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Three essays on business intelligence system success

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ABSTRACT

Today, business intelligence (BI) systems have become a critical foundation for several organizations. BI systems have consistently been ranked among the topmost priority of CIOs due to their ability to transform huge amount of data into organizationally-valued information to fulfil current business needs and faster decision making. However, the success of these systems is still questionable, as in many cases, BI systems have failed to yield the expected value for organizations. Literature shows that majority of prior research either discussed the benefits of BI systems or identified the factors that improve organizational performance. None of the studies focussed to comprehensively count on adoption, utilization, and success (AUS) of BI systems, providing an appropriate success metrics, and proposing factors that can improve the success of BI systems. Therefore, the overarching aim of the thesis is to; i) present comprehensive knowledge about the current state of BI system AUS, ii) provide a success metrics to measure the success of BI system, iii) identify the factors to assess BI system use and decision-making performance at individual level. The findings revealed a detailed and comprehensive knowledge of current state of BI system AUS. In addition, the results revealed success metrics for measuring the success of BI system. The empirical analysis demonstrated the significance of system factors i.e. system quality and information quality, and human factors i.e. user competence for improved decision-making performance, which in turns increases the potential of success. The research will provide direction for researchers and practitioners to understand the ways to obtain the maximum value from implemented BI systems.

DEDICATION

I dedicate this dissertation to my beloved parents Amjad Hussain (late) and Rashida Bano, and to my aunt Nargis Bano (late), whose encouragement, love, support, and prayers made me able to achieve such success and honor.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

i. Introduction

Throughout the years, organizations have been investing considerable resources on information systems (IS) to increase their performance and competitive advantage. Dating back to 1960s, initially, Decision support system (DSS) was developed. DSS provided end-users relevant information and analytical capabilities to support organizational decision making (Alter, 1977). In 1970s and 1980s, other computer applications appeared, popular one includes "Executive information system" (EIS), "Transaction Processing System (TPS), and "Expert systems" (ES). EIS was designed to provide high-level strategic decision making. It enabled end-users to retrieve and analyse internal and external information to enhance performance (Rockart & Treacy, 1980). Later in 1989, an analyst Howard Dresner first coined the term "business intelligence" (originally used by Luhn (1958)) as an umbrella to describe the methods and concepts to enhance organizational decision making by utilizing "fact-based systems". However, the popularity of business intelligence grew in the late 1990s. Nowadays, the significance of BI systems is more widely accepted. BI systems are considered as one of the most significant technology investments for organizations, offering organizations with the solutions critical to improving both their adaptation to change and their performance (Işık, Jones, & Sidorova, 2013).

A BI system is defined as an integrated set of technological tools aimed at presenting knowledge workers such as managers, analysts, and executives with intelligent information for effective decision making (Chaudhuri, Dayal, & Narasayya, 2011; Işık et al., 2013). The primary characteristics of a BI system are; i) the ability to provide representative information to support strategic activities such as integrating data, profiling, planning, forecasting, goal setting, and performance tracking, ii) provide access to both real-time and historical data through ad-hoc queries, iii) provide a visualization of data that enables access to meaningful information and dynamic exploration of patterns (Bara et al., 2009; Chaudhuri et al., 2011). A study on investigation of key information technology and management issues in over 472 organizations from United States, Latin America, Europe, and Asia revealed BI system as one of the key requirements of IT executives to overcome local and global business challenges (Luftman & Zadeh, 2011).

Several contemporary organizations have implemented BI systems to get faster access to large amount of information about their operations, customers, products, and environments (Tyson, 1986) to make effective decision making (Xuemei Tian, Arefin, Hoque, & Bao, 2015). However, evidence suggests that the success of these systems has not been fully realized (Işık et al., 2013). In some cases, implementation of BI system fails due to end-users rejection, technological, or infrastructural issues (Boonsiritomachai, McGrath, & Burgess, 2016; Deng & Chi, 2012; Popovič, 2017), while in others, organizations fail to achieve the expected benefits from the BI system use (Olszak, 2016). As a result, there is an ongoing debate among academic researchers and practitioners on the approaches that can make BI systems' implementation a success. Majority of the anecdotal reports and existing literature documented the benefits of BI system, its impact on organizational performance, and its use for decision making (Chau & Xu, 2012; Elbashir, Collier, & Davern, 2008; Ranjan, 2009). A more systematic and deliberate research on BI system success is needed to gain a deeper understanding of the perspectives that could lead to the success of these systems (Olszak, 2016). Thus, this thesis focuses on the success of BI systems and divided into three studies.

In the first study, a systematic literature review (SLR) was conducted to understand the current state of the BI system research domain. The study followed the guidelines suggested by Kitchenham (2004), which involved the following steps; the development of review protocol, identification of research, research questions, search procedure, criteria for study selection, quality assessment, data extraction, and data synthesis. To find the relevant literature, both automated and manual search was performed. Electronic search was conducted using electronic databases such as ‘Emerald insight, ScienceDirect, EBSCOhost, ProQuest, Wiley Online Library, IEEE Xplore, JSTOR Archive, Taylor & Francis Online, Sage Journals, Springer-Link, and Web of Science’, whereas manual search was performed using backward and forward approach (Webster and Watson, 2002). In backward approach, identified articles were reviewed to trace additional references, whereas, in the forward approach, the collected references were used to explore the relevant studies. On the completion of both automated and manual search, 612 articles were found potentially relevant to BI domain. Upon scanning and quality assessment, a total of 111 studies, covering three categories – adoption, utilization and success – published between the period of 2000 to 2019 were retained for the review. The descriptive findings revealed the chronological distribution of studies, BI system/tools adoption over time, research methods (conceptual, qualitative, quantitative and mixed methods), studies coverage by geographical regions and sectors. In addition, the results revealed the primary area of investigation i.e. adoption, utilization, and success of BI system, key theoretical frameworks/models and key factors used, and key challenges faced by the organizations. Moreover, the findings revealed that knowledge gaps within the BI system adoption, utilization, and success research domain, and provided suggestions for future research to evaluate and improve BI system success.

The second study focuses on the review of success measures in the BI system context. Using DeLone & McLean’s IS success framework as a foundation, the study proposed the measures indispensable for the success of the BI system. The study followed literature review approach to integrate the past knowledge of BI system research domain. To identify the relevant literature, a structured approach (Webster & Watson, 2002) was used. Initially, the literature search was performed using keywords in leading electronic databases. Upon search and scanning, 92 studies from the period of 2000-2017 were retained for the review. The data of each identified study was extracted based on the success constructs, dimensions, and measures being used in the study. The analysis of the data revealed several measures at both individual and organizational levels. All the identified measures were captured under six IS success dimensions system quality, information quality, service quality, use, satisfaction, and net benefits to provide consolidated success metrics to evaluate the BI system's success. The study has guidance and direction for future research to evaluate the BI system's success.

The third study focuses on the investigation of the system and human factors to assess the BI system use and decision-making performance at the individual level by using the theoretical groundings of DeLone & McLean's IS success framework and social cognitive theory. The study aims to seek answer to the following research question; What are the factors that impact BI system use and employees' decision-making performance? To validate the proposed framework, the quantitative approach was used. Data was randomly collected from 211 respondents from Pakistani telecommunication companies using survey questionnaire. The respondents were first-level management, second-level management, third-level management, consultants, data analysts, and executives from nine functional departments; accounting and finance, information technology, human resource, marketing and sales, customer support, research and development, production/supply chain management, legal department, and revenue assurance. The collected data was analysed using statistical software SPSS and SmartPLS. The findings of the study demonstrated that system quality and information quality, and the human factor, i.e. user competence positively influence BI system use. In addition, system use and user competence positively influence decision making performance. The study contributes to the literature in the following way: i) it operationalizes and validates user competence construct in the BI system context, ii) it extends DeLone & McLean's IS success framework by incorporating competence construct. The empirical validation of user competence construct enables future research to use this construct and its instrument to investigate various phenomena regarding the individuals in BI system context. Whereas, the empirical validation of proposed framework provides a more comprehensive framework to measure IS use and success in general and BI system success in particular.

The following sections present each study's research objective, methodology, analysis, findings, discussion, conclusions, and implications in detail.

