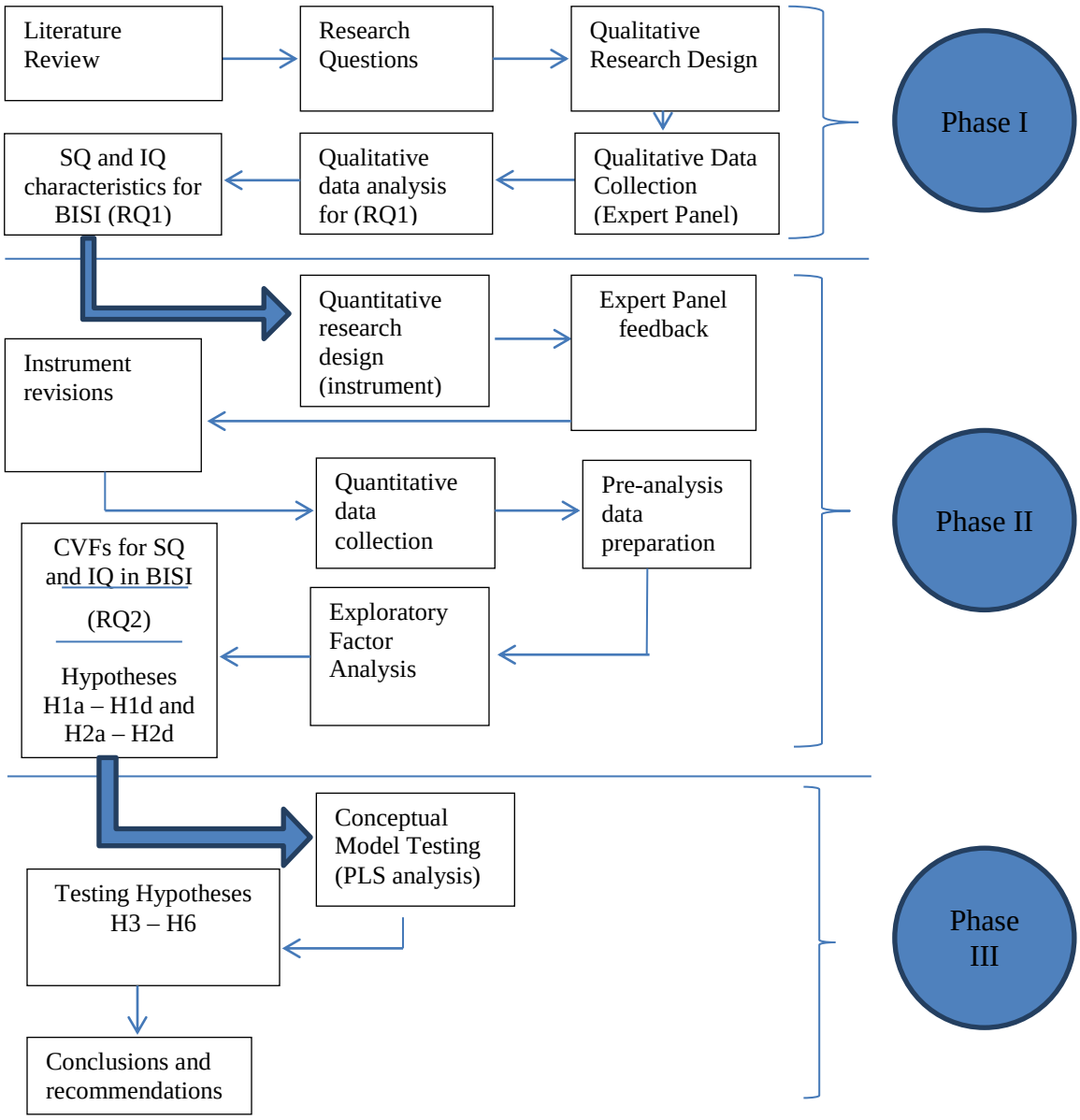


Figure 2. Research Method Process

Adopted Research Methods Applied

Phase I: Qualitative Method

Qualitative data collection. Following the qualitative research approach of Keeney (1999), the qualitative process (Phase I) began with the creation and distribution of an open-ended questionnaire (Appendix B) designed to elicit SQ and IQ characteristics

considered to be important in BISI. Development of the instrument followed the process proposed by Straub (1989). The open-ended questionnaire was developed to uncover new characteristics of SQ and IQ for BISI. An expert panel was formed, consisting of a small group of six individuals with experience in business analytics. The experts included business analysts who are responsible for decision making using BI system output, BI system developers with experience in the design, development, and use of BI system applications, as well as BI data architects with experience in extracting, transforming, and loading BI data from integrated sources.

Following Keeney's methodology (1999), part one of the instrument began by asking the expert panel open-ended questions, requesting them to list what is important when it comes to SQ and IQ in BISI. Due to the emerging nature of technologies such as BI, it is necessary to determine underlying or hidden SQ and IQ characteristics that may be valued, thereby increasing available choices (Dhillon et al., 2002; Keeney, 1999). Open-ended questions helped to expose such potentially valued SQ and IQ characteristics and augmented the list of known SQ and IQ characteristics for BISI. Characteristics identified in the literature review are found in Appendix A. Part two of the open-ended questionnaire provided a definition of four main SQ categories, namely reliability SQ, response time SQ, flexibility SQ, and integration SQ (Nelson et al., 2005). Four main categories of IQ were also defined, namely intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ (Arazy & Kapak, 2011; Lee et al., 2002). After reading the definitions, participants then completed the questionnaire which again requested them to identify what is important when it comes to SQ and IQ in BISI. At the end of this phase, responses were reviewed and all similar responses were grouped together. The similar

responses were then converted to common terms and assigned to the SQ and IQ category that matched the characteristic most closely based on the framework for IQ assessment established by Lee et al. (2001) and the key dimensions of SQ suggested by Nelson et al. (2005).

Qualitative data analysis. SQ and IQ characteristics drawn from the expert panel's responses to the open-ended questionnaire and the literature review of validated sources (Arazy & Kopak, 2011; Goodhue, 1995; Jarke & Vassiliou, 1997; Lee et al., 2002; Nelson et al., 2005; Wand & Wang, 1996; Wang & Strong, 1996) were analyzed using Keeney's (1999) approach. Similar SQ and IQ characteristics identified from literature, provided in Appendix A, as well as responses from the expert panel were grouped into the four main proposed SQ categories of reliability SQ, response time SQ, flexibility SQ, and integration SQ as well as the proposed four high level IQ categories of intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ. These SQ and IQ characteristics were evaluated for inclusion in an updated list of SQ and IQ items. Items that did not appear to relate to any category were investigated for inclusion in a new SQ or IQ category. This addressed the first research question, "What SQ and IQ characteristics are valued in BISI by users?"

Phase II: Quantitative Method

Quantitative data collection. Following phase I, the quantitative process began with the development of a two part quantitative survey instrument (Appendix C) to collect data. This preliminary survey instrument was based on the results of phase I. Phase II required a quantitative assessment of the SQ and IQ characteristics found in literature, augmented by additional SQ and IQ characteristics uncovered in phase I of the study

using Keeney's (1999) methodology. The intension of this phase was to develop an instrument that had content validity, construct validity, and reliability based on a further review conducted by the expert panel. Feedback from the expert panel was used to adjust the proposed instrument and included the removal of unnecessary items and the modification of questions, language, and the layout of the instrument (Straub, 1989). The final survey instrument emerged from this process which was distributed to a larger group of users of BI systems.

Internal Validity. Internal validity, according to Straub (1989) refers to "whether the observed effects could have been caused by or correlated with a set of non-hypothesized and/or unmeasured variables" (p. 151). Straub (1989) suggested that "internal validity in management information systems (MIS) research can be maximized by an investigation of all the appropriate constructs and variables related to the studied phenomenon" (p. 151). In establishing internal validity, the researcher is attempting to rule out alternative explanations of the dependent variable (Straub, Boudreau, & Gefen, 2004). This study gathered values from BI users through an expert panel prior to the development of the final survey instrument to minimize internal validity threats. The proposed BI SQ and IQ research model, based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005) contained empirically tested constructs and measures designed to minimize threats to internal validity.

External Validity. External validity refers to the generalized nature of the findings to other settings (Sekaran, 2003). Cook and Campbell (1979) suggested that the results of studies can be generalized for specific persons, settings, and times. Results may also be generalized across these types of targeted groupings. This study focused on the

relationships between the CVFs from SQ and IQ of BISI and BI users' satisfaction with SQ and IQ for BISI. This study also developed an instrument to measure CVFs for SQ and IQ of BISI in the context of IS success that can be generalized to other information systems.

Instrument Validity. Instrument validity examines the validity of content and constructs (Levy, 2006). According to Straub (1989), an instrument can be deemed invalid based on the content of the measurement items and whether they comprehensively represent the construct. Straub (1989) argued that research findings may be better substantiated with instrument validation. He recommended qualitative and quantitative research methods be used to validate instruments, thereby ensuring that the instrument is not obstructing the collection of accurate data. For this study, content validity was facilitated through a thorough review of existing literature and feedback from an expert panel, drawn from a representative sample of the BISI expert population. Construct validity examines the measures chosen to ensure that they adequately capture the meaning of the construct (Straub, 2004). Consistent with the recommendations of Straub (1989), PCA was utilized to assess the construct validity of the SQ and IQ for BISI measures by identifying patterns in data that provided similarities and differences (Gopalan & Sivaselvan, 2009).

Reliability. Instrument reliability is essentially an evaluation of measurement accuracy (Straub, 1989). Joppe (2000) defined reliability as the extent to which results are consistent over time. If the results of a study can be reproduced using a similar methodology, the instrument is said to be reliable. Straub (1989) suggested that Cronbach's Alpha provided accurate measurements of reliability for a given construct. As a result Cronbach's Alpha was used to validate each factor to determine reliability.

Cronbach's Alpha values range from 0 to 1 and research has indicated that readings in excess of .70 are desirable to indicate reliability for a construct (Sprinthall, 1997). Within the quantitative phases of this study, the overall Cronbach's Alpha reliability measures were calculated for each SQ and IQ factor and all other constructs in the research model. The results were closely inspected to ensure that all items added to the reliability of each factor.

Measures of constructs. The measurement items were selected as described in the Research Method Process (Figure 2). The survey instrument was based on a 7-point Lickert scale, ranging from not important to highly important. Following the collection of data, factorial validity established the measurement items that corresponded to the CVFs of SQ and IQ in a successful BISI. Each construct in the proposed BI SQ and IQ research model (Figure 1) was then tested using measures implicitly advocated by DeLone and McLean (1992; 2003) as well as Nelson et al. (2005).

Measures of Perceived SQ of BISI. The items established by Nelson et al. (2005) used to measure perceived SQ of BISI were also used in this study (Figure 1). The three items identified by Nelson et al. (2005), with wording modifications to fit the analytical BI context of the study, were used as the final measure of perceived SQ of BISI (Appendix C). The survey instrument was based on a 7-point Lickert scale, ranging from strongly disagree to strongly agree.

Measures of Perceived IQ of BISI. Nelson et al. (2005) assessed items for measuring IQ for BI in the context of data warehousing by means of a literature review and selected those items that were categorized most accurately with each IQ dimension. The measurement items of perceived IQ of BISI in this study (Appendix C) corresponded

with the three items identified by Nelson et al. (2005) with wording modified to fit the analytical BI context of the study. The survey instrument was based on a 7-point Lickert scale, ranging from strongly disagree to strongly agree.

Measures of Perceived User System and Information Satisfaction from BISI. The constructs of perceived user system satisfaction from BISI and perceived user information satisfaction from BISI were assessed using the foundation for measure implicitly advocated by DeLone and McLean (2003) as well as Nelson et al. (2005). The items for each construct identified by Nelson et al. (2005), with wording modifications to fit the BI analytical context of the study were used as the final measure of perceived user system satisfaction and perceived user information satisfaction (Appendix C). The survey instrument was based on a 7-point Lickert scale, ranging from extremely dissatisfied to extremely satisfied.

Population and sample. This study used the revised quantitative survey instrument to collect data in order to empirically determine the CVFs of SQ and IQ for BISI success. Hair, Teo, and Wong (1998) suggested 15 to 20 observations for each variable for the results of a study to be generalizable. This study targeted 250 participants as an appropriate sample size (Schumacker & Lomax, 2010). Approximately 1300 survey invitations were sent to achieve the response rate necessary to reach the targeted sample size of 250 participants. Surveys were sent to analysts who had implemented analytical BI systems. Appendix D provides the Institutional Review Board (IRB) approval letter.

Pre-analysis data screening. Pre-analysis data screening supports the process of detecting irregularities or problems with collected data (Levy, 2006), and includes checking for data accuracy and missing data. This provided protection against lack of

accuracy, attentiveness, completeness, and aberrations in collected data (Levy, 2003). According to Levy (2003), there are four reasons to instill protection measures to detect and resolve problems with collected data. First, it is important that collected data is accurate. The risk to accuracy was mitigated in this study with the use of a tested Web-based survey instrument. The second reason for the pre-analysis data screening was to address the risk of respondents submitting the same score, also known as response set (Levy, 2003). According to Kerlinger and Lee (2000), data should be examined for response set as this may represent a threat to validity. To mitigate this risk, all data collected was examined for response set violations with violators removed prior to final data analysis. The third reason for pre-analysis data screening is to detect missing responses. It is necessary to ensure that all questions are answered (Sekaren, 2003). This risk was mitigated by ensuring that the Web-based survey was equipped to detect missing responses. The fourth reason for pre-analysis data screening focuses on the effects of extreme cases. According to Mertler and Vanatta (2001), outliers can cause a significant result to be insignificant. This risk was mitigated through the use of the Mahalanobis distance analysis which was used to identify multivariate outliers.

Quantitative data analysis. The main goal of this study was to empirically validate a model for IS success to investigate how an organization may gain benefits in the context of BISI by uncovering the CVFs of SQ and IQ necessary to derive BISI success. In phase II, the study used exploratory factor analysis (EFA) techniques to uncover the CVFs of SQ and IQ. The statistical package for the social sciences (SPSS) software calculated the relationship between all measurement items, which were then matched to the SQ construct categories of reliability SQ, response time SQ, flexibility SQ, and integration

SQ as well as the IQ construct categories of intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ, along with any new factors that might emerge (Arazy & Kapak, 2011; Lee et al., 2002). Factorial validity assessed whether the measurement items corresponded to the theoretically anticipated CVFs of SQ and IQ in a successful BISI. Principal component analysis (PCA) was used as the extraction method to provide variances of underlying factors (Mertler & Vannatta, 2001). This second phase of the study addressed the second specific research question: What are the CVFs for SQ and IQ that users' value in BISI? The second phase of this study also addressed hypotheses H1a – H1d and H2a – H2d:

H1a-d: The CVFs of reliability SQ, response time SQ, flexibility SQ, and integration SQ will have a positive significant impact on SQ for BISI success.

H2a-d: The CVFs of contextual IQ, intrinsic IQ, accessible IQ, and representational IQ will have a positive significant impact on IQ for BISI success.

Phase III: Quantitative Method

Quantitative data collection. In phase III, hypotheses were tested to validate the proposed BI SQ and IQ research model based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005). This study then gathered data regarding the perceived SQ and IQ of BISI as it relates to perceived user system satisfaction and perceived user information satisfaction from BISI. Since SQ and IQ can separately influence user satisfaction, after determining the CVFs for SQ and IQ of BISI, this study tested each construct of the proposed BI SQ and IQ research model for reliability followed by the testing of the entire model. This study and the associated instrument assessed the influence of perceived SQ and IQ of BISI on perceived user

system satisfaction and perceived user information satisfaction from BISI using measures implicitly advocated by DeLone and McLean (2003) and Nelson et al. (2005).

Quantitative data analysis. In phase III the hypothesized relationships in the conceptual model of the CVFs of SQ and IQ to perceived SQ and IQ of BISI as they relate to perceived user system satisfaction and perceived user information satisfaction from BISI were validated using the partial least squares (PLS) method, a subtype of structured equation modeling (SEM) used in performing confirmatory factor analysis (CFA). According to Levy and Green (2009), SEM has been documented in literature as a valid technique to analyze conceptual models. CFA was used to validate the BI SQ and IQ research model, based on the DeLone and McLean IS success model (2003) as extended by Nelson et al. (2005). CFA is used to empirically test theoretically developed models and requires a particular factor structure be specified, in which the researcher indicates which items load on what factor. The PLS method was then used to complete the validation of the model. PLS is well suited for predictive applications to indicate the strengths between dependent and independent variables (Iivari, 2005; Ringle, Sarsted, & Straub, 2012). The paths from user perceived SQ and user perceived IQ of BISI to perceived user system satisfaction and perceived user information satisfaction from BISI as hypothesized in the proposed BI SQ and IQ research model, based on the Delone and McLean IS success model (2003) as extended by Nelson et al. (2005) were tested in the overall context of BISI success. According to Gefen and Straub (1997), PLS can be used when "the measurement items on the latent constructs are specified explicitly in the model and correlates highly with each other" (p. 93). Moreover, according to Haenlein and Kaplan (2004), PLS can be used with a small sample size.

The results of the PLS test showing the hypotheses, relationships, and significance of each path are found in the results chapter. This study contributed to the IS literature by demonstrating that the CVFs for SQ and IQ of BISI influence BISI success. Investigation of these constructs is essential to understand how to obtain BISI success. The results of this study can be generalized to any organization that had implemented BI systems. The third phase of this study addressed hypotheses H3 – H7b:

H3: The perceived SQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H4: The perceived IQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H5: The perceived SQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H6: The perceived IQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7a: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7b: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user information satisfaction from BISI.

Resources

The resources required to conduct this research included the SurveyMonkey.com service for the development of the Web-based questionnaire and survey as well as for data collection. The statistical analysis tool SPSS (International Business Machines, nd) was used for EFA and PCA. SmartPLS 2.0 (beta) (Ringle, Wende, & Will, 2005) was used for SEM, CFA, and PLS analysis. Additionally, this study used a panel of six experts in BISI for phase I qualitative data gathering and 257 subjects for phase II data gathering. IRB approval was obtained before the study was conducted.

Format for Presenting Results

Results for this study are presented in a phased order. Phase I produced a list of SQ and IQ items compiled from a review of the literature, an open-ended questionnaire, and an expert panel's evaluation. The items were then mapped to the related proposed CVF of BISI. Phase II of the reported results starts with an analysis of data-screening including the evaluation of outliers. Demographic information is presented next in a table that outlines the population for this study, including gender, age, academic level, and degree of BI expertise. Reporting on this phase of the study continues with the results of the EFA for SQ and IQ analysis, culminating in the determination of the CVFs of BISI. The reliability for each SQ and IQ characteristic was then determined using Cronbach's alpha. Phase III of the reported results begins with the analysis of the conceptual model as well as the path coefficients. Lastly, the summaries of hypotheses results are presented.

Summary

This chapter outlined the approach and research methodology necessary to achieve the research goals of the study. The research method process (Figure 2) identified the three

phases of research used to achieve reliable and generalizable results. Phase I of the research method process identified SQ and IQ characteristics for BISI using Keeney's (1999) approach to elicit SQ and IQ qualitative research characteristics important to users in BISI. Phase II of the research method process used value-based exploration techniques in surveying users of BI systems to determine the level of importance they placed on SQ and IQ characteristics. The survey instrument was based on a 7-point Lickert scale. This study performed a Mahalanabis-distance analysis to identify multivariate outliers considered for removal. The results were closely inspected to ensure that the affected items did not add to the reliability of each factor. EFA techniques were used to uncover the CVFs of SQ and IQ that influenced BISI. Cronbach's Alpha was used to validate each factor to determine reliability. PCA was used as the extraction method that provided variances of underlying CVFs. Phase III of the research method process performed the confirmatory analysis of the conceptual model by testing the hypotheses of the study to validate the proposed BI SQ and IQ research model based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005). Using PLS the study also validated the relationship between the perceived SQ and IQ of BISI and perceived user system satisfaction from BISI and perceived user information satisfaction from BISI.

Chapter 4

Results

Overview

This chapter provides the detailed results of the investigation. The results of this research are reported following the same order in which the study was conducted. The chapter begins with the results of phase I qualitative research which included a literature review followed by the design, development and distribution of an open ended questionnaire delivered to an expert panel. This qualitative phase concluded with data collection and analysis that was used to determine the items to be used in the phase II quantitative aspect of the research.

Phase II of the study began with the finalization and distribution of the survey instrument followed by quantitative data collection, pre-analysis data preparation and the determination of the CVFs for SQ and IQ in BISI based on EFA using PCA. Phase II also included the results of tests for instrument reliability and validity as well as the measurement of the impact of the CVFs on the perceived SQ and IQ of BISI.

Phase III results included the testing of the BI SQ and IQ research model, based on the DeLone and McLean IS success model (2003) as extended by Nelson et al. (2005) using PLS. This phase also included the measurement of the variables in the model as well as the strength and direction of the relationships among the variables. In this phase of the study the impact of the relationships of perceived SQ and IQ of BISI on perceived SQ and IQ user satisfaction and their interaction effects were also tested.

Qualitative Phase (Phase I)

This study used a mixed method approach following the work of Keeney (1999), utilizing both qualitative and quantitative research methods. In the qualitative phase an expert panel was formed, consisting of a small group of six individuals with experience in analytical BISI. An open-ended questionnaire designed to elicit SQ and IQ characteristics considered to be important in BISI (Appendix B) was distributed to the expert panel. Similar SQ and IQ characteristics identified from literature, provided in Appendix A, as well as responses from the expert panel were grouped into the four main proposed SQ categories of reliability SQ, response time SQ, flexibility SQ, and integration SQ as well as the proposed four high level IQ categories of intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ. Items that did not appear to relate to any category were investigated for inclusion in a new SQ or IQ category. The results gathered were analyzed using Keeney's (1999) approach whereby characteristics with similar terminology were converted and matched with similar SQ and IQ characteristics. For example, 'frequency of output' and 'output frequency must be flexible' were merged into one SQ characteristic. Items that did not fall under an SQ or IQ category such as "amount of training requested by users" were removed. Any new items that were discovered during this exploratory phase were added to the list of SQ and IQ characteristics. After considering the grouping of similar responses as well as the feedback from the expert panel using Keeney's (1999) approach there were 33 SQ and IQ characteristics identified, consisting of 16 SQ items and 17 IQ items identified and grouped under the appropriate SQ and IQ category. This included nine SQ and IQ items identified by the expert panel that did not correspond with any of the initial sources of BI

success identified in the literature. As such, the following nine measurement items were added to the survey instrument provided in Appendix B as follows: functionality and features of the BI system are dependable, frequency of data generation and refresh in the BI system are flexible, the BI system accommodates remote access, the BI system is scalable, the BI systems has an intuitive user interface, the BI system provides appropriate navigation to obtainable information, the BI system provides portability of data and data sources including import and export features, the source of BI information is traceable and verifiable, information is reproducible in the BISI. The revised list of 33 SQ and IQ characteristics of BISI is presented in table 5.

Table 5. SQ and IQ Characteristics from Phase I: Qualitative Method

No.	Proposed Factors	SQ and IQ Characteristics
1	**Reliability SQ**	The functionality and features of the BI system are dependable
2		The BI system has a low percentage of hardware and software downtime
3		The BI system can easily recover from malfunctioning equipment and restore data
4		The BI system is of high technical quality
5	**Response Time SQ**	The time between when information is requested and received in the BI system is acceptable
6		Information is up-to-date for the task at hand
7		The frequency of data generation and refresh in the BI system is flexible
8		The BI system accommodates remote access
9	**Flexibility SQ**	The BI system is adaptable to user needs
10		The BI system is extendible, expandable, modular, and configurable

Table 5. SQ and IQ Characteristics from Phase I: Qualitative Method

No.	Proposed Factors	SQ and IQ Characteristics
11		The BI system is scalable (e.g. hardware, software, memory)
12		The BI system has an intuitive user interface (UI)
13	**Integration SQ**	The ability of the BI system to combine information with other information and deliver to the user.
14		The compatibility of BI system software with other software and hardware
15		The ability of the BI system to communicate and transmit a variety of data between other systems servicing different functional areas.
16		The BI system provides portability of data and data sources including import and export features
17	**Intrinsic IQ**	Accuracy of information in BISI
18		Consistency of information in BISI
19		Reliability of information in BISI
20		Correctness of information in BISI
21	**Contextual IQ**	Relevancy of information in BISI
22		Sufficiency of information in BISI
23		Currency and timeliness of information in BISI
24		Traceability and verifiability of the source of information in BISI
25	**Representational IQ**	Understandability of information in BISI
26		Format of information in BISI
27		Information is easily joined, aggregated, updated, configured, and manipulated in BISI
28		Information is reproducible in the BISI

Table 5. SQ and IQ Characteristics from Phase I: Qualitative Method

No.	Proposed Factors	SQ and IQ Characteristics
29		Information is mapped into suitable representations at the user level in the BISI
30	**Accessibility IQ**	Ease of accessing information in BISI
31		Security of accessed information in BISI
32		Accessibility to locatable and searchable information in BISI
33		Appropriate navigation to obtainable information in BISI

Quantitative Phase (Phase II)

Quantitative data collection. The quantitative process began with the development of a quantitative survey instrument (Appendix C) to collect data. This survey instrument was based on the results of phase I and an assessment of the SQ and IQ characteristics found in literature, augmented by additional SQ and IQ characteristics uncovered in phase I of the study with the assistance of the expert panel. The survey instrument developed using the proposed items of BISI SQ and IQ was reviewed again by the expert panel to establish the validity of the items. The experts recommended the rewording of some items within the survey. Thus, the survey instrument developed consisted of 33 SQ and IQ items as well as three measures of perceived SQ in BISI and three measures of perceived IQ in BISI. The survey instrument also contained three measures of perceived user system satisfaction from BISI and three measures of perceived user information satisfaction from BISI. The result of the expert panel review was a valid survey instrument consisting of clear and complete items that appropriately measured the constructs of the conceptual model.

The final survey instrument emerged from this process and was distributed to a larger group of users of BI systems. Email invitations were sent to over 1,200 analysts through a service of SurveyMonkey. In addition, links to the survey were sent to over 100 BI users in a variety of commercial and government organizations that have implemented analytical BI systems. Out of 1,300 invitations extended, 270 survey responses were collected, giving a 20.8% response rate.

Pre-analysis data screening. Survey responses were subjected to pre-analysis data screening whereby the data collected were reviewed for data accuracy, response set, missing data, and outliers. The risk to data accuracy was mitigated with the use of a tested web-based survey instrument. The survey was configured to only allow a single valid answer for each question and required a response to all questions. However, surveys with case ID's 168, 252, and 253 were eliminated from consideration due to missing demographic data. Survey data was also examined for response set to mitigate the threat to validity. To address the risk to response set, a visual inspection of all responses was performed to identify cases that had the same response to all the questions. There were seven response set violations and these cases were also removed from consideration. Furthermore, the risk associated with extreme cases was mitigated through the use of the Mahalanobis distance analysis which was used to identify multivariate outliers. SPSS was used to calculate the Mahalanobis distance for the 47 items in the survey. Table 6 details the cases with extreme values that resulted from the Mahalanobis distance analysis. Based on this examination, Case ID's 74, 26, 226, 221, and 194 were identified as problematic multivariate outliers and were selected for further evaluation and possible elimination.

Table 6. Mahalanobis Distance Extreme Values

Extreme Values

			Case Number	CaseID	Value
Mahalanobis Distance	Highest	1	74	74	192.61830
		2	26	26	180.37569
		3	225	226	153.73759
		4	220	221	130.17074
		5	193	194	125.29292
	Lowest	1	58	58	5.89881
		2	56	56	5.89881
		3	48	48	5.89881
		4	40	40	5.89881
		5	31	31	5.89881

The results of the Mahalanobis distance analysis box plot (Figure 3) were then reviewed and Case ID's 74, 26, and 226 were identified as significant outliers. Based on the overall Mahalanobis distance analysis and the box plot, only case ID's 74, 26, and 226 were eliminated. These outliers have an asterisk (*) next to them in the box plot diagram (figure 3). At the end of the pre-analysis data screening, a total of 13 cases were eliminated from further analysis consisting of three cases of missing demographics data, seven cases of 100% response set violations and three cases of multivariate outliers. As such 257 responses remained for final analysis.

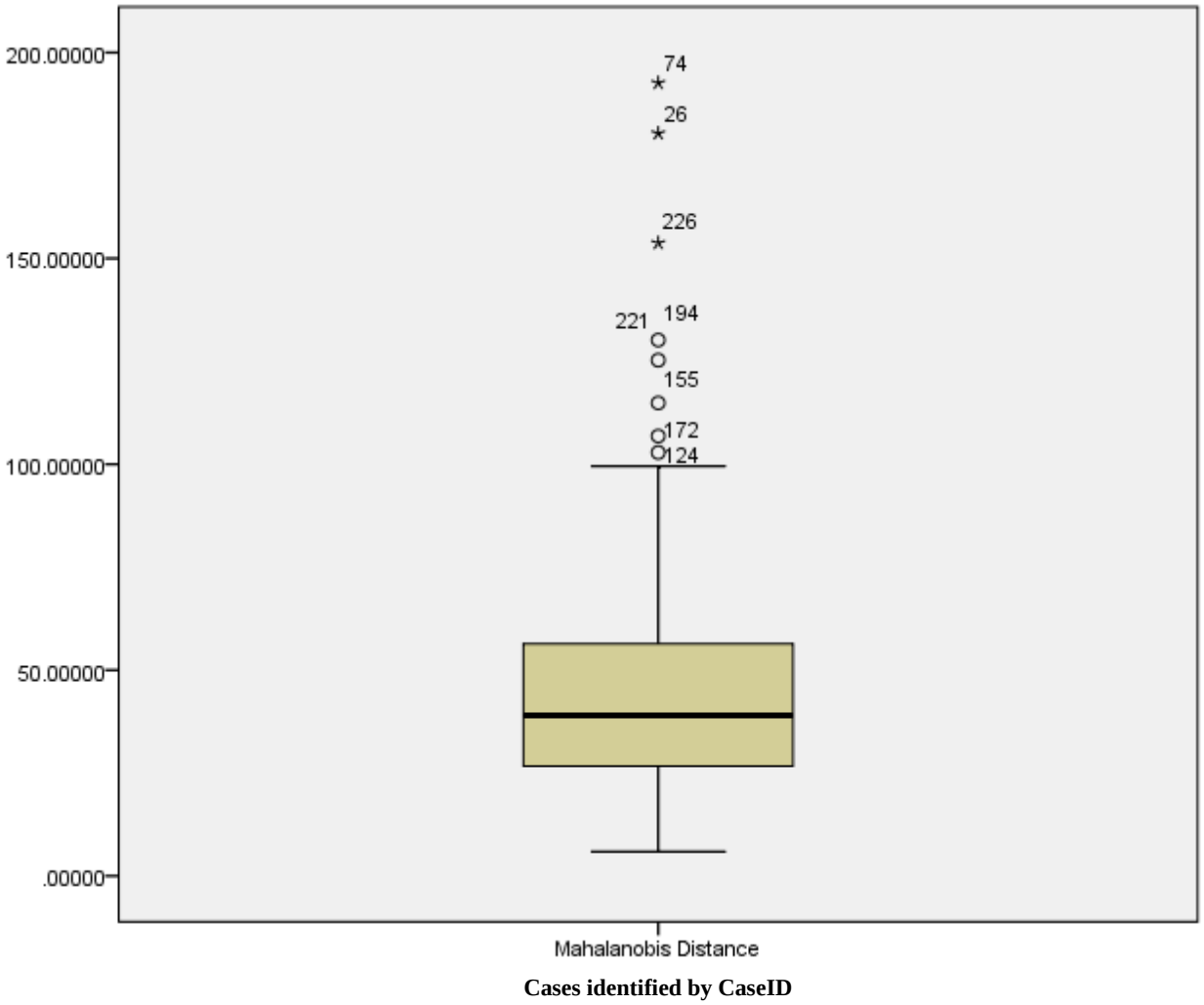


Figure 3. Mahalanobis Distance Box Plot

Demographic Analysis

After completion of the pre-analysis data screening, of the 257 responses remaining for analysis 176 or 68.5% were completed by females and 31.5% were completed by males. Analysis of the ages of respondents indicated that 217 or 84.4% were above the age of 30. Additionally, 55 or 21.4% of the respondents considered themselves novices in the use of BI systems, 115 or 44.7% considered themselves average users, 77 or 30% considered themselves advanced users and only 10 or 3.9% considered themselves expert users. Respondents with graduate degrees comprised 35% of the subject population.