ǂ[1] Two decades of research on business intelligence system adoption, utilization and success – A systematic literature review

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Abstract

In the recent era of technological advances and hyper-competition, Business Intelligence (BI) systems have attracted significant attention from executives and decision-makers due to their ability to provide complex and competitive information inputs for the decision process. Following the world of practice, research into the adoption, utilization, and success of BI systems has grown substantially over the past two decades. The literature suggests that organizations have largely failed to capture the benefits of BI systems to their full extent and are seeking ways to leverage value from the implemented systems. However, prior studies do not have any comprehensive study that discusses the issues and challenges related to adoption, utilization, and success of BI systems. In this study, using a systematic literature review, we present comprehensive knowledge about what has been found in the domain of BI system adoption, utilization, and success. A total of 111 peer-reviewed studies, covering three categories – adoption, utilization, and success – published between 2000 and 2019, were selected. The findings present the research methods, underpinning theories, and key factors employed to study BI system adoption, utilization, and success. In addition, the review identified the key issues related to BI adoption, utilization, and success, and highlighted the areas that have attracted more or less attention. This study also suggests future directions for researchers and practitioners in terms of unexplored themes that may help organizations to obtain value from BI systems.

[1] The paper has been presented in the Hawaii International Conference on System Sciences (HICSS-52), USA. The paper has been published in the Journal **Decision Support Systems**.

1. Introduction

Advances in organizational information systems and technologies led to the emergence of business intelligence systems in the late 1990s (Chen, Chiang, & Storey, 2012; Wixom & Watson, 2010). A business intelligence (BI) system is commonly known as a suite of technological solutions (Chaudhuri et al., 2011) that facilitates organizations to amass, integrate, and analyze vast stocks of data in order to understand their opportunities, strengths, and weaknesses (Harrison, Parker, Brosas, Chiong, & Tian, 2015). BI is an information system that supports decision processes by i) facilitating more aggregation, systematic integration, and management of unstructured and structured data, ii) dealing with a huge amount of data (e.g. "Big Data"), iii) providing end-users with increased processing capabilities to discover new knowledge (Wieder & Ossimitz, 2015), and iv) offering analysis solutions, ad hoc queries, reporting, and forecasting (Grublješič & Jaklič, 2015; Yoon, Ghosh, & Jeong, 2014). According to Clark, Jones, and Armstrong (2007) BI systems are quite close to the original DSS concept since they extend the categories of users and support a wider variety of decisions. Certainly, as part of the broad call of management support systems (MSS), they are designed to reduce uncertainty in the decision-making process, and support the decision-makers efficiently and effectively (Clark et al., 2007).

A BI system is a combination of tools, such as a data warehouse, online analytical processing (OLAP), and dashboards. A data warehouse gathers accurate, clean and detailed data from multiple sources for in-depth analysis (Yoon, 2008), whereas online analytical processing (OLAP) supports multidimensional analysis in real-time and enables users to apply operations such as aggregation, filtering, roll up and drill down for details (e.g. products, customers, times, country, region), and pivoting (Bach, Čeljo, & Zoroja, 2016; Clark et al., 2007). Furthermore, dashboard servers as the front-end application for data visualization and performance management. It enables users to create graphs, charts, widgets, and ad hoc reports, and decision-makers to track the key performance indicators of the business (Clark et al., 2007).

With increased competition from both online and traditional businesses, these technological solutions have become extremely important for organizations to improve their managerial practices and performance as well as their products and services (Elbashir, Collier, Sutton, Davern, & Leech, 2013; Trieu, 2017). The BI market increased worldwide by about 7.3% in 2017, with revenues up to $18.3 billion, and it is expected to reach $22.8 billion by the end of 2020 (Gartner, 2017). However, despite the growing investments and great market expansion, the evidence has suggested that many organizations fail to reap benefits from the implemented BI systems (Audzeyeva & Hudson, 2016). Above 70% of BI projects fail to yield the expected returns (Gartner, 2015) or result in few or no benefits for organizations (Yeoh & Popovič, 2016). Organizations are in a continuous struggle to find the best way to leverage value from BI systems and to make their implementation a success (Visinescu, Jones, & Sidorova, 2017).

Scholars and practitioners are still debating strategic and tactical approaches to the successful adoption and use of BI systems, producing hundreds of publications through different media. However, a limited number of studies have attempted to synthesize this existing body of knowledge. For instance, Jourdan, Rainer, and Marshall (2008) reviewed BI studies from 1997 to 2006 with a focus on research strategies and methods. Similarly, Fitriana, Eriyatno, and Djatna (2011) reviewed the progress made in BI studies from 2000 to 2011. They discussed the most popular research approaches – the single approach and the integrated approach – used within BI studies. Their analysis revealed that 50% of the research focused on a single approach and discussed the definition, theory, methodology, and architecture of BI systems, whereas the rest of the research focused on BI integration with other areas, like supply chain management, customer relationship management, and artificial intelligence. Trieu (2017) analysed BI studies from 2000 to 2015 to understand the processes through which organizations can attain value from BI systems.

Meanwhile, an extensive stream of BI research has been conducted in the past two decades. In fact, hundreds of single studies have been published in the categories of adoption, utilization or success at the organizational and individual levels (Arefin, Hoque, & Bao, 2015; Arnott, Lizama, & Song, 2017; Dawson & Van Belle, 2013; Gaardboe, Nyvang, & Sandalgaard, 2017). However, to date, no synthesis exists on the three categories of the adoption, utilization, and success of BI systems as a means of ascertaining the current status of the BI research. Therefore, through a systematic literature review (SLR), this study aims to: *(i) comprehensively report on areas of investigation (adoption, use, and success)), theories/framework/models, key factors and challenges and (ii) identify knowledge gaps that need further investigation and suggest opportunities for future research*.

The remainder of the paper is structured as follows. The second section outlines the research questions and research methodology to explain the process of finding relevant articles from leading databases. The third section presents the findings of the proposed research questions. The fourth section discusses the limitations of the study. The fifth section outlines the theoretical and practical implications of our findings, and the conclusions.

2. Methodology

This study undertook SLR based on the guidelines suggested by Kitchenham (2004). Initially, a comprehensive review protocol was developed to guide the SLR. The aim of a review protocol is to minimize the likelihood of bias in a study, and it is thus considered as an essential element of SLR (Kitchenham, 2004). The protocol provided a detailed plan for the systematic review by specifying the approaches to be followed and the quality measures or conditions to apply while selecting the literature (Brereton, Kitchenham, Budgen, Turner, & Khalil, 2007). It involved the following stages: the identification of research, research questions, search procedure, criteria for study selection, quality assessment, data extraction process, and data synthesis (Kitchenham & Charters, 2007). The previous section of this study described the first stage, that is, the identification of the research, while the following sections describe the remaining steps.

2.1. Research Questions

The research on BI system AUS is still progressing; however, no effort has been made to systematically review existing research in the BI research domain from AUS perspective. Given that, this study aims to firstly investigate the main areas of investigation within the BI AUS research domain. This provides a rich overview of BI AUS studies from 2000-2019, indicating the current state of BI AUS research. Secondly, the study aims to report on areas of investigation (adoption, use, and success), theories/framework/models, key factors adopted, challenges and knowledge gaps. To achieve the objectives, the following five research questions are introduced.

Since the domain of this research is BI AUS, it is helpful to understand how much research attention has been given to each of these categories; therefore, the following research question was developed:

RQ1*: What is the main area of investigation in BI system AUS studies; adoption, use or success?*

Researchers need to better understand the various information system and organizational theories used in BI studies in order compare and contrast BI research findings and to create a cumulative knowledge of BI AUS; therefore, the following research question was developed:

RQ2*: What are theories/frameworks/models adopted by studies regarding BI system AUS?*

Researchers and practitioners are interested in the organizational, informational and user factors that drive adoption, use, and success; therefore, the following research question was developed:

***RQ3**: What are the key factors identified in the BI system AUS studies?*

Researchers and practitioners are also interested in the challenges faced when implementing BI: therefore, the following research question was developed:

***RQ4**: What challenges are faced by organizations with respect to BI system AUS?*

A better understanding of knowledge gaps in BI research will open new windows for researchers and practitioners to understand the areas where further research is required; therefore, the following research question was developed:

***RQ5**: What are the knowledge gaps within the current BI system AUS research?*

The following section presents the criteria for BI studies inclusion and exclusion.