Overall, 198 respondents or 77% had a university degree. Details of the demographics of the population are presented in table 7.

Table 7. Descriptive Statistics of Population (N=257)

Item	Frequency	Percentage (%)
Gender		
Male	81	31.5
Female	176	68.5
Age		
18 to 29	40	15.6
30 to 44	79	30.7
45 to 60	99	38.5
Over 60	39	15.2
Academic Level		
High School Graduate	9	3.5
Some College or Associate	50	19.5
Bachelor	108	42.0
Graduate	90	35.0
BI Expertise		
Expert	10	3.9
Advanced	77	30.0
Average	115	44.7
Novice	55	21.4

Exploratory Factor Analysis via Principal Component Analysis

Quantitative data analysis. In phase II, the study used EFA techniques to uncover the CVFs of SQ and IQ of BISI. The statistical package for the social sciences (SPSS) software calculated the relationships between all measurement items, which were then matched to the SQ construct categories of reliability SQ, response time SQ, flexibility SQ, and integration SQ as well as the IQ construct categories of intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ (Arazy & Kapak, 2011; Lee et al., 2002). Factorial validity assessed whether the measurement items corresponded to the

theoretically anticipated CVFs of SQ and IQ in a successful BISI. PCA was used as the extraction method to provide variances of underlying factors (Mertler & Vannatta, 2001). The perceived SQ and IQ CVFs of BISI were identified by conducting EFA via PCA using Varimax rotation. PCA was used to extract as many factors as indicated by the data. No new factors emerged from the analysis.

SQ Factor Analysis. The literature review identified four overall categories of SQ which were proposed as potential CVFs of BISI. After conducting Exploratory Factor Analysis (EFA) via Principal Component Analysis (PCA) using Varimax rotation the Kaiser criteria was applied to the factor analysis. The Kaiser criterion dictates that only factors with eigenvalues greater than one should be retained as common factors (Child, 2006) and factors with eigenvalues less than one should be considered for deletion. Based on the Kaiser criterion, the results of the PCA factor analysis suggested that two factors with a cumulative variance of 61.9% should be retained.

The results of the scree test (figure 4) further supported the findings of the PCA factor analysis. Examination of the graph indicated that there were two points above the knee of the graph or bend. The number of points above the bend is indicative of the number of factors to be retained. After conducting the PCA analysis, scree test and in consideration of the differing results of the literature review, the number of factors was further analyzed by forcing the number to three and then four factors. Based on the loading of the items it was determined that in spite of the limitations of EFA, which is based on correlations alone, forcing the number of factors of SQ to three and then four did not provide the best loading of items on each proposed factor. As such, based on an analysis of the results

provided by both the Kaiser criterion and the scree test, it was concluded that the appropriate number of SQ factors for extraction was two.

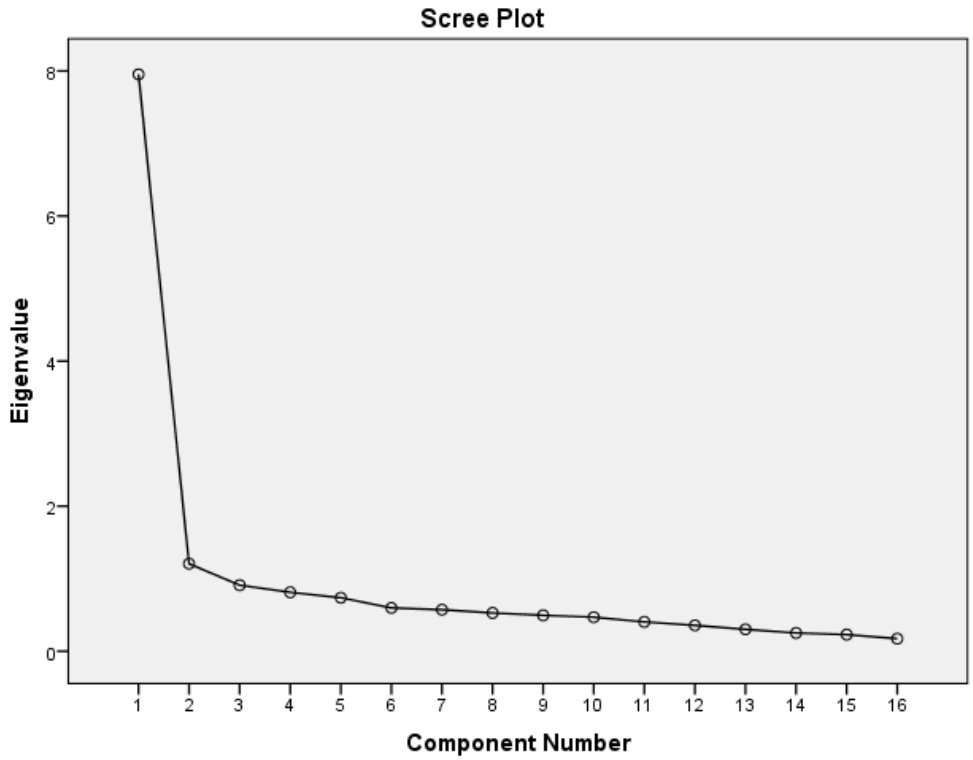


Figure 4. Scree plot for SQ of BISI

SQ Reliability Analysis. Using the factor loadings, survey items were scrutinized for low loadings (< .4) or for medium to high loadings (~.4 to .6) on more than one factor. The results of this review indicated that five items could be eliminated from further analysis. Consequently, the final analysis included 12 items of SQ. PCA was performed on the remaining items after pre-analysis data preparation. Results of the PCA analysis showed that certain items in the four proposed SQ dimensions suggested in the exploratory Phase I of the study (reliability SQ, response time SQ, flexibility SQ, and integration SQ) should be eliminated or regrouped into two SQ categories. For example, the four items found in Phase I under response time SQ loaded high on more than one

factor and were therefore removed. Moreover, all items found in Phase I under the proposed SQ factors of integration SQ and flexibility SQ loaded high on the same factor. Therefore, these items were grouped together to form a new factor which was named integration flexibility SQ.

EFA for SQ. The two CVFs of SQ identified via EFA/PCA had relatively high reliability and a cumulative variance of nearly 62%. Furthermore, the Cronbach Alpha analysis indicated that all items supported the reliability of all factors. Moreover, the Cronbach's Alpha of each factor was 0.83 or higher, indicating very high reliability.

The Cronbach's Alpha of each individual factor was: integration flexibility SQ - 0.898, reliability SQ - 0.837 (table 8). Integration flexibility SQ was found to explain the largest variance in the data collected and consisted of characteristics that addressed the ability of the BI system to combine information using compatible systems that support integrated communication and transmissions among a variety of systems and the associated data in various functional areas. The new factor of integration flexibility SQ was also comprised of the BISI SQ characteristics of extendibility, expandability, modularity, and configurability, as well as adaptability and scalability with an intuitive user interface. In particular the characteristic of data portability was considered to be very important to BI users. It is clear that flexibility in integrated systems is important to BISI success. Reliability SQ explained the remaining variance in the data collected and represented a combination of the characteristics of system dependability, recoverability, and low downtime. In essence, BI users find the technical quality of the system to be important.

Table 8. SQ CVFs of BISI resulting from PCA

Factor Name	Item	1	2	Factor's Alpha if Item is Deleted
Integration Flexibility SQ	SQI3	.797	.060	.888
	SQI1	.770	.291	.879
	SQI2	.758	.260	.883
	SQF2	.730	.348	.878
	SQF3	.707	.356	.881
	SQI4	.662	.295	.889
	SQF4	.621	.318	.891
	SQF1	.610	.369	.889
Reliability SQ	SQR2	.203	.851	.765
	SQR3	.328	.795	.761
	SQR1	.217	.735	.827
	SQR4	.376	.663	.814
Cronbach's Alpha		.898	.837	

IQ Factor Analysis. The literature review identified four overall categories of IQ which were proposed as potential CVFs of BISI. The perceived IQ factors of BISI were further explored by conducting Exploratory Factor Analysis (EFA) via Principal Component Analysis (PCA) using Varimax rotation. PCA was used to extract as many factors as indicated by the data. The Kaiser criterion dictates that only factors with eigenvalues greater than one should be retained as common factors (Child, 2006) and factors with eigenvalues less than one should be considered for deletion. Based on the Kaiser criterion, the results of the PCA factor analysis suggested that three factors with a cumulative variance of 75.3% should be retained.

The results of the scree test (figure 5) further supported the findings of the PCA factor analysis. Examination of the graph indicated that there were three points above the knee

of the graph or bend. The number of points above the bend is indicative of the number of factors to be retained. After conducting the PCA analysis, scree test and in consideration of the differing results of the literature review, the number of factors was forced to four factors. Based on the loading of the items it was determined that in spite of the limitations of EFA, which is based on correlations alone, forcing the number of factors of IQ to four did not provide the best loading of items on each proposed factor. As such, based on an analysis of the results provided by both the Kaiser criterion and the scree test, it was concluded that the appropriate number of IQ factors for extraction was three.

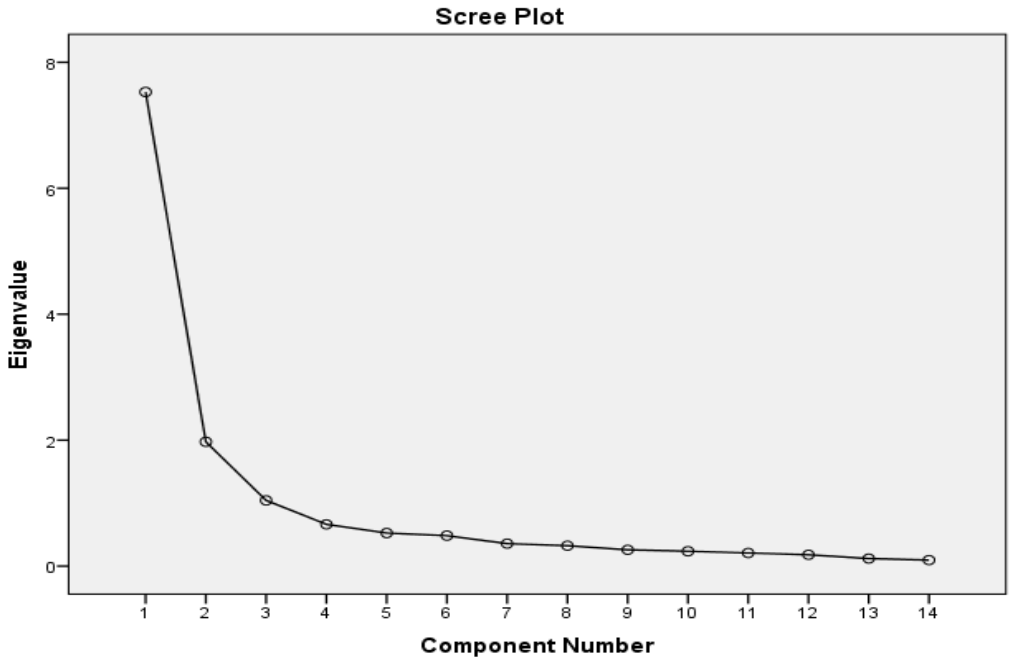


Figure 5. Scree Plot for IQ of BISI

IQ Reliability Analysis. Using the factor loadings, survey items were scrutinized for low loadings (< .4) or for medium to high loadings (~.4 to .6) on more than one factor. The results of this review indicated that three items can be eliminated from further analysis. Consequently, the final analysis included 14 items of IQ. PCA was performed on the remaining items after pre-analysis data preparation. Results of the PCA analysis

showed that certain items in the four proposed IQ dimensions suggested in the exploratory Phase I of the study (intrinsic IQ, contextual IQ, representational IQ, and accessibility IQ) should be eliminated or regrouped into three IQ categories. For example, results of the PCA analysis showed that all items in the proposed CVF of contextual IQ loaded high on more than one factor with the exception of the item IQC4 "traceability and verifiability of the source of information in BISI" which loaded high on the CVF of representation IQ and was therefore retained and included in that factor for further analysis (table 9).

EFA for IQ. The three CVFs of IQ identified via EFA/PCA had relatively high reliability and a cumulative variance of over 75%. The Cronbach's Alpha's of the individual factors were: representation IQ - 0.896, intrinsic IQ - 0.957, accessibility IQ – 0.852. As a further test of reliability, the Cronbach's Alpha "if item is deleted" was calculated to test the reliability of the items for all IQ factors. The results of the analysis indicated that the reliability of the accessibility IQ CVF increased minimally if item IQA2 (security of accessed information in BISI) was deleted. However, given that this item is supported in the literature as a characteristic of accessibility IQ and also considering its relatively high factor loading, it was retained in the study (table 9). Representation IQ was found to explain the largest variance in the data collected and consisted of characteristics that addressed the representation of information in BI systems which rely on the user to ensure that IQ is retained as information from various sources is joined, aggregated, updated, configured, manipulated, and mapped into suitable representations and formats. Accessibility IQ explained the next largest variance in the data collected and included items representing a combination of ease of access to

locatable, obtainable, and searchable information. In essence, BI users found interactive information access for the purpose of improving information content quality important in their BI IQ work. The IQ CSV of BISI with the third highest variance belonged to intrinsic IQ and consisted of the items of information accuracy, consistency, reliability, and correctness.

Table 9. IQ CVFs of BISI Resulting from PCA

Factor Name	Item	1	2	3	Factor's Alpha if Item is Deleted
Representation IQ	IQR3	.848	.171	.144	.873
	IQR4	.798	.296	.002	.883
	IQR5	.733	.143	.335	.876
	IQR1	.703	.290	.381	.871
	IQR2	.693	.078	.400	.883
	IQC4	.604	.320	.334	.884
Intrinsic IQ	IQI1	.176	.914	.196	.937
	IQI3	.223	.905	.231	.932
	IQI4	.211	.877	.214	.949
	IQI2	.249	.864	.178	.953
Accessibility IQ	IQA3	.358	.255	.765	.772
	IQA2	.048	.304	.764	.873
	IQA4	.476	.158	.720	.784
	IQA1	.527	.160	.615	.816
Cronbach's Alpha		.896	.957	.852	

Upon completion of the phase II EFA, two SQ CVFs comprised of 12 items were retained. Moreover, three IQ CVFs consisting of 14 items were retained. Table 10 provides the final list of SQ items aligned with their associated CVFs and definitions. Table 11 provides the final list of IQ items aligned with their CVFs and definitions. The results of this analysis provided an answer to the first set of research questions: What SQ

characteristics are valued in BISI by users? What IQ characteristics are valued in BISI by users?

Table 10. List of Reliable SQ Items Grouped by CVF

Item	CVF	Perceived SQ Items
SQI3	**Integration flexibility SQ**	The ability of the BI system to communicate and transmit a variety of data between other systems servicing different functional areas.
SQI1		The ability of the BI system to combine information with other information and deliver to the user.
SQI2		The compatibility of BI system software with other software and hardware
SQF2		The BI system is extendible, expandable, modular, and configurable
SQF3		The BI system is scalable (e.g. hardware, software, memory)
SQI4		The BI system provides portability of data and data sources including import and export features
SQF4		The BI system has an intuitive user interface (UI)
SQF1		The BI system is adaptable to user needs
SQR2	Reliability **SQ**	The BI system has a low percentage of hardware and software downtime.
SQR3		The BI system can easily recover from malfunctioning equipment and restore data
SQR1		The functionality and features of the BI system are dependable
SQR4		The BI system is of high technical quality

Table 11. List of Reliable IQ Items Grouped by CVF

Item	CVF	IQ Items
IQR3	**Representation IQ**	Information is easily joined, aggregated, updated, configured, and manipulated in BISI
IQR4		Information is reproducible in the BISI
IQR5		Information is mapped into suitable representations at the user level in the BISI
IQR1		Understandability of Information in BISI
IQR2		Format of information in BISI
IQC4		Traceability and verifiability of the source of information in BISI
IQI1	**Representational IQ**	Accuracy of information in BISI
IQI3		Reliability of information in BISI
IQI4		Correctness of information in BISI
IQI2		Consistency of information in BISI
IQA3	**Accessibility IQ**	Accessibility to locatable and searchable information in BISI
IQA2		Security of accessed information in BISI
IQA4		Appropriate navigation to obtainable information in BISI
IQA1		Ease of accessing information in BISI

The results of the quantitative analysis in Phase II of the study identified two SQ CVFs of BISI and three IQ CVFs of BISI as compared to four proposed SQ CVFs of BISI and four proposed IQ CVFs of BISI as suggested in the qualitative Phase I exploratory phase of the study. As such, Phase II of the study addressed the second set of research questions: What are the CVFs for SQ that users' value in BISI? What are the CVFs for IQ that users' value in BISI.

Quantitative Phase (Phase III)

Quantitative data collection. In phase III of the study, hypotheses were tested to validate the proposed BI SQ and IQ research model based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005). Data collected in phase II of the study were empirically evaluated under CFA using the PLS method. In addition to the data analysis performed in phase II of the study that established the CVFs for SQ and IQ of BISI, data was also analyzed in Phase III for the conceptual model constructs of perceived system quality of BISI, perceived information quality of BISI, perceived user system satisfaction from BISI, and perceived user information satisfaction from BISI. Since SQ and IQ can separately influence user satisfaction, after determining the CVFs for SQ and IQ of BISI, this study tested each construct of the proposed BI SQ and IQ research model for reliability followed by the testing of the entire model. This study assessed the influence of perceived SQ and IQ of BISI on perceived user system satisfaction and perceived user information satisfaction from BISI using measures implicitly advocated by DeLone and McLean (2003) and Nelson et al. (2005).

Quantitative data analysis. In phase III of the study the strength and direction of the hypothesized relationships in the conceptual model of the CVFs of SQ and IQ to perceived SQ and IQ of BISI as they relate to perceived user system satisfaction and perceived user information satisfaction from BISI were validated using the PLS method, a subtype of structured equation modeling (SEM) used in performing CFA. The bootstrapping resampling method (5,000 samples) was also employed. As a result of Phase II factor analysis, the hypothesized paths from the two empirically assessed CVFs of SQ to the perceived SQ of BISI have been named H1.1 and H1.2. Likewise, the

hypothesized paths from the three empirically assessed CVFs of IQ to the perceived IQ of BISI have been named H2.1, H2.2, and H2.3. Furthermore, the paths from user perceived SQ and user perceived IQ of BISI to perceived user system satisfaction and perceived user information satisfaction from BISI as hypothesized in the BI SQ and IQ research model, based on the Delone and McLean IS success model (2003) as extended by Nelson et al. (2005) were tested in the overall context of BISI success. The paths and strength of the relationships between the constructs of the conceptual model as assessed by CFA and PLS are shown in figure 6.

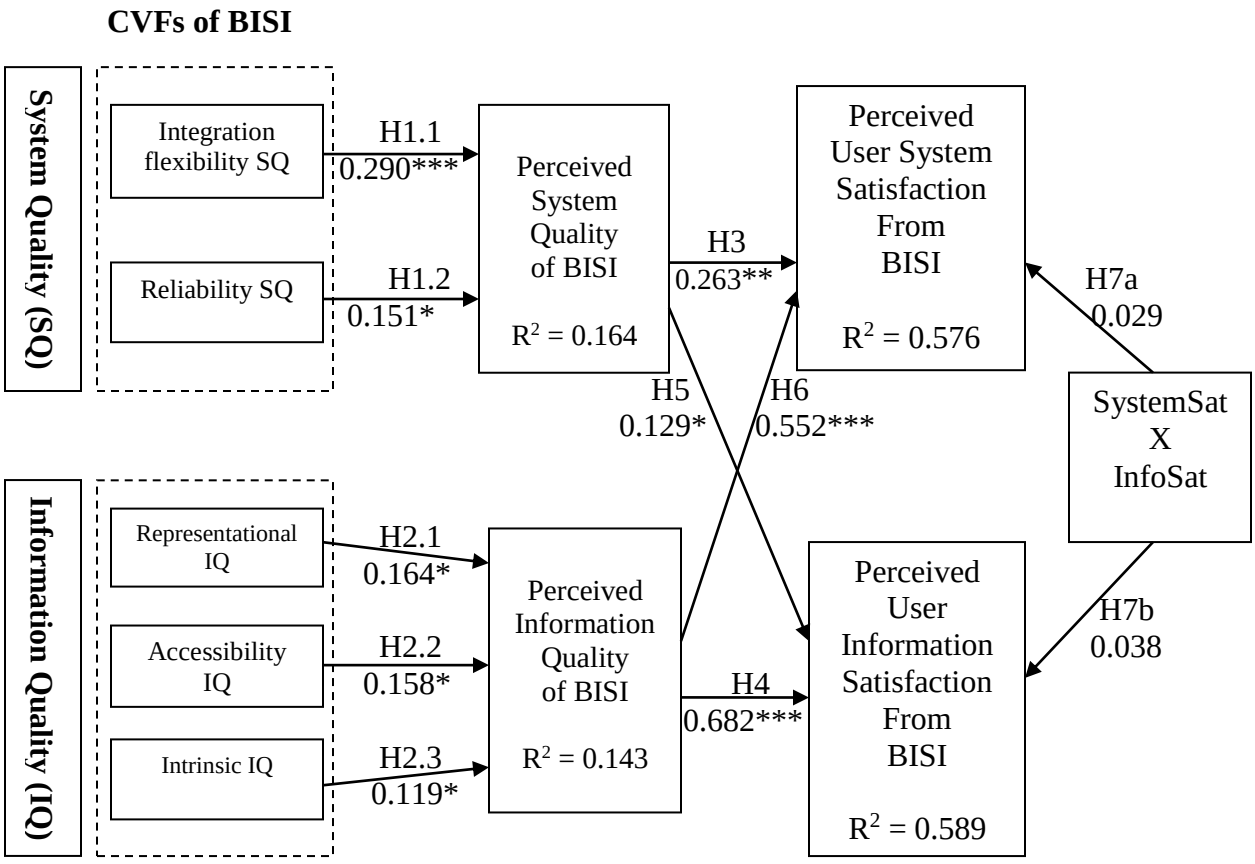


Figure 6. Structural Equation Model Testing Results of Conceptual Model

PLS was used to empirically test the conceptual model path coefficients to determine the significance of the relationships. As indicated in the conceptual model in figure 6, all CVFs of BISI for SQ or IQ have a significant positive impact on the perceived SQ or IQ of BISI. It is particularly interesting to note that the perceived SQ of BISI had a significant positive impact on perceived user system satisfaction from BISI and that the perceived IQ of BISI had a significant positive impact on perceived user information satisfaction from BISI. Moreover, it is noteworthy that the perceived IQ of BISI had a significant positive impact on perceived system satisfaction from BISI and that the perceived SQ of BISI had a significant positive impact only at $p<.05$ on user information satisfaction from BISI. It is also noted that the interaction effect of system satisfaction and information satisfaction did not have a significant positive impact on either perceived user information satisfaction from BISI or perceived user system satisfaction from BISI. The findings in table 12 indicate the results of this analysis.

Table 12. Model Coefficients for Hypothesized Paths

Model Path Coefficients	Std. Error	T Stat	Sig-Level	Significance
Accessible IQ → Perceived IQ of BISI	.0922	1.7078	0.0444	*
Integration flexibility SQ → Perceived SQ of BISI	.0891	3.2588	0.0006	***
Intrinsic IQ → Perceived IQ of BISI	.0611	1.9538	0.0259	*
Perceived IQ of BISI → Perceived User Information Satisfaction From BISI	.0617	11.0546	0.0000	***
Perceived IQ of BISI → Perceived User System Satisfaction From BISI	.0787	7.0173	0.0000	***
Perceived SQ of BISI → Perceived User Information Satisfaction From BISI	.0699	1.8458	0.0330	*
Perceived SQ of BISI → Perceived User System Satisfaction From BISI	.0871	3.0207	0.0014	**
Reliability SQ → Perceived SQ of BISI	.0913	1.6515	0.0499	*
Representational IQ → Perceived IQ of BISI	.0902	1.8188	0.0351	*
SysSat X InfoSat → Perceived User System Satisfaction From BISI	.0443	0.6498	0.2582	NS
SysSat X InfoSat → Perceived User Information Satisfaction From BISI	.0449	0.8419	0.2003	NS

NS = no significance
p<.05 *
p<.01 **
p<.001 ***

Findings

The results of the tests of the hypotheses are summarized in table 13.

Table 13. Summary of Hypotheses Results

Hypotheses	Results
H1.1 and H1.2: The CVFs of integration flexibility SQ and reliability SQ will have a positive significant impact on SQ for BISI success.	Supported
H2.1-3: The CVFs of representational IQ, accessibility IQ, and intrinsic IQ will have a positive significant impact on IQ for BISI success.	Supported
H3: The perceived SQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.	Supported
H4: The perceived IQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.	Supported
H5: The perceived SQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.	Supported
H6: The perceived IQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.	Supported
H7a: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user system satisfaction from BISI.	Not Supported
H7b: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user information satisfaction from BISI.	Not Supported

Summary

This chapter outlined the approach and research methodology necessary to achieve the research goals of the study. The research method process (Figure 2) identified the three phases of research used to achieve reliable and generalizable results. Phase I of the research method process identified SQ and IQ items for BISI using Keeney's (1999) approach to elicit SQ and IQ qualitative research characteristics important to users in BISI. Phase II of the research method process used a survey instrument that was based on a 7-point Lickert scale, ranging from not important to highly important to collect data for each proposed SQ and IQ item of BISI. This study also performed a Mahalanabis-distance analysis to identify multivariate outliers. The results were closely inspected to ensure that the affected items did not add to the reliability of each factor. Cronbach's Alpha was used to validate each factor to determine reliability. Value-based exploration techniques were used in surveying users of BI systems to determine the level of importance they placed on SQ and IQ characteristics. EFA techniques were then used to uncover the CVFs of SQ and IQ that influenced BISI. PCA was used as the extraction method that provided variances of the underlying CVFs. Phase III of the research method process performed the confirmatory analysis of the conceptual model by testing the hypotheses of the study to validate the BI SQ and IQ research model based on the DeLone and McLean (2003) IS success model as extended by Nelson et al. (2005). Using PLS, the study also validated the relationship between the perceived SQ of BISI and the perceived IQ of BISI with the perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI. The results confirmed that all

empirically determined CVFs had a positive significant impact on BISI and that the underlying items are important in BISI success.

To summarize the results of the study, it appears that users of BI systems desire integration flexibility and reliability in their BI systems that accurately, consistently, and correctly represent information which may be securely transformed and mapped into suitable representations or formats and reproduced as necessary. Users appear less concerned with whether information is current or with a particular response time threshold. These results have implications for both research and the implementation of BI applications. This study contributed to the IS success literature by demonstrating what CVFs for SQ and IQ of BISI influenced BISI success.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusions

This chapter provides the conclusions, implications, recommendations for future research, and a summary of the study. Discussions regarding the studies main goal, research questions, and hypotheses are followed by a description of the contributions of the study to the BoK, as well as the limitations. The chapter ends with recommendations for future research.

The main goal of this study was to validate empirically a model for IS success that investigated user satisfaction in the context of BISI by uncovering the CVFs of SQ and IQ necessary to derive BISI success. The main goal was achieved by answering two research questions and addressing seven research hypotheses. The first research question had two parts: What SQ characteristics are valued in BISI by users? What IQ characteristics are valued in BISI by users? Using a thorough review of literature supplemented by the results of an expert panel, 33 BISI SQ and IQ items of importance to BI users were identified. These items were used in the development of the survey instrument utilized in the quantitative phase of this study. These BISI SQ and IQ items also included items previously identified in SQ, IQ, and BI research as well as nine additional items that were obtained from an expert panel.

The study addressed recommendations for further research in assessing the universal set of characteristics for SQ and IQ to determine what is important to users of BISI (Nelson et al., 2005). Moreover, this study addressed the user perceived ambiguity

between the expectations of the BI system and the responsibilities of users for its output as measured by perceived user system and information satisfaction in successful BISI projects. The CVFs deemed important to users of BI were empirically evaluated through EFA and CFA. The study found that a BISI project should place emphasis on the CVFs of integration flexibility SQ and reliability SQ as the primary drivers for SQ of BISI. Emphasis should also be placed on the CVFs for IQ of representational IQ, intrinsic IQ, and accessible IQ, as the primary drivers for IQ of BISI.

The CVF of integration flexibility SQ had the most significant effect on the SQ of BISI as greater emphasis was placed on the capability of the BI system to easily combine information from multiple sources while retaining compatibility with other software and hardware. This is important to users of BISI as the ability of the BI system to communicate and transmit a variety of data between other systems supporting different functional areas is necessary for BISI success. This had been understood to be merely a relevant attribute and expected in BI systems that leveraged data warehouse technologies (Nelson et al., 2005). The results of this study also confirm the importance of integration flexibility SQ to facilitate integration of changing information from various sources to support business decisions. The system must be flexible in supporting ad hoc and unplanned requests for information in various representations. Reliability SQ was also considered as an important CVF as system dependability, recoverability, and low downtime are valued by BI users. On the other hand, the SQ CVF of response time SQ was not a reliable CVF in BISI success. It may be that response time for BISI was considered less important as a separate CVF but was assumed to be available in reliable and flexible BI systems. It might also be possible that due to the analytical nature of BI

systems, response time does not carry the same level of importance as would be necessary in a transaction based system.