2.2. Study inclusion/exclusion criteria

Inclusion/exclusion criteria were applied to ensure that the studies were relevant and within the boundaries of the research objective (Kitchenham & Charters, 2007). The inclusion criteria were applied to full-length peer-reviewed studies and conference papers related to BI systems – adoption, utilization, and success (AUS) research, as depicted in the following Table 1. Furthermore, studies that were not available in full, book chapters, discussion notes, editorials and reports, highly technical articles and duplicated studies were excluded from the review list. Table 1 presents the detailed inclusion/exclusion criteria.

Table 1. Study inclusion/exclusion criteria

Inclusion Criteria	Exclusion Criteria
• Studies published between the period of 2000-2019	• Studied outside the domain of BI system AUS research
• Studied within the domain of BI systems AUS research	• Studied with a highly technical perspective, books, discussions, reports, and non-scholarly work
• Full-length peer-reviewed studies	• No full-length peer-reviewed studies
• Published in the English language	• Not published in the English language
• Available in selected electronic databases	• Duplicated

2.3. Search and selection procedure

To explore the relevant material for this review, the search was conducted through both an automated and a manual search (Kitchenham, 2004). First, the automated search was primarily based on search terms or keywords and was performed as an electronic search using electronic databases (Webster & Watson, 2002). Accordingly, ten leading databases were located through Google Scholar, encompassing journals in the field of information systems, management information systems, operations management, business, management, social science interdisciplinary and information science, as shown in Table 2. The selected databases were deemed to be highly relevant, providing a comprehensive census of the literature in the BI field.

The search terms of interest, as shown in Table 2, were applied to the identified electronic databases to assess the relevant literature. The selected search terms included business intelligence system, data warehouse, online analytical processing (OLAP), and dashboards, and the adoption, use, and success terms were used interchangeably. Apart from simple search strings, the Boolean operators AND/OR were applied to collect as many results as possible. The year 2000 was chosen as the starting year, as the first few academic articles related to BI were found to have been published in that year (Soliman, Mao, & Frolick, 2000; Wixom & Watson, 2001).

Table 2. Search procedure

Years	**2000–2019**
Search terms	"Business intelligence"; "business intelligence system"; "antecedents of business intelligence system success"; "business intelligence system success, BI system acceptance, intelligence system adoption, intelligence system use"; "data warehouse 'adoption' and/or 'use', OLAP 'adoption' and/or 'use', dashboard 'adoption' and/or 'use'"; "business intelligence system" and/or "success" and/or "adoption" and/or "acceptance" and/or "use"
Sample Journals	- MIS Quarterly - MISQ Executive - Decision Support Systems - Journal of Management Information Systems - European Journal of Information Systems - Journal of Information Systems - Information & Management - Communications of ACM - Information Systems Management - Journal of Management Information Systems - Expert systems with Applications - Behaviour & Information Technology - Computers in Human behavior - Journal of Strategic Information systems - Information development - Telematics and Informatics - Highly relevant articles from other journals
Databases	Emerald insight, ScienceDirect, EBSCOhost, ProQuest, Wiley Online Library, IEEE Xplore, JSTOR Archive, Taylor & Francis Online, Sage Journals, Springer-Link, Web of Science

Additionally, a manual search was performed by adopting the backward and forward approach (Webster & Watson, 2002) to ensure the completeness of the systematic search. In the former approach, citations of the identified articles were reviewed to trace additional references, and, in the latter approach, the collected references were used further to identify relevant articles. Along with the empirical studies that had a key focus on BI system AUS, this review also takes into account conceptual research that contributed to the BI system AUS literature.

On completion of the search process, the study identified 612 articles that were potentially relevant to the BI domain. The inclusion/exclusion criteria discussed in the previous section and demonstrated in Table 1 were applied to the results to find the most relevant studies. Initially, the title and abstract of each article were scanned. Despite having search terms appearing in the titles or abstracts, some studies were not conducted in the BI system context and were thus found to be irrelevant to this review. Therefore, in the first step, 413 articles were excluded. This reduced the number of studies to 199, which were further filtered by skimming the full contents of the articles to ensure their relevance to BI system AUS. This resulted in the elimination of 76 irrelevant articles from the review list, leaving 123 articles relevant to this study's subject. The following Figure 1 presents the article selection and retention process.

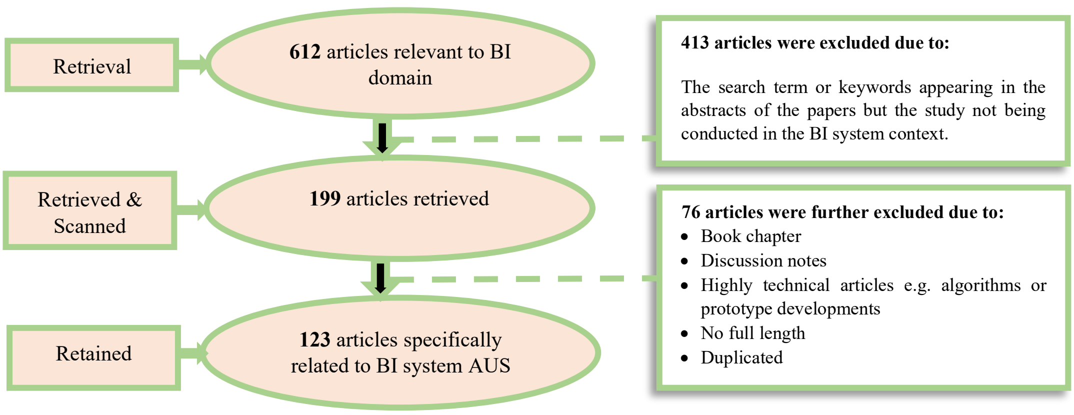

Figure 1. Articles selection and retention process

2.4. Quality assessment

In the final step, the quality of all 123 identified studies was assessed using quality assessment criteria. The aim of the quality assessment (QA) was to make decisions regarding the overall quality of the identified studies to ensure the value of their findings and interpretations (Kitchenham, 2004; Nidhra, Yanamadala, Afzal, & Torkar, 2013). In doing so, the five (QA criteria) questions listed below were developed to evaluate the remaining studies:

Q1*: Does the research topic addressed pertain to BI system adoption, utilization, and success?*

Q2*: Is the context of the research clear?*

Q3*: Does the research adequately delineate the methodology?*

Q4*: Is the data collection procedure adequately explained?*

Q5*: Is the approach used for data analysis appropriately explained in the research?*

To assess the quality level, three quality rankings – "high", "medium", and "low" – were used for each QA criterion (Nidhra et al., 2013). A study was assigned a score of 1 for a quality criterion if it completely satisfies that criterion. Similarly, a study was assigned a rating of 0.5 if it partially satisfied a quality criterion, and a score of 0 was given when a study did not satisfy a quality criterion. In this study, the highest possible rating was considered to be 5 (i.e. 5 × 1) with regard to the 5 QA criteria, while the lowest possible rating was 0 (i.e. 5 × 0). Based on the coding scheme, a study was considered to be of high quality: if > 3 e.g. 3.5, medium quality: if <3 and >1 e.g. 1.5, 2, and 2.5, low quality: if <1 e.g. 0.5. as exemplified in Table 3 (see Appendix A).

Table 3. Quality Assessment Criteria (QAC)

Study ID	Q1	Q2	Q3	Q4	Q5	Total
B1	1	1	0.5	1	0.5	4
B2	1	1	1	1	1	5

In total, 97 studies were found to be of high quality (79%), whereas 14 studies (11%) were assigned to the group of medium-quality studies. The 12 studies representing low quality (quality score < 1) were excluded from the review list, leaving 111 studies for the SLR.

3. Results

3.1. Data Extraction and Synthesis process

After the selection of 111 relevant studies, the next step was to extract data from them. In this step, a data extraction form was developed to record information from the identified studies to ensure the completeness of the data collection (Kitchenham, 2004). Prior studies have suggested several elements to extract data from the literature (Adams, Nelson, & Todd, 1992; Hoehle, Scornavacca, & Huff, 2012; Kitchenham et al., 2009; Kitchenham et al., 2010). Accordingly, this review considered elements such as the study identifier, for example, a study ID (SID), study reference and year, study type, study objective, study context, tool/system used, framework/theory, key factors, research method and country/region, as shown in Table 4.