The CVF of representation IQ had the most significant effect on the IQ of BISI as the representation of information in BI systems, as with most analytical based applications, relies on the user to ensure that IQ is retained as information from various users and sources are joined, aggregated, updated, configured, manipulated, and mapped into suitable representations and formats. Of particular interest was the high level of importance placed on the traceability, verifiability, and ability to reproduce information in BISI. This may point to user recognition of the need for accountability for the output produced by the user in BI systems. The CVF of accessibility IQ was also considered important in successful BISI as emphasis was placed on the importance of ease of access to locatable, obtainable and searchable information as well as the security of the accessed information and the ability to navigate within the BI system. Intrinsic IQ was also a reliable CVF as information accuracy, consistency, reliability, and correctness has generally been a cornerstone to BI success. The CVF of contextual IQ, however, was not a reliable CVF of perceived IQ of BISI. This may be due to the nature of BI systems which often rely on historical data to perform analytics and, as with response time expectations and assumptions, the contextual characteristics of currency, timeliness, sufficiency, and relevancy of information may be assumed to be of less importance than in systems that are more time dependent and transaction oriented.

Of particular interest in this study was the results related to the effects of perceived SQ on perceived user system and information satisfaction as well as the effects to perceived IQ of BISI on perceived user system and perceived user information satisfaction. The

perceived IQ of BISI had a significant positive impact on perceived user information satisfaction. Perceived IQ of BISI also had a significant positive impact on perceived user system satisfaction from BISI. While the perceived SQ of BISI also had a significant positive impact on perceived user system satisfaction from BISI there was less of an impact on perceived user information satisfaction from BISI, thereby highlighting the differences between the BI system and the information produced. It is apparent that BI systems provided functionality that features advanced interfacing capabilities that may influence the users' perception that the interaction with the interface has an impact on the output produced thereby making it difficult to differentiate between the interface and the user's responsibility for the output produced. This study also confirms that while empirically determined CVFs of SQ and IQ of BISI and their crossover effects are perceived to be important to user perceived SQ and IQ user satisfaction from BISI, the strength of the impact of IQ on the system corresponds to the importance users place on the output in analytical BISI. Moreover, this finding emphasizes the differences between the BI system tools and the output that is produced as well as the need for BI system implementers to accept responsibility for IQ. The results of this study and the crossover effects found in the research model also shed light on our understanding of quality. They highlight a continuum of interactivity in BISI that distinguishes SQ and IQ characteristics and their interfaces with user interaction and the effects on the data. This study provided a comprehensive and parsimonious empirical analysis of BISI for SQ and IQ that emphasized the importance of integration flexibility SQ and reliability SQ in BISI success. This study has also empirically assessed the value users of BI analytical systems

place on intrinsic IQ and the high regard in which information representation IQ and accessibility IQ are held.

Implications

This study has several implications in the field of IS. First, this study contributes to the body of knowledge by empirically identifying the CVFs of SQ and IQ that users find important in successful BISI. Secondly, this study addressed the relationship between the qualities of the BI system (SQ) and its output (IQ). The study determined that there was a significant positive impact from SQ and IQ of BISI on perceived user system and information satisfaction from BISI. Previous studies in BISI placed emphasis on the use of a data warehouse within the BISI domain and there had been ambiguity between the system (SQ) and its output (IQ) whereby the strength of the relationship between IQ and system satisfaction was stronger than the relationship between IQ and information satisfaction. The empirically developed findings of this study are in line with expectations for system success as theorized in the Delone and McLean (1992) IS success model as extended by Nelson et al. (2005). Lastly, this study identified characteristics of SQ and IQ that are valued or important in BISI, thereby assisting researchers and practitioners in determining the best areas of focus for BISI success.

Study Limitations

This study had three main limitations. The first limitation was that the study measured data from users of BI systems who possessed varying degrees of expertise in business analytics. Further studies may be required using other populations and systems to better validate and enhance the generalizability of the results. The second limitation of this study concerned the many industries surveyed. Consequently, future research may be

required to examine analytical BISI in relation to specific industries such as financial institutions. The final limitation relates to the use of different BI systems with different levels of sophisticated BI user tools. The features and functionality of BI systems may have different effects on user perceptions of the SQ and IQ of BISI as they relate to user perceived SQ and IQ satisfaction in successful BISIs.

Recommendations for Future Research

This research study empirically identified two CVFs of SQ in BISI with 12 reliable characteristics as well as three CVFs of IQ with 14 reliable characteristics. The study provided a solid theoretical foundation from which future studies can originate. Firstly, this study was designed to empirically validate a model for IS success for user satisfaction in the context of BISI and although the individual CVFs of SQ and IQ necessary to derive BISI success were significant, future studies may be warranted to examine and assess other constructs and items that are important to BI systems users that lead to BISI success. Furthermore, future research could assess the needs of a big data environment whereby information is often unstructured. With more attempts to manipulate input streams, many issues have been raised, accompanied by a wide variety of potential failures. There have been few attempts to actually apply big data analytics to the validation of big data, particularly in used in analytics. Social media for instance is open to a wider range of validation techniques. This could explain, in part, the high degree of importance placed by BI users in this study on validity of data sources. This finding may also point to the need to establish tailored systems development methodologies with emphasis on testing and verification for the delivery of BI systems in the future.

Summary

This study addressed the preponderance of failed BI systems projects, promulgated by a lack of attention to SQ and IQ in BISI. The purpose of this research was to validate empirically a model for IS success that investigated user satisfaction in the context of BISI by uncovering the CVFs of SQ and IQ necessary to derive BI success. Moreover, this research studied the crossover effects of system and information satisfaction and the concerns regarding the difficulties in differentiating the BI system from the output it produces, leading to the potential for over-reliance on the system for IQ while ignoring the responsibility for user interaction with the interface and the generation of output.

Although there has been a growing body of research that seeks to determine the role of SQ and IQ in IS success, little attention has been given in the literature to addressing the role of SQ and IQ in the success of BISI. Furthermore, few empirical studies have sought to uncover the SQ and IQ characteristics that are important to users of BI systems, as measured by user satisfaction from BISI. Moreover, research had been limited to studies that relied only on specific SQ and IQ factors for IS success that were based on prior research, not on the universal set of antecedents for SQ and IQ for BISI that have been subject to empirical analysis. In this study, a review of existing literature on SQ, IQ, user satisfaction, and BI success was conducted. BI users were asked to identify the characteristics of SQ and IQ that were important to them, culminating in a list of SQ and IQ characteristics that would affect perceived user satisfaction in BISI. The main research questions addressed in this study were:

RQ1: What SQ characteristics are valued in BISI by users? What IQ characteristics are valued in BISI by users?

RQ2: What are the CVFs for SQ that users' value in BISI? What are the CVFs for IQ that users' value in BISI?

Stemming from the research questions, this study then addressed the following specific hypotheses:

H1.1 and H1.2: The CVFs of SQ will have a positive significant impact on perceived SQ of BISI.

H2.1-3: The CVFs of IQ will have a positive significant impact on perceived IQ of BISI.

H3: The perceived SQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H4: The perceived IQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H5: The perceived SQ of BISI will have a positive significant impact on perceived user information satisfaction from BISI.

H6: The perceived IQ of BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7a: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user system satisfaction from BISI.

H7b: The interactions of perceived user system satisfaction from BISI and the perceived user information satisfaction from BISI will have a positive significant impact on perceived user information satisfaction from BISI.

To address these research questions and hypotheses, a three phase qualitative and quantitative methodology was employed. Phase I included an exploratory analysis whereby an open-ended questionnaire was sent to an expert panel of BI users. The list of items gathered was combined with the list developed from the review of the literature. An analysis was performed based on Keeney's (1999) approach and a list of SQ and IQ characteristics was used to develop the survey instrument for Phase II of the study.

In Phase II, a quantitative analysis was performed which included a web-based survey and a solicitation of 1300 analysts. The survey was delivered via SurveyMonkey.com and responses were collected from 270 users of BI systems, representing a 20.6 % response rate prior to pre-analysis data screening. Of the data collected, 257 responses were usable after additional testing for missing data, response set and outlier violations were taken into account.

Following pre-analysis data screening, SPSS was used to perform EFA using PCA with Varimax rotation to determine the CVFs of SQ and IQ in BISI. The two CVFs of SQ identified were integration flexibility SQ and reliability SQ. The three CVFs of IQ identified were representation IQ, intrinsic IQ, and accessibility IQ. Four items of SQ were deemed to be not reliable and were deleted, leaving a remaining list of 12 highly reliable SQ characteristics. Three items of IQ were deemed to be not reliable and were also eliminated from further consideration, leaving a remaining list of 14 highly reliable characteristics.

In Phase III, the BI SQ and IQ research model, based on the DeLone and McLean IS success model (1992) as extended by Nelson et al. (2005) was validated using CFA with PLS to assess the influence of the CVFs of SQ and IQ on the constructs of perceived SQ

of BISI and IQ of BISI as antecedents of the constructs of perceived user satisfaction from BISI and perceived user information satisfaction from BISI. The results of the analysis and validation indicated that the newly formed CVFs of SQ and IQ had a significant positive impact on perceived SQ and IQ of BISI. This study provided compelling evidence that the antecedents of integration flexibility SQ and reliability SQ are important to BISI success. Moreover, this study also provided compelling evidence that the antecedents of representation IQ, accessibility IQ, and intrinsic IQ are important to successful BISIs. These findings confirm the widely held view that BISI is not a conventional application-based IT project but a complex undertaking requiring an appropriate infrastructure over a lengthy period of time. The findings also confirm that successful BISIs require a robust and easy to use interface for user-driven information representation in an analytical user-based decision support system context from multiple integrated heterogeneous sources (Yeoh & Koronios, 2010; Goodhue & Thompson, 1995). This study also provided compelling evidence that there is a significant effect in the relationships of perceived IQ of BISI to perceived user information satisfaction from BISI and in perceived IQ of BISI to perceived user system satisfaction from BISI, thereby confirming the importance BI system users place on information and the BI system output produced.

After completion of the CFA, the results and conclusions were discussed, interpreted, and compared with prior research. Implications of this study were then addressed, followed by the limitations of the research. Finally, recommendations for further research were presented. These results contribute to the BoK for BISI success.

Appendix A

SQ Characteristics

Proposed Factors	SQ Characteristics	Sources
Reliability SQ	The functionality and features of the BI system are dependable	DeLone & McLean, 1992; Nelson et al., 2005; Wang & Strong, 1996
	The BI system has a low percentage of hardware and software downtime	Wang & Strong, 1996; Zmud, 1978
	The BI system can easily recover from malfunctioning equipment and restore data	Halloran, Manchester, Moriarity, Riley, Rohrman, & Skramstad, 1978; Wang & Strong, 1996
	The BI system is of high technical quality	Shaw, 2002; Wang & Strong, 1996
Response Time SQ	The time between when information is requested and received in the BI system is acceptable	Bailey & Pearson, 1983; DeLone & McLean, 1992; Nelson et al., 2005
	The elapsed time between a user initiated service request and problem correction in the BI system is acceptable	Ahituv, 1980; Nelson et al., 2005; Wang & Strong, 1996
	Data from the BI system is available without delay and at a time suitable for its use	DeLone & McLean, 1992; Marshall & de la Harpe, 2010; Miller, 1996; Wang & Strong, 1996; Yeoh & Koronios, 2009
	Information is up-to-date for the task at hand	Nelson et al., 2005; Wang & Strong, 1996, Zmud, 1978
	The frequency of data generation in the BI system is acceptable	Ahituv, 1980; Nelson et al., 2005
	The BI system responds to user needs within an acceptable time	Halloran et al., 1978; Nelson et al., 2005
Flexibility SQ	The BI system is adaptable to user needs	DeLone & McLean, 1992; Nelson et al., 2005; Wang & Strong, 1996
	The BI system is extendible and expandable	Nelson et al., 2005; Wang & Strong, 1996
	The BI system has the capacity to change in	Miller & Doyle, 1987; Nelson et al., 2005; Wang & Strong, 1996

Proposed Factors	SQ Characteristics	Sources
	response to new conditions, demands, or circumstances without customization.	
	The BI system is responsive to react to changing needs.	Halloran et al., 1978; Miller & Doyle, 1987; Nelson et al., 2005; Wang & Strong, 1996
Integration SQ	The ability of the BI system to combine information with other information and deliver to the user.	DeLone & McLean, 1992; Miller, 1996; Nelson et al., 2005; Wang & Strong, 1996
	The compatibility of BI system software with other software and hardware	Nelson et al., 2005, Shaw, 2002; Wang & Strong, 1996
	The ability of the BI system to communicate and transmit data between other systems servicing different functional areas.	Bailey & Pearson, 1983; Nelson et al., 2005; Wang & Strong, 1996
	The ability of the BI system to support a variety of data and data sources.	Loshin, 2013; Nelson et al., 2005; Wang & Strong, 1996
	The BI system provides portability of data and data sources	Loshin, 2013; Nelson et al., 2005

IQ Characteristics

Proposed Factors	IQ Characteristics	Sources
Intrinsic IQ	Accuracy of information in BISI	DeLone & McLean, 1992; Goodhue, 1995; Jarke & Vassiliou, 1997; Marshall & de la Harpe, 2010; Nelson et al., 2005; Wang & Strong, 1996; Yeoh & Koronios, 2009; Zmud, 1978;
	Believability of information in BISI	Wang & Strong, 1996; Marshall & de la Harpe, 2010
	Reputation of information in BISI	Wang & Strong, 1996; Marshall & de la Harpe, 2010
	Objectivity of information in BISI	Wang & Strong, 1996; Marshall & de la Harpe, 2010
	Consistency of information in BISI	DeLone & McLean, 1992; Jarke & Vassiliou, 1997; Marshall & de la Harpe, 2010
	Completeness of information in BISI	Jarke & Vassiliou, 1997; Miller, 1996; Nelson et al., 2005; Yeoh & Koronios, 2009
	Precision of information in BISI	DeLone & McLean, 1992
	Reliability of information in BISI	DeLone & McLean, 1992; Goodhue, 1995; Marshall & de la Harpe, 2010
	Correctness of information in BISI	Marshall & de la Harpe, 2010; Wand & Wang, 1996
Contextual IQ	Relevancy of information in BISI	DeLone & McLean, 1992; Jarke & Vassiliou, 1997; Marshall & de la Harpe, 2010; Yeoh & Koronios, 2009
	Sufficiency of information in BISI	DeLone & McLean, 1992; Wang & Strong, 1996
	Appropriate amount of information in BISI	Wang & Strong, 1996, Zmud, 1978
	Importance of information in BISI	DeLone & McLean, 1992
	Usefulness of information in BISI	DeLone & McLean, 1992; Jarke & Vassiliou, 1997; Kulkarni, Ravindran, and Freeze, 2007
	Informative nature of information in BISI	DeLone & McLean, 1992
	Currency and timeliness of information in BISI	DeLone & McLean, 1992; Goodhue, 1995; Jarke & Vassiliou, 1997; Nelson et al., 2005

Proposed Factors	IQ Characteristics	Sources
	Comprehensiveness of information in BISI	Goodhue, 1995; Redman, 1992
	Understandability of information in BISI	DeLone & McLean, 1992; Marshall & de la Harpe, 2010; Wang & Strong, 1996; Yeoh & Koronios, 2009
Representational IQ	Interpretability of information in BISI	Marshall & de la Harpe, 2010; Wang & Strong, 1996; Yeoh & Koronios, 2009
	Concise representation of information in BISI	DeLone & McLean, 1992; Wang & Strong, 1996
	Consistent representation of information in BISI	Marshall & de la Harpe, 2010; Wang & Strong, 1996; Yeoh & Koronios, 2009
	Complete representation of information in BISI	Marshall & de la Harpe, 2010
	Format of information in BISI	DeLone & McLean, 1992; Kulkarni et al., 2007; Marshall & de la Harpe, 2010; Miller, 1996; Nelson et al., 2005
	Presentation of information in BISI	Goodhue, 1995
	Information is easily joined and aggregated in BISI	Loshin, 2013; Wang and Strong, 1996
	Information is easily updated in BISI	Loshin, 2013; Wang and Strong, 1996
	Information is easily used for multiple purposes in BISI	Loshin, 2013; Wang and Strong, 1996
	Information is easily customized in BISI	Loshin, 2013; Wang and Strong, 1996
Accessibility IQ	Ease of operations accessing information in BISI	Wang & Strong, 1996
	Security of information in BISI	Marshall & de la Harpe, 2010; Miller, 1996; Wang & Strong, 1996
	Information availability in BISI	Jarke & Vassiliou, 1997; Marshall & de la Harpe, 2010
	Privileges/Privacy of information in BISI	Jarke & Vassiliou, 1997; Marshall & de la Harpe, 2010
	Convenience of access to information in BISI	DeLone & McLean, 1992
	Locatable information in BISI	Goodhue, 1995
	Obtainable information in BISI	Redman, 1992

Proposed Factors	IQ Characteristics	Sources
	Access to integrated sources of information in BISI	Nelson et al., 2005; Yeoh & Koronios, 2009

Appendix B

Open-Ended Qualitative Questionnaire

Dear Participants,

I am requesting your assistance in gathering system quality and information quality characteristics that you consider to be important in business intelligence systems implementation success. System quality is defined as the information processing system required to produce the output. Information quality is defined as information for business intelligence systems that is valued for a specific purpose or use. Business intelligence systems are defined as systems that provide business information and business analysis within the context of key business processes that lead to decisions and actions that result in improved business performance. The system quality and information quality characteristics provided in the survey instrument were discovered after a review of the system quality, information quality and business intelligence literature. The purpose of this study is to gather information that will lead to the understanding of system quality and information quality factors that will lead to business intelligence system implementation success.