Table 4. Elements of the data extraction form

Data extraction elements	Description
Study ID	As a study identifier
Study reference and year	To present the authors and publication year
Study type	To identify studies as journal articles or conference papers
Study objective	To describe the aim of the study
Study context/topic	To state the study theme, for example adoption/utilization/success
Tool/system used	To identify the investigated tool, for example, a data warehouse or OLAP, and system, for example, a BI system
Framework/Model used	To identify the framework/model adopted by BI AUS studies
Key factors	To identify the key factors adopted to study AUS
Research method	To identify the research approach, for example quantitative, qualitative or mixed
Country/region	To identify the countries or regions in which the study was carried out

To record the data for each element accurately, the content of each article was carefully reviewed to extract data from each study using Microsoft Excel spreadsheets and Endnote.

Table 5. Data Extraction Form

SID	Author (s)	Study type	Objective (s)	Topics	Tool/ System	Key theories/ frameworks /models	Key factors	Sample	DC method	Country
B1	(Soliman et al., 2000)	Journal (I&M)	Identified factors of end-user satisfaction with Data warehouses	Adoption	Data ware house	NA	Support provided to end-users, Accuracy, Format and preciseness, Fulfillment of end-user needs	42 business managers	Survey	United States
Note: *DC=Data collection, *NA= Not Available										

Table 5, shown above, exemplifies the recording of data in the data extraction form (See Appendix B). Along with the above-mentioned data extraction elements, articles were also scanned for challenges faced by organizations regarding BI system AUS to investigate the fourth research question. Table 13 presents the extracted challenges in detail.

3.2. Descriptive findings

For this study, a total of 111 studies were selected to be reviewed. Among the 111 studies, 27 were published in the highest publication outlets, according to the Association of Business School (ABS) ranking. Table 6 shows the number of BI AUS articles published in journals ranked as 4*, 4 & 3 by the ABS. Note that among these top-ranked journals Decision Support Systems has published the most articles (6).

Table 6. Publications by Journals

Journals	**Association of Business Schools (ABS) Ranking**		
	4*	**4**	**3**
Information Systems Research	1		
MIS Quarterly	1		
The Accounting Review	1		
Journal of Management Information Systems		3	
Journal of the Association for Information Systems		1	
Decision Support Systems			6
Expert Systems with Applications			4
Journal of Strategic Information Systems			2
European Journal of Information Systems			1
Computers in Human Behaviour			1
Information Systems Journal			1
Totals	**3**	**4**	**20**

Following the data extraction process, the information obtained from the identified studies was analyzed further. The following sections present a descriptive analysis of the results.

3.2.1. Chronological distribution of the studies

The research on BI system AUS has gained prominence over the last two decades. Figure 2 represents the distribution of all the studies from the period 2000 to 2019. It was noticed that there were only a few publications in the years 2000, 2001 and 2002, while the number increased to two in 2003, three in 2004, three in 2005 and two in 2006 and 2007. Likewise, a total of 11 studies were found in the period 2008–2010.

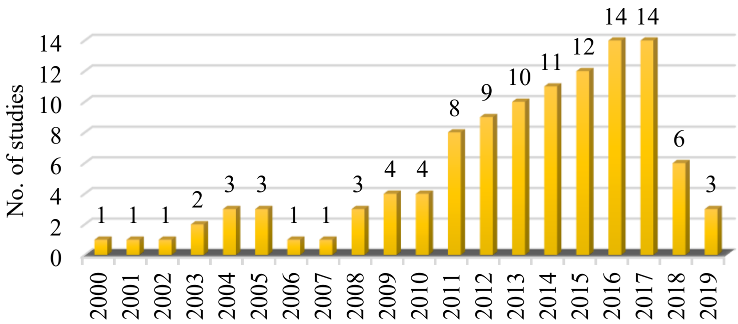

Figure 2. Publications by years from 2000 – 2019

From 2011 to 2019, there was a significant increase in the number of studies: a total of 87 articles were published. In addition, the data analysis revealed a change in the focus from BI systems' components to BI systems over the period 2000 - 2019. In the earlier years, research primarily focused on either data warehouses (DW) or online analytical processing (OLAP), or in some cases, both tools were studied together, as shown in Table 7.

Table 7. BI system/BI tools adoption since 2000-2019

Years	Year System/tool studies						
	DW	OLAP	Combined (DW and OLAP)	Dashboards	Combined (DW and BI system)	BI system	Total
2000-2004	6	1	2	0	0	1	10
2005-2008	3	2	0	0	0	3	8
2009-2012	1	0	0	0	0	22	23
2013-2015	2	0	0	0	0	31	33
2015-2017	1	0	0	1	0	26	28
2018-2019	0	0	0	0	2	7	7
Total	13	3	2	1	2	90	111

In the later years, the focus of research shifted to BI systems. From 2009 to 2019, a total of 86 studies referred to BI systems.

3.2.2. Research methods

Several research approaches, including the qualitative and quantitative methods, have been adopted in the BI system AUS research. The distribution of research types, namely conceptual, qualitative, quantitative, and mixed methods (quantitative + qualitative), is presented in Figure 3.

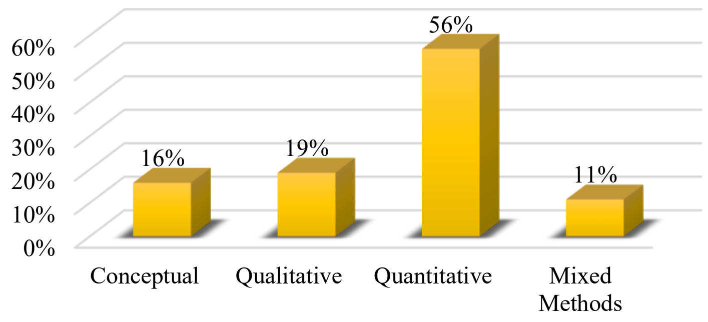

Figure 3. Distribution of research approaches (2000-2019)

Figure 3 reveals that a quantitative research approach has been used by the majority of BI system AUS research. Out of 111 studies, 56% adopted a quantitative approach, as shown in Figure 3. The survey method was chosen frequently in these studies (62 studies), as shown in Table 8. Mail or web-based questionnaires were used to collect data, and the majority of respondents were managers, BI professionals, and executives who were using BI systems (Foshay, Taylor, & Mukherjee, 2014; Han, Shen, & Farn, 2016; Işık et al., 2013). On the other hand, 19% used a qualitative approach, as depicted in Figure 3. However, Table 8 presents a total count of 27 studies employing qualitative research methods - the difference in number is due to, in some cases, two or more research methods (e.g. case study and interviews) being used in a single study. In addition, it was found that eight studies used interviews, one used the Delphi method, and two used observations, whereas 12 studies adopted the case study method (Table 8). In-depth interviews and the Delphi method were utilized to express employees' perceptions of BI systems use (Grublješič & Jaklič, 2015; Yeoh & Koronios, 2010).

Table 8. Research methods

Research Approach	Research Method	Article Count
Qualitative Approach		
	Case study	12
	Interviews	9
	Delphi	1
	Observations	2
	Secondary data	3
Quantitative Approach		

	Survey	62
Mixed-Method Approach		
	Mixed method	11
Others	Not available	11

Of the total, 11% of studies used mixed methods, as shown in Figure 3.

3.2.3. Studies coverage by geographical regions

The 111 studies selected for this systematic review covered at least 39 countries, as shown in Table 9. The number of articles conducted in the United States was relatively high with 24 studies. Taiwan contributed the second greatest number of studies with 17, followed by Australia, China and South Africa (identified in twelve, eight, and seven studies, respectively).

Table 9. Studies published by regions

Country	Article Count	Country	Article Count	Country	Article Count
United States	24	United Kingdom	2	Japan	1
Taiwan	17	India	2	Hong Kong	1
Australia	12	Peru	2	Lithuania	1
China	8	North America	2	Morocco	1
South Africa	7	Canada	2	Nigeria	1
Slovenia	6	Asia	2	Puerto Rico	1
Germany	5	Denmark	1	Scandinavia	1
France	3	Netherlands	1	Switzerland	1
Malaysia	3	Middle East	1	Austria	1
Europe	2	Ghana	1	Israel	1
Iran	2	Italy	1	Jordon	1
Peru	2	Korea	1	Brazil	1
Thailand	2	Bangladesh	1	Middle East	1

In addition, among the developed economies, Germany contributed five studies, France three studies, the United Kingdom two studies, Canada two studies, and Italy one study. On the other hand, among the emerging economies, two studies were found from Iran, Thailand, Peru, and India, respectively, as shown in Table 9. In summary, the majority of research focusing on BI system adoption, utilization, and success, was focused on the United States, Taiwan, Australia, and China. At the same time BI systems are a truly global business solution.

3.2.4. Distribution of studies by sector

The analysis revealed that multiple sectors were frequently addressed by BI system AUS research (40% of the research), such as government services, transportation, insurance, communications, health care, banking, agriculture, construction, and professional services

(Elbashir, Collier, & Sutton, 2011; Ramakrishnan, Jones, & Sidorova, 2012). We found fewer studies in the finance (6%), telecommunications (4%), education (2%), manufacturing (3%), health (2%), retail (3%), and semiconductor sectors (3%), as shown in Figure 4.

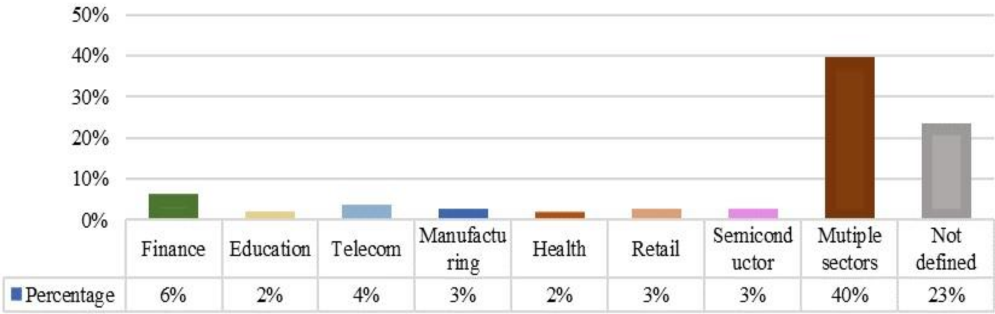

Figure 4. Distribution of studies by sector

However, 23% of the research did not mention or clearly define the sectors in which the study was conducted.

3.3. Descriptive findings with respect to proposed research questions

3.3.1. Areas of investigation

The 111 studies were reviewed to determine their primary area of investigation, that is, the adoption, utilization, or success of BI systems. Hence, the research topic categorization is aligned with these three areas of investigation based on the primary focus of each study. We defined the adoption, utilization, and success concepts as follows (Table 10):

Table 10. Research topic categorization

Topic categorization	Description
Adoption	***Definition***: The initial BI system usage (Karahanna, Straub, & Chervany, 1999; Wang, 2014) ***Description***: Studies explaining the adoption, initial BI system usage, users' intention and satisfaction and system evaluation
Utilization	***Definition***: The intensity of the BI system use (Hou & Papamichail, 2010; Ngai, Poon, & Chan, 2007) ***Description***: Studies explaining the extent of BI system use and its validation
Success	***Definition***: A satisfactory/favourable outcome (Hou & Papamichail, 2010; Ngai et al., 2007) ***Description***: Studies explaining the benefits, effectiveness, impact, and performance, value creation or outcomes

From the categorization, we can state that the topic BI system adoption was covered by 28 (28%) out of the total 111 studies (Figure 5). These studies mainly focused on how BI systems are adopted by end-users while also identifying the factors that exert an impact on the adoption. For instance, Zhao, Navarrete, and Iriberri (2012) identified factors related to the organization (industry and size of resources), provider (vendor recognition, administration and deployment), project (team size and cost) and system (code, data and documentation quality) as being critical to the adoption of open-source BI tools. Mathew (2012) investigated the factors associated with BI system adoption, namely task characteristics (decision support and task complexity), retailer category (management and size), BI system provider characteristics (access and affordability), and decision-maker characteristics (technology, familiarity, and quantitative skills).

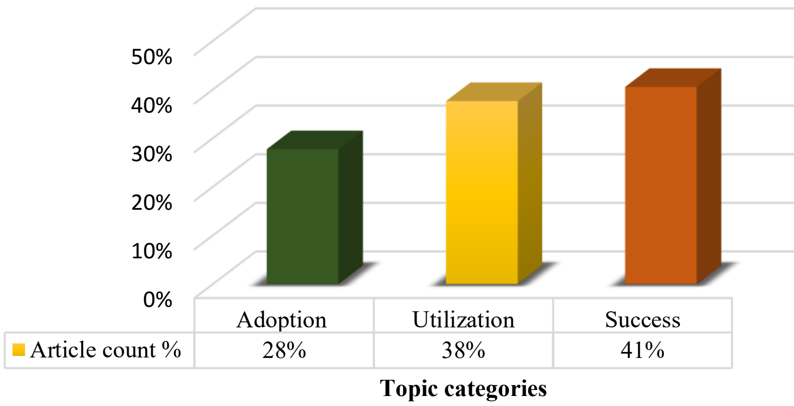

Figure 5. BI system adoption, utilization, & success – Topic Categories

The second category is BI system utilization, which has the second greatest number of studies, specifically 38% as shown in Figure 5. Studies within this research category have provided a discussion on users' behaviours towards BI systems and the motivating factors that allow users to use or continue to use these systems. For example, Bischoff, Aier, Haki, and Winter (2015) adopted a mixed-method approach to explore the factors affecting BI systems' continuous use. Their research revealed constructs such as governance, coverage of user requirements, influence of peers, influence of the organization, perceived ease of use and usefulness, user support, and trust as the main drivers.

The third category is the BI systems' success, highlighted in 41% of the studies. The studies within this research category focused on how organizations achieve success through the use of a BI system and mainly discussed success factors and outcomes, such as impacts, benefits, and performance. Wieder, Ossimitz, and Chamoni (2012) identified factors such as BI management, data quality, BI scope, user satisfaction, and BI use as being important for achieving benefits or success (decision quality and performance) from BI tools.

3.3.2. Key theories/frameworks/models adopted in BI system adoption, utilization, and success research

The data analysis revealed that the selected studies employed a wide range of theories and models to examine BI system AUS. A total of 28 theories/frameworks/models were found covering the BI system research domain, as shown in Table 11.

Table 11. Key Theoretical lenses

Category	Theory/Model/Frameworks	No. of times used	References
Success	DeLone & McLean IS success model	16	(Candal-Vicente, 2009; Dedić & Stanier, 2017; Foshay et al., 2014; Gaardboe et al., 2017; R. Gonzales, Wareham, & Serida, 2015; Hong, Katerattanakul, Hong, & Cao, 2006; Hou, 2012; Kulkarni & Robles-Flores, 2013; Mudzana & Maharaj, 2015; Popovič, Hackney, Coelho, & Jaklič, 2012; Schieder & Gluchowski, 2011; Serumaga-Zake, 2017; Shin, 2003; Wieder & Ossimitz, 2015; Wieder et al., 2012; B. H. Wixom & Watson, 2001)
Adoption and utilization	Technology Acceptance Model	15	(Bach et al., 2016; Brockmann, Stieglitz, Kmieciak, & Diederich, 2012; Chang, Hsu, & Shiau, 2014; Foshay et al., 2014; Gorla, 2003; Grublješič, Coelho, & Jaklič, 2014; Hart, Esat, Rocha, & Khatieb, 2007; Hart & Porter, 2004; Hong et al., 2006; Hou, 2013, 2015; Jiang, 2009; Kohnke, Wolf, & Mueller, 2011; Ramamurthy, Sen, & Sinha, 2008; Zhao et al., 2012)
	Diffusion of innovation theory	10	(Ahmad, Ahmad, & Hashim, 2016; Boonsiritomachai et al., 2016; Jaklič, Grublješič, & Popovič, 2018; Jiang, 2009; Lautenbach, Johnston, & Adeniran-Ogundipe, 2017; Popovič, Puklavec, & Oliveira, 2019; Puklavec, Oliveira, & Popovic, 2014; Puklavec, Oliveira, & Popovič, 2017; Ramamurthy et al., 2008; Yoon et al., 2014)
	Resource based view	4	(Arefin et al., 2015; Fink, Yogev, & Even, 2017; Jaklič et al., 2018; Torres, Sidorova, & Jones, 2018)
	Unified Theory of acceptance and use of technology (UTAUT)	3	(Grublješič et al., 2014; Hou, 2014a; Jaklič et al., 2018)