The survey should take about 15 minutes to complete. The information you provide will be treated as strictly confidential. Your participation is voluntary and you are free to exit at any time.

Sincerely,

Paul Dooley

Graduate Student, Nova Southeastern University

Email: pd344@nova.edu

Open-Ended Qualitative Questionnaire

***1. System Quality**

System quality is aligned with the information processing system required to produce outputs. Please list five (or at least three) system quality characteristics that are important to you in business intelligence systems implementations. Examples include reliability, response time, flexibility, and integration

1.
2.
3.
4.
5.

***2. Reliability system quality refers to the dependability of a system over time as measured by uptime, downtime, or time between failures. Examples include the characteristics of hardware and software downtime, recoverability, validity, and technical quality.**

Please think of five (or at least three) reliability system quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***3. Response time system quality refers to the degree to which a system offers quick (or timely) responses to requests for information or action. Examples include the characteristics of timeliness and the suitable frequency of output.**

Please think of five (or at least three) response time system quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***4. Flexibility system quality refers to the extent to which system features and options lend themselves to accommodating change without modifications to programs. Examples include the characteristics of adaptability, extendibility, and expandability.**

Please think of five (or at least three) flexibility system quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***5. Integration system quality refers to the degree to which a system facilitates the combination of information from various sources to support business decisions. Examples include the characteristics of compatibility and the ability to combine data from a variety of data and data sources.**

Please think of five (or at least three) integration system quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***6. Information Quality**

Information quality is defined as information that is valued for a specific purpose or use. Please list five (or at least three) information quality characteristics that are important to you in business intelligence systems implementations. Examples include information quality that is intrinsic (quality within its own right without regard to context), contextual, representational and accessible.

1.
2.
3.
4.
5.

***7. Intrinsic information quality refers to information that has quality in its own right with innate correctness regardless of the context in which it is being used. Such qualities may include accuracy, believability, precision, reliability, consistency, and correctness.**

Please think of five (or at least three) intrinsic information quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***8. Contextual information quality refers to information that must be considered within the proper context. Contextual information quality characteristics may include relevance, completeness, timeliness, and importance.**

Please think of five (or at least three) contextual information quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***9. Representational information quality concerns the proper presentation of information for ease of interpretation and manipulation as well as the degree to which the information being assessed is easy to understand and is presented in a clear manner. Examples include the characteristics of understandability, format, conciseness, readability, clarity, compatibility, and meaningfulness. In BI systems implementations, representational information quality characteristics may also include ease of joining, changing, updating, downloading/uploading, manipulating, aggregating, reproducing, and customizing information.**

Please think of five (or at least three) representational information quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

***10. Accessibility information quality concerns the availability of the information and the timeliness of its receipt. Examples include availability and the ability to use and locate information.**

Please think of five (or at least three) accessibility information quality characteristics that are important to you in business intelligence systems implementations.

1.
2.
3.
4.
5.

Appendix C

Quantitative Survey Instrument

Dear Participants,

I am requesting your assistance in gathering system and information quality characteristics that you consider to be important in business intelligence systems implementation (BISI) success. System quality is aligned with the information processing system required to produce outputs. Information quality is defined as information that is valued for a specific purpose or use. Business intelligence systems are defined as systems that provide business information and business analysis within the context of key business processes that lead to decisions and actions that result in improved business performance. The system and information quality characteristics that are listed in this survey instrument were found by delivering a previous questionnaire to another group of business intelligence system implementers. The purpose of this study is to gather information that will lead to the understanding of factors that will lead to business intelligence systems implementation success.

The survey should take about 15 minutes to complete. The information you provide will be treated as strictly confidential. Your participation is voluntary and you are free to exit at any time.

Sincerely,

Paul Dooley

Graduate Student\Nova Southeastern University

Email: pd344@nova.edu

Survey for Users of Business Intelligence Systems

Thank you for your participation in completing this survey. You are asked to answer each question to the best of your ability.

"*** Please note that you are asked to participate in this study only if you have used Business Intelligence (BI) systems or analytical systems before ***

This survey is part of an extensive, multi-scale research study that addresses the preponderance of failed analytical based business intelligence systems implementations (BISI). The goal of this study is to validate a model for Information Systems success that investigates user satisfaction in the context of BISI by uncovering critical value factors of system quality and information quality necessary to attain success in BISI.

Unlike traditional IT systems, analytical based BI systems combine products, technology, and methods to organize key information needed to improve profit and performance. BI systems are not considered to be conventional information systems and often rely on the integration of a complex information infrastructure.

This study will empirically develop critical value factors for system quality and information quality based for those characteristics that you deem as important to BISI. The system and information quality characteristics used in this survey instrument were selected after assessing the results of a questionnaire previously delivered to a panel of experts.

The survey will take about 15 to 20 minutes to complete. Please note that I have received Institutional Review Board (IRB) approvals for the survey and the information you submit is confidential. Your participation is completely voluntary and you are free to exit at any time.

Sincerely,

Paul Dooley

Candidate for Ph.D. in Information Systems
Nova Southeastern University

Email: pd344@nova.edu

***If you use BI systems or analytical systems, how do you rate yourself?**

- ◯ Expert
- ◯ Advanced
- ◯ Average
- ◯ Novice

***Have you been involved in BI systems or other analytical systems implementations?**

- ◯ Yes
- ◯ No

Please indicate the level of importance you place on the specified system quality and information quality characteristics of analytical based business intelligence systems implementations (BISI) by clicking the associated value. You will also be asked to rate overall system and information quality and your level of satisfaction.

For the purpose of this research:

- System quality is defined as the desired characteristics of the information system that produces information.

- Information quality is defined as information that is valued for a specific purpose or use in analysis and decision making.

An asterisk indicates response required

A1. System Quality Reliability (SQR)

***SQR1 - The functionality and features of the BI system are dependable**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***SQR2 - The BI system has a low percentage of hardware and software downtime**

1. Not Important	2. Not so Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***SQR3 - The BI system can easily recover from malfunctioning equipment and restore data**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***SQR4 - The BI system is of high technical quality**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

A2. System Quality Response Time/Responsiveness (SQRT

***SQRT1 - The time between when information is requested and received in the BI system is acceptable**

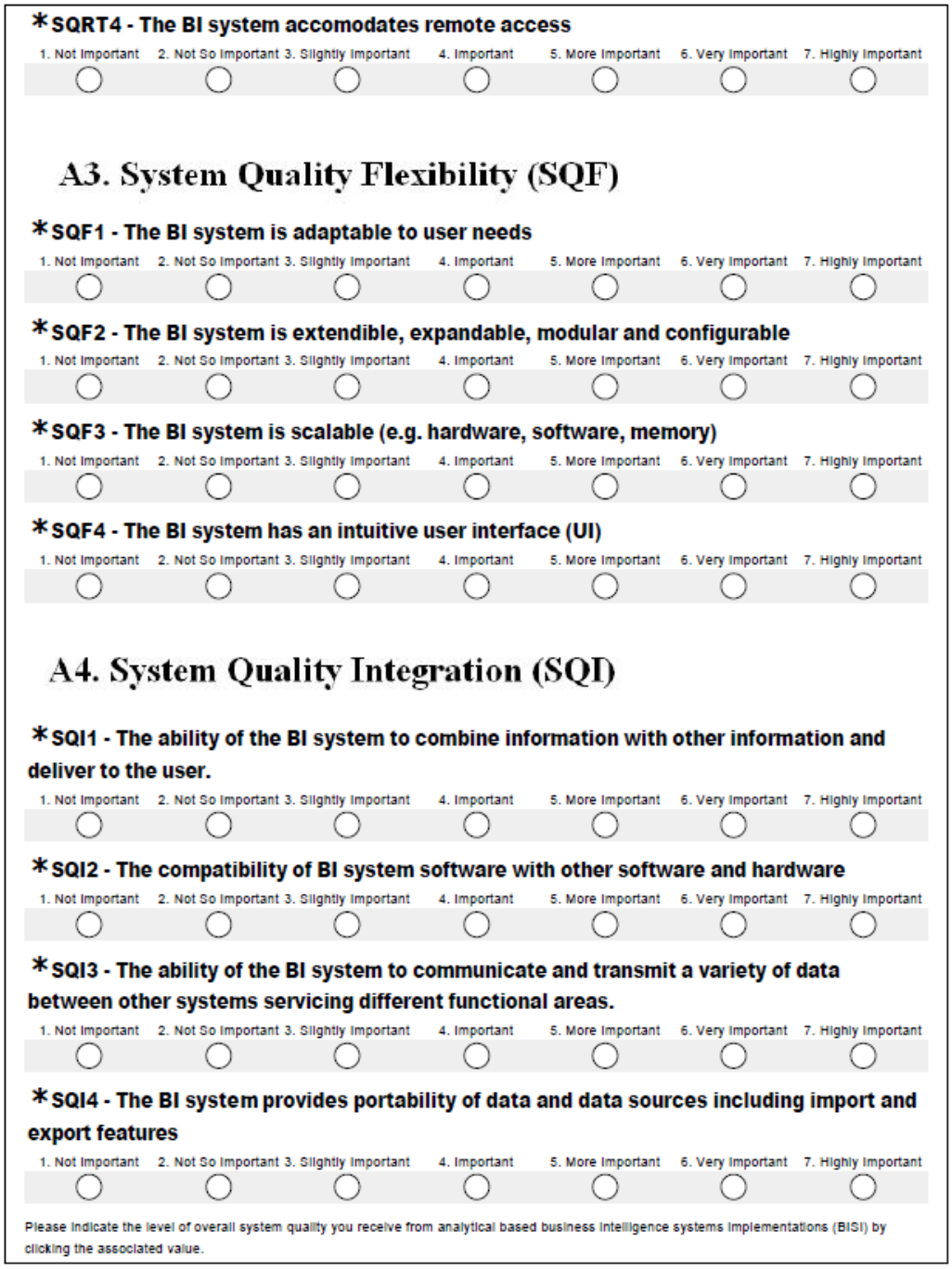
1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Importnat	7. Highly Important
○	○	○	○	○	○	○

***SQRT2 - Information in the BI system is up-to-date for the task at hand**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***SQRT3 - The frequency of data generation and refresh in the BI system is flexible**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○



*SQRT4 - The BI system accomodates remote access

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

A3. System Quality Flexibility (SQF)

*SQF1 - The BI system is adaptable to user needs

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQF2 - The BI system is extendible, expandable, modular and configurable

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQF3 - The BI system is scalable (e.g. hardware, software, memory)

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQF4 - The BI system has an intuitive user interface (UI)

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

A4. System Quality Integration (SQI)

*SQI1 - The ability of the BI system to combine information with other information and deliver to the user.

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQI2 - The compatibility of BI system software with other software and hardware

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQI3 - The ability of the BI system to communicate and transmit a variety of data between other systems servicing different functional areas.

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

*SQI4 - The BI system provides portability of data and data sources including import and export features

1. Not Important 2. Not So Important 3. Slightly Important 4. Important 5. More Important 6. Very Important 7. Highly Important

Please indicate the level of overall system quality you receive from analytical based business intelligence systems implementations (BISI) by clicking the associated value.

B. System Quality Overall (SQOV)

***SQOV1 In terms of system quality, I would rate the Business Intelligence System Implementation high**

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Agree nor Disagree	5. Slightly Agree	6. Agree	7. Strongly Agree
○	○	○	○	○	○	○

***SQOV2 Overall, the Business Intelligence System Implementation is of high system quality**

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Disagree nor Agree	5. Slightly Agree	6. Agree	7. Stongly Agree
○	○	○	○	○	○	○

***SQOV3 Overall, I would give the system quality of the Business Intelligence System Implementation a high rating**

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Disagree nor Agree	5. Slightly Agree	6. Agree	7. Stongly Agree
○	○	○	○	○	○	○

Please indicate the level of importance you place on the specified information quality characteristics of analytical based business intelligence systems implementations (BISI) by clicking the associated value.