	Motivational theory	3	(Jiang, 2009; Li, Hsieh, & Rai, 2013; Yoon et al., 2014)
	Technology, Organization, Environment (TOE)	3	(Lautenbach et al., 2017; Puklavec et al., 2014; Puklavec et al., 2017)
	Information processing theory	2	(Richards, Yeoh, Chong, & Popovič, 2019; Torres et al., 2018)
	Expectation-confirmation Model of IS	2	(Han et al., 2016; Hou, 2015)
	Bagozzi, Dholakia and Basuroy (BDB) model	2	(Chang, Hsu, Shiau, & Wu, 2017; Chang, Hsu, & Wu, 2015)
	Theory of Planned Behavior (TPB)	2	(Hou, 2013; Yoon et al., 2014)
	Gorry and Scott Morton framework of management information system	2	(Arnott et al., 2017; Işık et al., 2013)
	Technology to Performance Chain (TPC) model	1	(Kositanurit, Osei-Bryson, & Ngwenyama, 2011)
	Nomological net model	1	(Hou, 2012)
	Expectancy Theory	1	(Chang et al., 2015)
	Social exchange theory	1	(Chang et al., 2015)
	Theory of effective use	1	(Trieu, 2013)
	Porter's value-chain activities framework	1	(Elbashir et al., 2008)
	Institutional theory	1	(Ramakrishnan et al., 2012)
	Technology adoption model	1	(Mathew, 2012)
	Theory of Reasoned action (TRA)	1	(Jiang, 2009)
	Wixom & Watson framework	1	(Dawson & Van Belle, 2013)
	Theory of effective use	1	(Trieu, 2013)
	Limayem et al.'s IS continuance model	1	(Han & Farn, 2013)
	Strategic orientation of business enterprise (STROBE) framework	1	(Arefin et al., 2015)
	Burton-Jones and Straub dimensions	1	(Grublješič & Jaklič, 2015)
	Clark's model	1	(Visinescu et al., 2017)
	Integrative Model of IT Value	1	(Richards et al., 2019)

Among these theories/frameworks/models, DeLone and McLean's (D&M) IS success model, the technology acceptance model, and the diffusion of innovation theory were found to be the most commonly used models in BI system AUS studies, as shown in Figure 6.

DeLone and McLean's (D&M) IS success model (1992, 2003) is one of the most-cited models to assess information technology success. The model proposes six IS success dimensions, namely information quality, service quality, system quality, use, user satisfaction and net benefits (DeLone & McLean, 1992, 2003). These dimensions cover the whole spectrum of information flows from the original production through consumption to the influence on individual and organizational performance. In the context of BI system research, the D&M model has remained the most influential framework in exploring BI system success. A total of

16 studies adopting this framework mainly discussed the factors critical to BI system success and the way in which BI systems influence individuals' decision-making performance and organizations' performance. For instance, a study conducted by Shin (2003) applied the IS success framework to identify success measures in the business intelligence context. The study found that users' satisfaction is dependent on system quality factors, such as data locatability, data quality, and system throughput. Mudzana and Maharaj (2015) amplified the IS success framework as a means of investigating how quality factors, including system quality, information quality, and service quality, contribute to the success of a BI system.

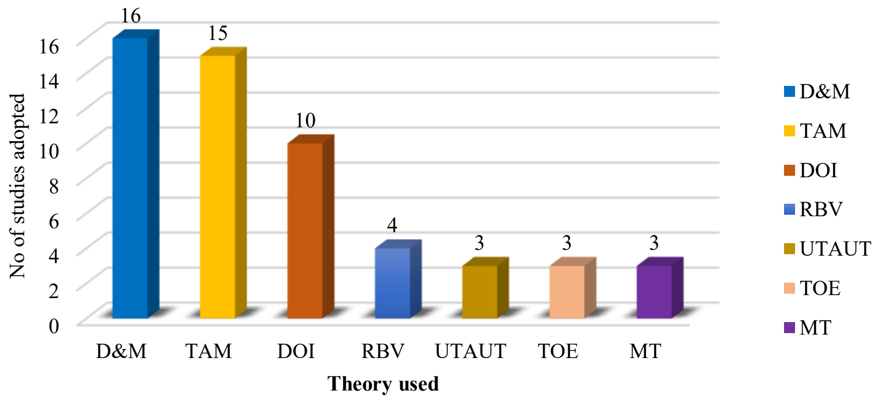

Figure 6. Key theoretical lenses used in BI system research

The second-most-adopted model in the BI system adoption, utilization, and success research reviewed was the *technology acceptance model* (TAM), proposed by Davis (1989). TAM is considered as one of the most famous and parsimonious models for evaluating individuals' IT acceptance. The model constitutes two key constructs, namely perceived usefulness (PU) and perceived ease of use (PEOU), which measure individuals' usage behaviour indirectly through behavioural intention. Fifteen studies have adopted the TAM to study perceptions of BI technology or the intention to accept or use BI technology (Brockmann et al., 2012; Kohnke et al., 2011; Zhao et al., 2012). For instance, Kohnke et al. (2011) applied the TAM to predict users' acceptance of a BI system. They found PEOU to be the strongest predictor of users' behavioural intention in the BI system context.

The next most-cited theory is *diffusion of innovation* (DOI), proposed by Rogers Everett (1995). According to DOI, innovation is communicated through different channels over time and within a particular social system (Rogers Everett, 1995). The theory proposed five perceived characteristics of innovation adoption: compatibility, complexity, observability, relative advantage, and trialability. The analysis revealed ten studies in total that used the DOI theory to explore BI technology adoption. For instance, Yoon et al. (2014) and Boonsiritomachai et al. (2016) amplified DOI to investigate how relative advantage, compatibility, complexity, and related factors affect BI technology adoption.

On the other hand, the adoption rate of other theories such as resource-based view (RBV), the unified theory of acceptance and use of technology (UTAUT), technology–organization–environment (TOE) framework, and the motivation theory (MT) was relatively low, as depicted in Figure 6. Additionally, the absence of decision theory among the 111 BI AUS articles is surprising since the primary purpose of a BI system is to provide actionable intelligence to improve managerial decision-making. The application of decision theory to the effective use of information is crucial to the success of BI systems. This shortcoming is further discussed as an area for BI research improvement in section 5.

3.3.3. Key factors in BI system adoption, utilization, and success

The selected studies were analysed further to identify the theoretical constructs or factors that influence BI system AUS. Taking into account the categorization method by Hwang, Ku, Yen, and Cheng (2004), the analysis revealed three main factors or driver categories, as shown in Table 12. The first category is the "organizational perspective" which focuses on how the alignment of organizational goals, strategies, plans and priorities with the BI systems affects system AUS. This category includes organization-related factors, such as management support (Dawson & Van Belle, 2013), BI management (Wieder & Ossimitz, 2015), and technology-driven strategy (Bach et al., 2016). The second category is the "information system (IS) perspective" which focuses on the importance of a scalable and flexible IT infrastructure, easy-to-use system interface, and a high-quality data and source system for BI system AUS. The "IS perspective" demonstrates the impact of IS-related factors, such as technological BI capabilities (Kokin & Wang, 2014), information and system quality (Mudzana & Maharaj, 2015), and IT infrastructure (Grublješič & Jaklič, 2015), as listed in Table 12.

Table 12. Categorization of key factors adopted in BI system AUS studies

Perspectives \ Categories	Key factors	Adoption	Utilization	Success
Organizational Perspective—Organizational related factors	Management support	(Hwang et al., 2004; Puklavec et al., 2017)	(Kohnke et al., 2011; Lautenbach et al., 2017; Nofal & Yusof, 2016)	(Candal-Vicente, 2009; Işık et al., 2013; Ravasan & Savoji, 2014; Wixom & Watson, 2001)
	Champion	(Hwang et al., 2004; Puklavec et al., 2014; Puklavec et al., 2017)		(Candal-Vicente, 2009; Dawson & Van Belle, 2013; Wixom & Watson, 2001; Yeoh & Koronios, 2010)
	Support and training	(Soliman et al., 2000)	(Bischoff et al., 2015; Hong et al., 2006; Nofal & Yusof, 2016; Popovič, 2017)	(Ravasan & Savoji, 2014)
	Culture	(Puklavec et al., 2014; Puklavec et al., 2017)	(Popovič, 2017)	(Arefin et al., 2015; Kulkarni & Robles-Flores, 2013; Trieu, Cockcroft, & Perdana, 2018)
	Social influence	(Hou, 2013; Jaklič et al., 2018; Jiang, 2009; Yoon et al., 2014)	(Bischoff et al., 2015; Grublješič et al., 2014; Hou, 2014a)	
	Resources	(Yoon et al., 2014; Zhao et al., 2012)		(Dawson & Van Belle, 2013; Ravasan & Savoji, 2014)
	Change management	(Bach et al., 2016)	(Nofal & Yusof, 2016)	(Ravasan & Savoji, 2014; Yeoh & Koronios, 2010)
	Facilitating Conditions	(Hou, 2013; Soliman et al., 2000)	(Grublješič et al., 2014; Hart	(Candal-Vicente, 2009)

			et al., 2007; Hou, 2014a)	
	Organization size	(Puklavec et al., 2014; Ramamurthy et al., 2008; Zhao et al., 2012)		
	Service quality		(Popovič, 2017)	(Gonzales et al., 2015; Serumaga-Zake, 2017; Shin, 2003)
	Well defined vision and goals, BI & business Strategy alignment, effective communication, Effective project management, teamwork & composition, Agile values, Plan driven aspects		(Nofal & Yusof, 2016)	(Batra, 2018; Candal-Vicente, 2009; Ravasan & Savoji, 2014)
	Competitive pressure	(Boonsiritomachai et al., 2016)	(Ramakrishnan et al., 2012)	
	Structural empowerment		(Han et al., 2016; Han & Farn, 2013)	
	BI management			(Wieder & Ossimitz, 2015; Wieder et al., 2012)
	Organizational data environment, Organizational readiness, External support	(Puklavec et al., 2014; Puklavec et al., 2017)		
	User participation			(Dawson & Van Belle, 2013; Ravasan & Savoji, 2014)
	Organizational learning climate	(Yoon et al., 2014)		
	Organizational BI capabilities	(Wang, 2014)		
	Top management commitment			(Batra, 2018; Gonzales, Mukhopadhyay, Bagchi, & Gemoets, 2019)
	Knowledge sharing, Technology-driven strategy,	(Bach et al., 2016)		
IS Perspective – IS related factors	Information/Data Quality	(Bach et al., 2016; Bouchana & Idrissi, 2015; Nelson, Todd, & Wixom, 2005; Soliman et al., 2000; Zhao et al., 2012)	(Adams et al., 1992; Bischoff et al., 2015; Foshay et al., 2014; Hart et al., 2007; Hart & Porter, 2004; Hong et al., 2006; Hou, 2012; Kohnke et al., 2011; Kositanurit et al., 2011; Nofal & Yusof, 2016; Visinescu et al., 2017; Wixom, Watson, & Werner, 2011)	(Dawson & Van Belle, 2013; Gaardboe et al., 2017; R. Gonzales et al., 2015; Işık et al., 2013; Masa'Deh, Obeidat, Maqableh, & Shah, 2018; Mudzana & Maharaj, 2015; Popovič, Hackney, Coelho, & Jaklič, 2014; Shin, 2003; Trieu et al., 2018; Yeoh & Koronios, 2010;

				Zellal & Zaouia, 2015)
	System quality	(Bouchana & Idrissi, 2015; Gorla, 2003; Nelson et al., 2005; Zhao et al., 2012)	(Grublješič & Jaklič, 2015; Kositanurit et al., 2011)	(Gaardboe et al., 2017; Gonzales et al., 2015; Mudzana & Maharaj, 2015; Popovič et al., 2014; Shin, 2003)
	Perceived ease of use	(Bouchana & Idrissi, 2015; Chang et al., 2014; Hou, 2013; Jiang, 2009)	(Brockmann et al., 2012; Hart & Porter, 2004; Hou, 2015)	(Masa'Deh et al., 2018)
	Result demonstrability	(Jaklič et al., 2018)	(Grublješič et al., 2014; Hart et al., 2007; Hart & Porter, 2004)	
	Perceived Usefulness	(Hou, 2013; Jiang, 2009)	(Han et al., 2016; Hou, 2015; X. Li et al., 2013)	(Masa'Deh et al., 2018)
	Relative advantage	(Boonsiritomachai et al., 2016; Puklavec et al., 2017)		(Ahmad et al., 2016)
	Job relevance		(Hart et al., 2007; Hart & Porter, 2004)	
	BI system maturity, BIS effectiveness	(Skyrius et al., 2016)		(Popovič et al., 2012; Richards et al., 2019)
	Comprehensiveness of usage		(Han et al., 2016; Han & Farn, 2013)	
	Compatibility	(Hou, 2013; Jaklič et al., 2018; Yoon et al., 2014)		
	Performance expectancy, effort expectancy	(Jaklič et al., 2018)	(Grublješič et al., 2014; Hou, 2014a)	
	IT infrastructure, integration		(Nofal & Yusof, 2016)	(Gonzales et al., 2019; Peters, Wieder, Sutton, & Wakefield, 2016; Torres et al., 2018; Yeoh & Koronios, 2010)
	Information and analysis usage, Technical readiness of BI			(Karim, 2011)
	Integration with other systems, user access			(Işık et al., 2013)
	BIS dependence			(Trieu et al., 2018)
	BIS infusion			(Trieu et al., 2018)
	Management capability, sensing capability, seizing capability, business process change capability			(Torres et al., 2018)
	Functional performance			(Torres et al., 2018)

	Impact on marketing & Sales, Impact on management and internal operations, Impact on procurement			(Popovič et al., 2019)
	Technological BI capabilities - Data source, Data type, Data reliability, interaction with other systems, User access			(Batra, 2018; Kokin & Wang, 2014)
Users Perspective – Human related factors	Anxiety		(Hart et al., 2007; Hou, 2014a)	
	Absorptive capacity	(Boonsiritomachai et al., 2016)	(Elbashir et al., 2011)	
	Team IT knowledge and technical skills	(Boonsiritomachai et al., 2016)	(Elbashir et al., 2013)	(Ravasan & Savoji, 2014; Torres et al., 2018)
	Self-efficacy	(Hou, 2013)	(Hou, 2014a)	
	User Involvement			(Kulkarni & Robles-Flores, 2013)
	Personal innovativeness	(Popovič et al., 2019; Wang, 2014)		
	Loss of power, Changes in decision-making approach, Job/skills change		(Popovič, 2017)	
	Conscientiousness, emotional stability, extraversion, openness to experience		(Chang et al., 2017)	

The third category is the “users’ perspective,” which shows the investigation of human-related factors, as shown in Table 12. The analysis of these key factors revealed that human factors have been largely ignored in the study of BI system AUS. Few studies have taken users’ perspective into account. The focus of the majority of studies has remained limited to either organizational or IS-related factors as the most important influencers to AUS.

3.3.4. Challenges in BI system adoption, utilization, and success

Undoubtedly, BI systems are critical for organizations because of their ability to predict, reason, plan and solve problems in a way that enhances organizational decision processes, enables effective actions, and helps to attain organizational goals (Popovič et al., 2012). However, this study found that organizations face many challenges in terms of system adoption, usage, and implementation success. A few challenges, highlighted in recent studies, are listed in Table 13. One important challenge to the adoption of BI systems is “individual-level acceptance and use.” Users’ low level of acceptance or their resistance to utilizing BI systems is a key challenge for the management (Chang et al., 2015; Foshay et al., 2014; Kohnke et al., 2011; Popovič, 2017). From this perspective, researchers have highlighted users' lack of motivation, capabilities, ability to explore the system and system logics, and system errors as key challenges at the user level (Seah, Hsieh, & Weng, 2010; Wieder et al., 2012).

Likewise, Popovič (2017) found that the fear of losing power over information, a change in job skills (e.g., the requirement of new skills to perform routine tasks) and a change in the decision-making approach (e.g., integrating BIS into organizational processes) are the main reasons for users' resistance to a system.

BI systems support analytical decision making in knowledge-intensive activities. In this view, some challenges include a lack of knowledge about the system and the absence of (required) technical skills (Boonsiritomachai et al., 2016). Users may be unwilling to embed a BI system into their routine tasks if they believe that they do not possess the knowledge and technical skills required to use that system.