C1. Information Quality - Intrinsic Characteristics (IQI)

***IQI1 - Accuracy of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***IQI2 - Consistency of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***IQI3 - Reliability of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***IQI4 - Correctness of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

C2. Information Quality - Contextual Characteristics (IQC)

***IQC1 - Relevancy of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

***IQC2 - Sufficiency of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQC3 - Currency and timeliness of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQC4 - Traceability and verifiability of the source of information in BISI**

1. Not Important	2. Not so Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

C3. Information Quality - Representational Characteristics (IQR)

***IQR1 - Understandability of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQR2 - Format of information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQR3 - Information is easily joined, aggregated, updated, configured and manipulated in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQR4 - Information is reproducable in the BISI**

1. Not Important	2. Not so Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQR5 - Information is mapped into suitable representations at the user level in the BISI**

1. Not Important	2. Not so Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

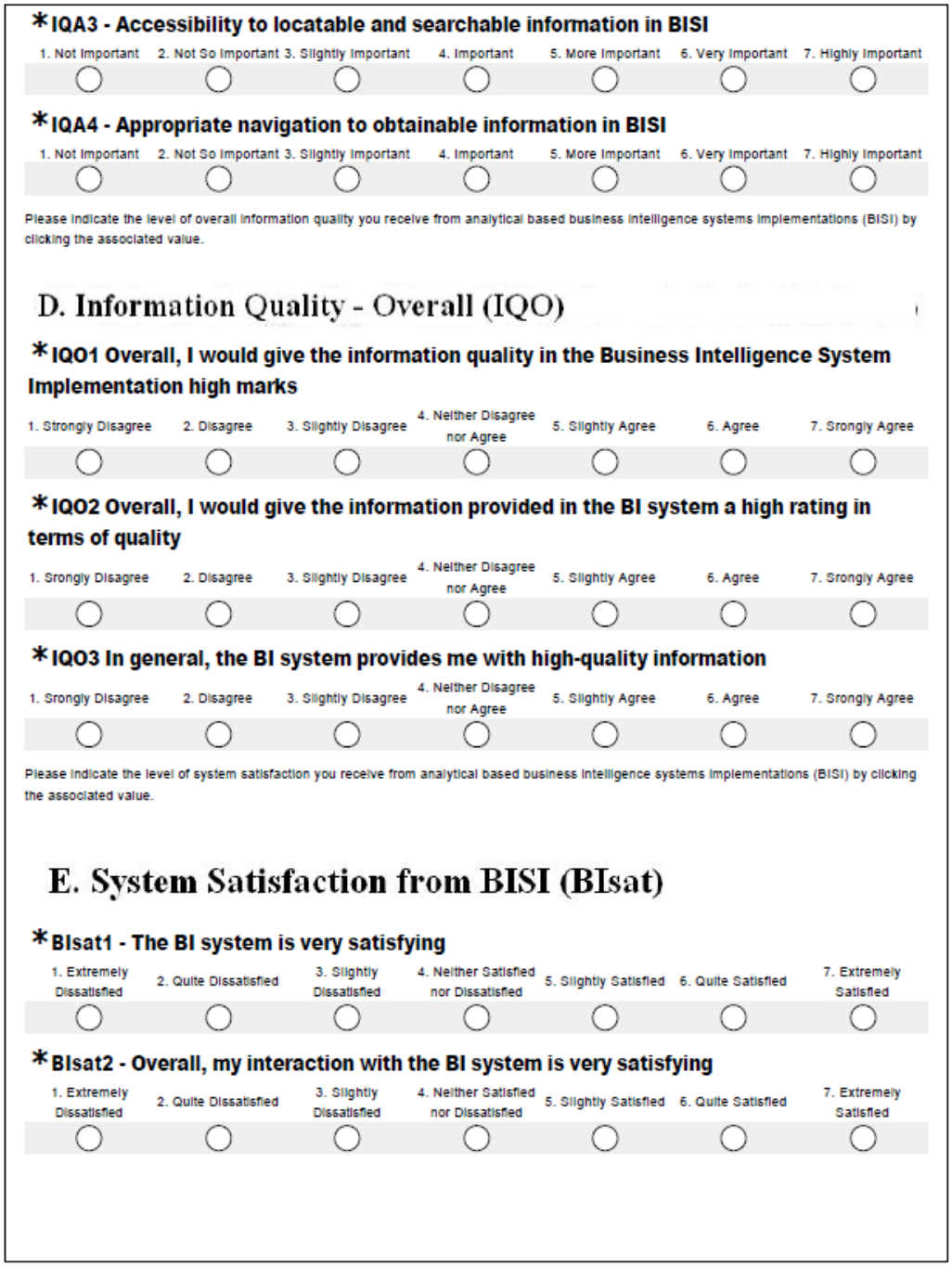
C4. Information Quality - Accessibility Characteristics (IQA)

***IQA1 - Ease of accessing information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯

***IQA2 - Security of accessed information in BISI**

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
◯	◯	◯	◯	◯	◯	◯



*IQA3 - Accessibility to locatable and searchable information in BISI

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

*IQA4 - Appropriate navigation to obtainable information in BISI

1. Not Important	2. Not So Important	3. Slightly Important	4. Important	5. More Important	6. Very Important	7. Highly Important
○	○	○	○	○	○	○

Please indicate the level of overall information quality you receive from analytical based business intelligence systems implementations (BISI) by clicking the associated value.

D. Information Quality - Overall (IQO)

*IQO1 Overall, I would give the information quality in the Business Intelligence System Implementation high marks

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Disagree nor Agree	5. Slightly Agree	6. Agree	7. Strongly Agree
○	○	○	○	○	○	○

*IQO2 Overall, I would give the information provided in the BI system a high rating in terms of quality

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Disagree nor Agree	5. Slightly Agree	6. Agree	7. Strongly Agree
○	○	○	○	○	○	○

*IQO3 In general, the BI system provides me with high-quality information

1. Strongly Disagree	2. Disagree	3. Slightly Disagree	4. Neither Disagree nor Agree	5. Slightly Agree	6. Agree	7. Strongly Agree
○	○	○	○	○	○	○

Please indicate the level of system satisfaction you receive from analytical based business intelligence systems implementations (BISI) by clicking the associated value.

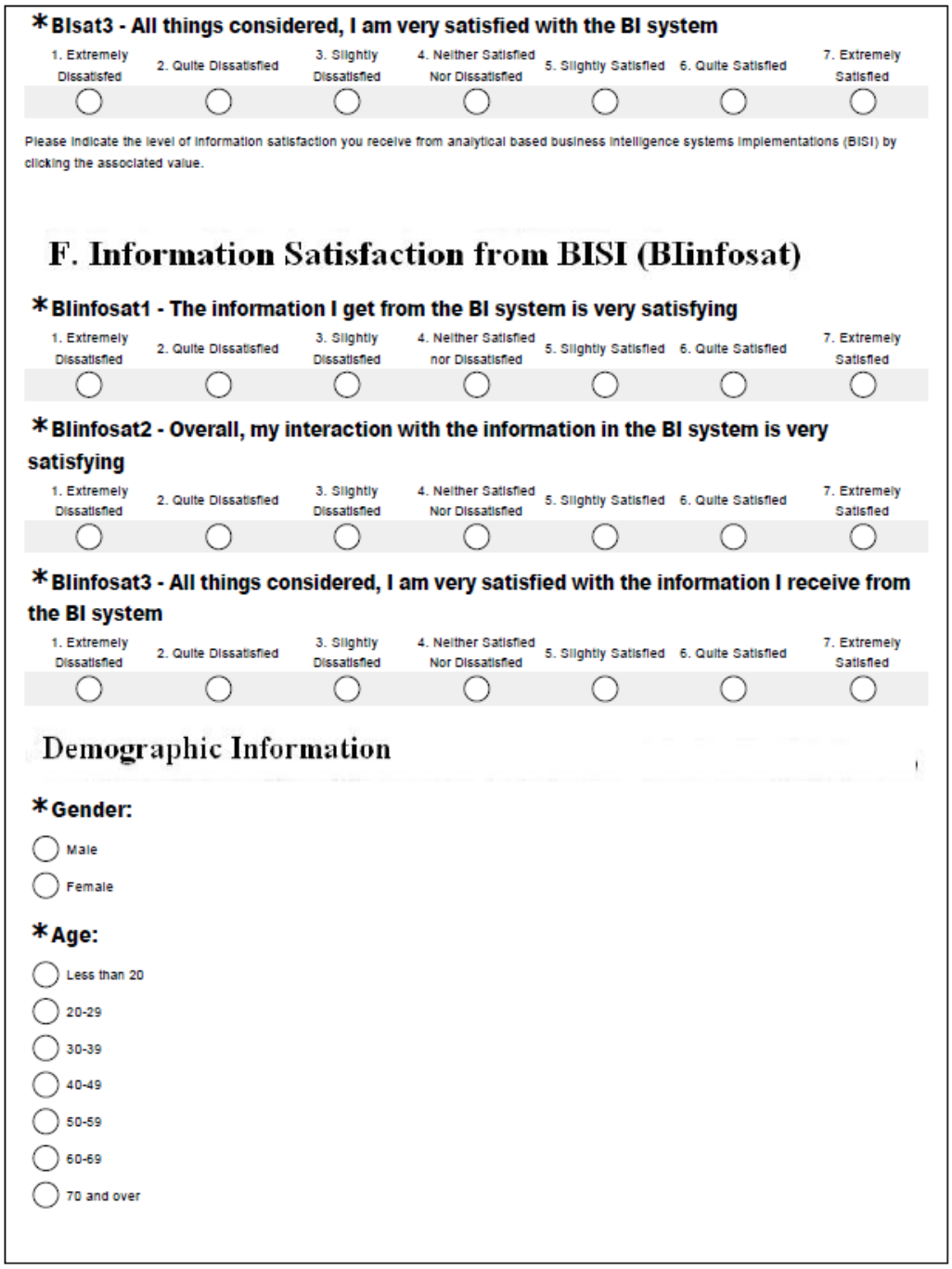
E. System Satisfaction from BISI (BIsat)

*BIsat1 - The BI system is very satisfying

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
○	○	○	○	○	○	○

*BIsat2 - Overall, my interaction with the BI system is very satisfying

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
○	○	○	○	○	○	○



***BIsat3 - All things considered, I am very satisfied with the BI system**

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied Nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
◯	◯	◯	◯	◯	◯	◯

Please indicate the level of information satisfaction you receive from analytical based business intelligence systems implementations (BISI) by clicking the associated value.

F. Information Satisfaction from BISI (BIinfosat)

***BIinfosat1 - The information I get from the BI system is very satisfying**

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
◯	◯	◯	◯	◯	◯	◯

***BIinfosat2 - Overall, my interaction with the information in the BI system is very satisfying**

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied Nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
◯	◯	◯	◯	◯	◯	◯

***BIinfosat3 - All things considered, I am very satisfied with the information I receive from the BI system**

1. Extremely Dissatisfied	2. Quite Dissatisfied	3. Slightly Dissatisfied	4. Neither Satisfied Nor Dissatisfied	5. Slightly Satisfied	6. Quite Satisfied	7. Extremely Satisfied
◯	◯	◯	◯	◯	◯	◯

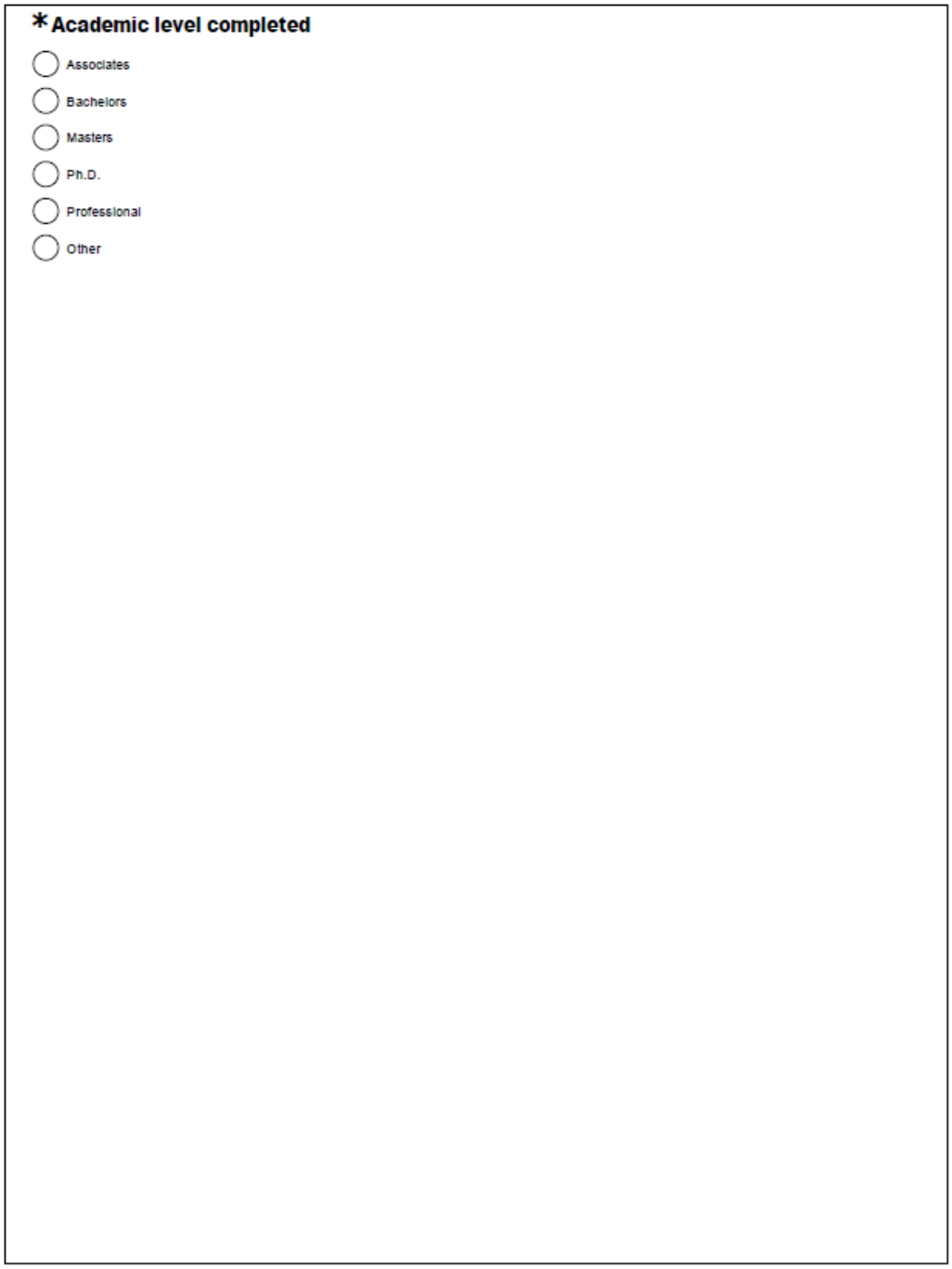
Demographic Information

***Gender:**

- ◯ Male
- ◯ Female

***Age:**

- ◯ Less than 20
- ◯ 20-29
- ◯ 30-39
- ◯ 40-49
- ◯ 50-59
- ◯ 60-69
- ◯ 70 and over


*Academic level completed
Associates
Bachelors
Masters
Ph.D.
Professional
Other

Appendix D

IRB Approval Letter

NOVA SOUTHEASTERN UNIVERSITY
Office of Grants and Contracts
Institutional Review Board

MEMORANDUM

To: Paul Dooley

From: Ling Wang, Ph.D.
Institutional Review Board

Date: September 26, 2013

Re: *An Empirical Development of Critical Value Factors (CVF) for System Quality and Information Quality in Business Intelligence Systems Implementations*

IRB Approval Number: wang09151303

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms these must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE REACTIONS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and 954-262-2020 respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Protocol File

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References

Ahituv, N. (1980). Assessing data reliability in an information system. *MIS Quarterly, 4*(4), 61-75.

Arazy, O., & Kopak, R. (2011). On the measurability of information quality. *Journal of the American Society for Information Science and Technology, 62*(1), 89-99.

Arnott, D., & Prevan, G. (2008). Eight key issues for the decision support systems discipline. *Decision Support Systems, 44*(1), 657-672.

Azadeh, A., Sangari, M. S., & Songhori, M. J. (2009). An empirical study of the end-user satisfaction with information systems using the Doll and Torkzedeh instrument. *International Journal of Business Information Systems, 4*(3), 324-339.

Baars, H., & Kemper, H. G. (2008). Management support with structured and unstructured data: An integrated business intelligence framework. *Information Systems Management, 25*(2), 132-148.

Bailey, J. E., & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. *Management Science, 29*(5), 530-545.

Bokhari, R. H. (2005). The relationship between system usage and user satisfaction: A meta-analysis. *The Journal of Enterprise Information Management, 18*(2), 211-234.

Boynton, A. C., & Zmud, R. W. (1984). An assessment of critical success factors. *Sloan Management Review, 25*(4), 17-27.

Cha-Jan Chang, J., & King, W. R. (2005). Measuring the performance of information systems: A functional scorecard. *Journal of Management Information Systems, 22*(1), 85-115.

Chandler. N. (2014, January 17). Agenda overview for analytics, business intelligence, and performance management (ID: G00260364). Retrieved from Gartner database.

Child, D. (2006). *The essentials of factor analysis*. New York, NY: Continuum International Publishing Group.

Clark, T. D., Jones, M. C., & Armstrong, C. P. (2007). The dynamic structure of management support systems: Theory development, research focus, and direction. *MIS Quarterly, 31*(3), 579-615.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-Experimentation: Design and analytical issues for field settings*. Chicago, IL: Rand McNally.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*(1), 60-95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9-30.

Dhillon, G., Bardacino, J., & Hackney, R. (2002). Value-focused assessment of individual privacy concerns for Internet commerce. *Proceedings of the Twenty-Third International Conference on Information Systems*, Barcelona, Spain, 705-709.

Dhillon, G., & Torkzadeh, G. (2001) Value-focused assessment of information system security in organizations. *Proceedings of the Twenty-Second International Conference on Information Systems*, New Orleans, LA., 561-565.

Dinter, B., Schieder, C., & Gluchowski, P. (2011). Towards a life cycle oriented business intelligence success model. *Proceedings of the Americas Conference on Information Systems*, Detroit, MI.

Doll, W. & Torkzadeh, G. (1988). The measurement of end-user computing satisfaction. *MIS Quarterly*, *12*(2), 259-274.

Doll, W., & Torkzadeh, G. (1991). The measurement of end-user computing satisfaction: Theoretical and methodological issues. *MIS Quarterly, 15*(1), 5-10.

Ellis, T. J., & Levy, Y. (2009). Towards a guide for novice researchers on research methodology: Review and proposed methods. *Issue in Informing Science and Information Technology, 6*, 323-337.

Eppler, M. J. (2006). *Managing information quality: Increasing the value of information in knowledge-intensive products and processes.* New York, NY: Springer.

Etezadi-Amoli, J., & Farhoomand, A. F. (1991). On end-user computing satisfaction. *MIS Quarterly, 15*(1), 1-5.

Forte, P. (1994). Data rich, information poor: Data, information and decision support in the NHS. *European Journal of Information Systems, 3*(2), 148-154.

Frolick, M. N., & Ariyachandra, T. R. (2006). Business performance management: One truth. *Information systems Management*, *23*(1), 41-48.

Galletta, D. F., & Lederer, A. L. (1989). Some cautions on the measurement of user information satisfaction. *Decisions Sciences, 20*(3), 419-439.

Gatian, A. W. (1994). IS user satisfaction: A valid measure of system effectiveness? *Information & Management, 26*(1), 119-131.

Gefen, D., & Straub, D. (2005). A practical guide to factorial validity using PLS-Graph: Tutorial and annotated example. *Communications of the Association for Information Systems, 16*(5), 91-109.

Ghazanfari, M., Rouhani, S., Jafari, M., & Taghavifard, M. T. (2009). ERP requirements for supporting management decisions and business intelligence. *IUP Journal of Information Technology, 5*(3), 65-84.

Golfarelli, M., Rizzi, S., & Cella, I. (2004). Beyond data warehousing: What's next in business intelligence? *Proceedings of the 7th ACM International Workshop on Data Warehousing and OLAP,* Washington, DC, 1-6.

Goodhue, D. L. (1995). Understanding user evaluations of information systems. *Management Science, 41*(12), 1827-1844.

Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly, 19*(2), 213-236.

Gopolan, N., & Sivaselvan, B. (2009). *Data mining: Trends and techniques*. New Dehli, India: PHI Learning Private Limited.

Haenlein, M., & Kaplan, A. M. (2004). A beginner's guide to partial least squares analysis. *Understanding Statistics, 3*(4), 283-297.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis.* Upper Saddle River, NJ: Prentice Hall.

Halloran, D., Manchester, S., Moriarity, J., Riley, R., Rohrman, J., & Skramstad, T. (1978). Systems Development Quality Control. *MIS Quarterly, 2*(4), 1-13.

Hanson, W. E., Plano-Clark, V. L., Petska, K. S., Creswell, J. W., & Creswell, J. D. (2005). Mixed methods research designs in counseling psychology. *Journal of Counseling Psychology, 52*(2), 224-235.

Hill, J., Moss, L. T., Sorensom, C., & Weeks, W. (2009). BI experts' perspective. *Business Intelligence Journal, 14*(3), 53-60.

Howson, C. (2008). *Successful Business Intelligence: Secrets to making BI a killer application.* New York, NY: McGraw-Hill.

Iivari, J. (2005). An empirical test of the DeLone-McLean model of information system success. *The Data Base for Advances in Information Systems, 36*(2), 8-27.

Iivari, J., & Ervasti, I. (1994). User information satisfaction: IS implementability and effectiveness. *Information & Management, 27*(4), 205-220.

International Business Machines. (nd). Statistical package for the social sciences. Retrieved April 9, 2012 from http://www-01.ibm.com/software/analytics/spss/.

Ives, B., Olson, M. H., & Baroudi, J. J. (1983). The measurement of user satisfaction. *Communications of the ACM, 26*(10), 785-793.

Jarke, M., & Vassiliou, Y. (1997). Data warehouse quality: a review of the DWQ project. *Proceedings of the Conference on Information Quality*, Cambridge, MA, 299-313.

Jiang, J.J., & Klien, G. (1999). User evaluation of information systems: By system topology. *IEEE Transactions on Systems, Man, and Cybernetics, 29*(1), 111-116.

Joppe, M. (2000). *The research process*. Retrieved August 1, 2012 from http://www.htm.uoguelph.ca/pagefiles/MJResearch/ResearchProcess/home.html

Jourdan, Z., Kelly, R. K., & Marshall, T. E. (2008). Business intelligence: An analysis of the literature. *Information Systems Management, 25*(2), 121-131.

Keeney, R. L. (1992). *Value-focused thinking*. Cambridge, MA: Harvard University Press.

Keeney, R. L. (1999). The value of Internet commerce to the customer. *Management Science, 45*(4), 533-542.

Kerlinger, F. N., & Lee, H. B. (2000). Foundations of behavioral research (4th ed.). Holt, NY: Harcourt College Publishers.

Kim, K. K. (1989). User satisfaction: A synthesis of three different perspectives. *Journal of Information Systems, 4*(1), 1-12.

Kulkarni, U. R., Ravindran, S., & Freeze, R. (2007). A knowledge management success model: theoretical development and empirical validation. *Journal of Management Information Systems, 23*(3), 309-347.

Lee, Y. W., Strong, D. M., Kahn, B. K., & Wang, R. Y. (2002). AIMQ: a methodology for information quality assessment. *Information & Management, 40*(1), 133-146.

Levy, Y. (2003). A study of learner's perceived value and satisfaction for implied effectiveness of online learning systems. *Dissertation Abstracts International*, A65(03), 1014. (UMI No. AAT3126765)

Levy, Y. (2006). *Assessing the value of E-learning systems*. Hershey, PA: Information Science Publishers.

Levy, Y. (2008). An empirical development of critical value factors (CVF) of online learning activities: An application of activity theory and cognitive value theory. *Computers & Education, 51*(4), 1664-1675.

Levy, Y. (2009). A value-satisfaction taxonomy of IS effectiveness (VSTISE): A case study of user satisfaction with IS and user-perceived value of IS. *International Journal of Information Systems in the Service Sector, 1*(1), 93-118.

Levy, Y., & Green, B. D. (2009). An empirical study of computer self-efficacy and the technology acceptance model in the military: A case of a U.S. Navy combat information system. *Journal of Organizational and End User Computing, 21*(3), 1-23.

Linn, H-F. (2010). An investigation into the effects of IS quality and top management support on ERP system usage. *Total Quality Management, 21*(3), 335-349.

Loshin, D. (2013). *Business intelligence: The savvy manager's guide*. Waltham, MA: Elsevier.

Luftman, J., & Ben-Zvi, T. (2010). Key issues for IT executives 2009: Difficult economy's impact on IT. *MIS Quarterly Executive, 9*(1), 49-59.

Marshall, L., & de la Harpe, R. (2009). Decision making in the context of business intelligence and data quality. *SA Journal of Information Management, 11*(2), 1-15.

McHaney, R., & Cronan, T. P. (1998). Computer simulation success on the use of the end-user computing satisfaction instrument: A comment. *Decision Sciences, 29*(2), 525-537.

Mertler, C. A., & Vannatta, R. A. (2001). *Advanced and multivariate statistical methods: Practical application and interpretation*. Los Angeles, CA: Pyrczak Publishing.

Miller, H. (1996). The multiple dimensions of information quality. *Information Systems Management, 13*(2), 79-83.

Miller, J., & Doyle, B. A. (1987). Measuring the effectiveness of computer-based information systems in the financial services sector. *MIS Quarterly, 11*(1), 107-124.

Mirani, R., & Lederer, A. L. (1998). An instrument for assessing the organizational benefits of IS projects. *Decision Sciences, 29*(4), 803-838.

Moss, L. T., & Atre, S. (2003). *Business intelligence roadmap: The complete project lifecycle for decision-support applications.* Boston, MA: Pearson Education.

Nah, F., Siau, H., & Sheng, H. (2005). The value of mobile applications: A study on a public utility company. *Communications of the ACM, 48*(2), 85-90.

Negash, S., & Gray, P. (2008). *Business Intelligence, Handbook on Decision Support.* Berlin, Germany: C.W. Holsapple.

Nelson, R. R., Todd, P. A., & Wixom, B. A. (2005). Antecedents of information and system quality: An empirical examination within the context of data warehousing. *Journal of Management Information Systems, 21*(4), 199-235.

Petter, S., & McLean, E. (2009). A meta-analytic assessment of the DeLone and McLean IS success model: An examination of IS success at the individual level. *Information & Management, 46*(3), 159-166.

Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: Models, dimensions, measures, and interrelationships. *European Journal of Information Systems, 17*(3), 236-263.

Popovic, A., Coelho, P. S., & Jaklic, J. (2009). The impact of business intelligence system maturity on information quality. *Information Research, 14*(4), 1-24.

Popovic, A., Hackney, R., Coelho, P. S., & Jacklic, J. (2012). Towards business intelligence systems success: Effects of maturity and culture on analytical decision making. *Decision Support Systems, 54*(1), 729-739.

Power, D. J. (2008). Understanding data-driven decision support systems. *Information Systems Management, 25*(2), 149-154.

Prybutok, V. R., Zhang, X., & Ryan, S. D. (2008). Evaluating leadership, IT quality, and net benefits in an e-government environment. *Information & Management, 45*(2), 143-152.

Qian, Z., & Bock, G. W. (2005). An empirical study on measuring the success of knowledge repository systems. *Proceedings of the 38th Hawaii International Conference on System Sciences*, Hawaii, USA.

Rai, A., Long, S. S., & Welker, R. B. (2002). Assessing the validity of IS success models: An empirical test and theoretical analysis. *Information Systems Research, 13*(1), 50-69.

Redman, T. C. (1992). *Data Quality: Management and Technology.* New York, NY: Bantam Books.

Reid, A., & Catterall, M. (2005). Invisible data quality issues in a CRM implementation. *Database Marketing & Customer Strategy Management, 12*(4), 305-314.

Ringle, C. M., Wende, S., & Will, A. (2005). *SmartPLS 2.0 (beta)* Retrieved April 9, 2012, from http://www.smartpls.de/.

Ringle, C. M., Sarstedt, M., & Straub, D. W. (2012). A critical look at the use of PLS-SEM. *MIS Quarterly, 36*(1), iii-xiv.

Rokeach, M. J. (1973). *Nature of human values*. New York, NY: The Free Press.

Ryu, K. S., Park, J. S., & Park, J. H. (2006). A data quality management maturity model. *ETRI Journal, 28*(2), 191-204.

Saeed, K. A., & Abdinnour-Helm, A. (2008). Examining the effects of information system characteristics and perceived usefulness on post adoption usage of information systems. *Information & Management, 45*(6), 376-386.

Schieder, C., & Gluchowski, P. (2011). Towards a consolidated research model for understanding business intelligence success. *Proceedings of the European Conference on Information Systems*, Helsinki, Finland.

Schumacker, R. E., & Lomax, R. G. (2010). *A beginner's guide to structural equation modeling*. New York, NY: Routledge.

Sciore, E., Siegal, M., & Rosenthal, A. (1994). Using semantic values to facilitate interoperability among heterogeneous information systems. *ACM Transactions on Database Systems, 19*(2), 254-290.

Scott, M., DeLone, W. H., & Golden, W. (2009). Understanding net benefits: A citizen-based perspective on egovernment success. *Proceedings of the International Conference on Information Systems*, Phoenix, AZ.

Sekaran, U. (2003). *Research methods for business: A skill building approach*. New York, NY: John Wiley & Sons.

Seddon, P. B. (1997). A respecification and extension of the DeLone and McLean model of IS success. *Information Systems Research, 8*(3), 240-253.

Sethi, V. & King, R. C. (1999). Nonlinear and noncompensatory models in user information satisfaction measurement. *Information Systems Research, 10*(1), 87-96.

Shank, G. (2006). Six alternatives to mixed methods in qualitative research. *Qualitative Research in Psychology, 3*(4), 346-356.

Shaw, N. G. (2002). Capturing the technological dimensions of IT infrastructure change: A model and empirical evidence. *Journal of the AIS, 2*(8), 1-33.

Sheng, H., Nah, K., & Siau, K. (2005). Strategic implications of mobile technology: A case study using value-focused thinking. *Journal of Association for Information Systems, 9*(6), 344-376.

Sheng, H., Siau, K., & Nah, F. F. (2010). Understanding the values of mobile technology in education: A value-focused thinking approach. *The Data Base for Advances in Information Systems, 41*(2), 25-44.

Siau, K., Nah, F., & Sheng, H. (2004). Value of m-commerce to customers. *Proceedings of the Tenth Americas Conference on Information Systems*, New York, NY, 2811-2815.

Sprinthall, R. (1997). *Basic statistical analysis*. Boston, MA: Allyn and Bacon.

Straub, D. (1989). Validating instruments in MIS research. *MIS Quarterly, 13*(2), 147-169.

Straub, D., Boudreau, M., & Gefen, D. (2004). Validation guidelines for IS positivist research. *Communications of the Association for Information Systems 13*, 380-427.

Strong, D. M., Lee, Y. W., & Wang, R. Y. (1997). Data quality in context. *Communications of the ACM, 40*(5), 104-108.

Thompson, S. H., Teo, P. O. H., & Wong, K. A. M. (1998). An empirical study of the performance impact of computerization in the retail industry. *Omega, 26*(5), 611-621.

Todd, G. (2009). The imperative of analytics. *Information Management, 19*(2), 44-47.

Urbach, N., Smolnik, S., & Riempp, G. (2008). A methodological examination of empirical research on information systems success: 2003 to 2007. *Proceedings of the Fourteenth Americas Conference on Information Systems*, Ontario, Canada.

Urbach, N., Smolnik, S., & Riempp, G. (2009). The state of research on information systems success: A review of existing multidimensional approaches. *Business & Information Systems Engineering, 1*(4), 315-325.

Vavpotic, D., & Bajec, M. (2009). An approach for concurrent evaluation of technical and social aspects of software development methodologies. *Information and Software Technology, 51*(2), 528-545.

Wand, Y., & Wang, R. Y. (1996). Anchoring data quality dimensions in ontological foundations. *Communications of the ACM, 39*(11), 86-95.

Wang, R. Y., & Strong, D. M. (1996). Beyond accuracy: what data quality means to data consumers. *Journal of Management Information Systems, 12*(4), 5-34.

Watson, H. J., Goodhue, D. L., & Wixom, B. H. (2002). The benefits of data warehousing: Why some organizations realize exceptional payoffs. *Information & Management, 39*(1), 491-502.

Williams, S., & Williams, N. (2007). *The profit impact of Business Intelligence.* San Francisco, CA: Morgan Kaufman.

Wixom, B. H., & Todd, P. A. (2005). A theoretical integration of user satisfaction and technology acceptance. *Information Systems Research, 16*(1), 85-102.

Wixom, B., & Watson, H. (2001). An empirical investigation of the factors affecting data-warehousing success. *MIS Quarterly, 25*(1), 17-41.

Yeoh, W., & Koronios, A. (2010). Critical success factors for business intelligence systems. *Journal of Computer Information Systems, 50*(3), 23-32.

Zmud, R. (1978). Concepts, theories and techniques: an empirical investigation of the dimensionality of the concept of information. *Decision Sciences, 9*(2), 187-195.