Table 13. Challenges

Challenges	Citations
- Low of system acceptance, - Resistance to use BI systems	Chang et al. (2015); (Foshay et al., 2014; Kohnke et al., 2011; Popovič, 2017)
- Lack of motivation - Lack of capabilities - Lack of ability to explore the system - Lack of system logics - System errors	Seah et al. (2010); (Wieder et al., 2012)
- Fear of losing power over information, - Change in job/job skills - Change in the decision-making approach - Absence of information culture - Inappropriate training - Insufficient service quality	Popovič (2017)
- Lack of knowledge - Absence of requisite technical skills	Boonsiritomachai et al. (2016)
- System issues - Infrastructural issues	Hannula and Pirttimaki (2003); Olszak (2016)
- Insufficient communication between IT staff and business users	Richards, Yeoh, Chong, and Popovič (2017)
- Lack of timely response, problems of reporting data, lack of knowledge, user-system interaction, system error	Deng and Chi (2012)

Other researchers have pointed out that the use and success of a BI system are affected by infrastructural issues (Hannula & Pirttimaki, 2003; Olszak, 2016), insufficient communication between IT staff and business users on the use of the system (Richards et al., 2017), the absence of an information culture, inappropriate training and insufficient service quality (Popovič, 2017). Deng and Chi (2012) emphasized that problems associated with system use must be overcome by the management to integrate systems into their routine work and to exploit the full benefits of the implemented systems. A lack of timely responses to users' difficulty in employing system features in their assigned tasks can limit the use of a BI system, which subsequently affects the task performance of both users and organizations negatively.

3.3.5. Knowledge gaps and prospects for future research

The examination of the selected studies revealed that the research on BI systems adoption, utilization, and success has evolved gradually and prompted increased interest and attention among scholars and practitioners over the last decade. From this review's findings, it is notable that the organizational and IS perspectives were considered frequently while investigating the adoption, utilization, or success of BI systems while the user perspective was less frequently considered. Individual user acceptance and effective use is one of the greatest challenges for BI systems. An organization's goal of achieving high returns through BI investments is highly dependent on the effective utilization of a BI system (Trieu, 2017), which in turn depends on the end-users. On the flip side, users' resistance or underutilization of BI systems may result in workflow problems (Popovič, 2017; Trieu, 2017), that ultimately produce strategy blindness (Arvidsson, Holmström, & Lyytinen, 2014) and negative business performance (Deng & Chi, 2012). Therefore, it is important to understand individual-level issues and resolve them to exploit the full benefits of BI systems and to reduce the risk of implementation failure (Deng & Chi, 2012; Popovič, 2017).

However, knowledge gaps exist for three user level areas and therefore represent opportunities for future research, namely, individual IT competences, user perceptions, and user decision performance.

The first promising focus for future research would be user IT competencies, namely IT-related skills, IT knowledge, utilization ability, or any other individual characteristics. Research on individual IT competencies is important since BI systems comprise reporting and analytics for end-users. The former involves the creation of reports through dragging and dropping, whereas the latter involves business knowledge discovery and deep analysis with advanced statistical functions (Chang et al., 2015). In the case of the presence of the required IT competencies (such as IT knowledge and skills), users would deploy a BI system in their routine tasks easily, while, in the case of their absence, users may have to invest more effort in gaining an understanding of the given functions and available data, which may lead them to avoid using the system. In addition, along with the IT competencies, the presence of specialized analytical skills such as skills to perform statistical, financial analysis and forecasting model building (Gholamreza Torkzadeh & Lee, 2003), would escalate the use and success of BI system. Many researchers have highlighted the significance of users' competencies for the system use and success of IS (Shih, 2006; Gholamreza Torkzadeh & Lee, 2003; Yoon, 2008) in general and BI systems specifically (Kohnke et al., 2011; Richards et al., 2017). However, this review's findings revealed that none of the empirical studies have empirically tested IT competencies at the individual level in BI system AUS research contexts. Therefore, future BI system research should include users' IT competencies. Future studies could also apply individual-level theories, such as the motivation theory (Deci & Ryan, 2002), to determine individual behaviour in the BI system research domain.

Secondly, the exploration of users' perception is important, because users' positive perception of a BI system performance would improve their likelihood of using the system (Grublješič & Jaklič, 2015) and ultimately the success of the system. The perceived positive performance impact would encourage users to apply the system frequently to their routine tasks. This review's findings revealed that, with the exception of researchers applying the TAM model, studies have overlooked the perceived system impact of BI system AUS. Thus, this study suggests that system perceived impact (e.g. task productivity, task innovation, and management control) – proposed by Golamreza Torkzadeh and Doll (1999) – could be taken into consideration to gain a better understanding of users' perspective about the innovative and productive use of BI systems.

Table 14. Summary of existing knowledge, knowledge gaps and future research prospects

	Existing body of knowledge	**Knowledge gaps and prospect for future research**
BI AUS research	*Organizational perspective* • Focused on organizational aspects such as management support (Dawson & Van Belle, 2013), BI management (Wieder & Ossimitz, 2015), well-defined vision and goals (Ravasan & Savoji, 2014), Clear vision & planning (Nofal & Yusof, 2016) etc. *IS perspective* • Focused on IS aspects such as scalable and flexible IT infrastructure (Peters et al., 2016), data quality (Hong et al., 2006), compatibility (Hou, 2013) etc.	*Measurement of the users' perspective* • Users' competencies – IT competencies and analytical skills etc. • Users' perceptions towards BI system – perceived system impact at the individual level. • Users' decision-making performance
Theoretical groundings	*Adaptation of IS theories* • D&M (16) • TAM (15) • DOI (10) • Others [See Table 11]	*Individual-level theories* • Motivation theory • Social cognitive theory *Decision theory* • Huber's theory

In addition, this review of the BI literature showed that the majority of BI research has focused on the adaptation of traditional IS theories to investigate BI system AUS. These studies have mainly focused on individuals' system use and their performance and organizational performance. According to Yuthas and Eining (1995), when information is critical to improving managerial decision making, then decision making performance would be relevant for the evaluation of an information system. BI systems are solutions typically designed to support decision making in an organization (Popovič et al., 2012), yet the measurement of individual's decision-making performance is largely missing from the BI system research. Thus, Huber's theory (Huber) could be applied in future research to understand the impact of advanced technologies such as BI technologies on organizational decision making to evaluate BI success. Table 14 presents the summary of past knowledge, gaps, and future research prospects.

4. Limitation of the research

This systematic review has several limitations that are important to note. These limitations, in turn, provide direction for future research. Firstly, the literature search was focused on three main categories of BI investigation, specifically the adoption, utilization and success of BI systems. Future research may broaden the research strategy to identify additional insights and opportunities in the BI system research domain. For example, future studies should focus on decision making performance as a key measure of BI success.

Secondly, the focus of the review was limited to BI systems and a limited set of their components, such as data warehouses, OLAP, and dashboards. Future studies could consider data exploration techniques, for example, data mining, to provide additional useful insights.

Lastly, the review comprehensively examined the theoretical lenses and the key factors that contribute to AUS. However, it did not consider the relationships among factors and their collective impact on success outcomes. Future research could employ a meta-analysis to extend knowledge in this area.

5. Implications and Conclusions

This SLR provides a contribution to both academic scholars and practitioners. For scholars, it offers a valuable synthesis of two decades of BI research to better understand the current state of BI system AUS research. BI system AUS research is still progressing. Thus, this review can serve as a reference for scholars as it reports on the theoretical lenses, key factors, and research methodologies used in the BI system AUS studies to date. Additionally, the review provides a rich picture of the existing literature, informing scholars of the areas in which the research is lacking and further exploration is needed. The results of the review will also be useful for scholars to direct their future efforts in research that might be more applicable to organizations in terms of helping them to improve the use and success of the implemented BI systems.

Researchers can apply one of the three most frequently used research frameworks or theories (DeLone & McLean IS Success Model, TAM, or DOI) as the foundation for their BI system research. However, the study of BI system success needs to be also grounded on decision theories to help understand how systems and the information they produce can benefit the decision process. In addition, scholars can apply and integrate individual-level theories to reflect a more comprehensive view of BI system AUS. Researchers should devote more attention to exploring the impact of user-centred factors, such as IT competencies on BI system AUS.

For practitioners, such as business analysts, managers, and IT executives, the analysis of the BI system AUS literature provides some needed insights. Despite increasing investments in BI systems, many organizations are still unable to attain the desired success from these systems due to underutilization and ineffective use (Arefin et al., 2015; Gartner, 2015). Our analysis of the past two decades of research on BI system AUS has revealed that management support, training, the organizational culture, well-defined vision and goals, BI & business strategy alignment, data, and system quality, and IT infrastructure as being important to BI AUS. Organizations also need to pay more attention to user-centred issues to improve the success of their BI system investments. BI AUS is dependent on users (Olszak, 2016), so organizations must emphasize the development of specific capabilities and competencies (of users) to realize organizational success. Additionally, a corporate culture based on facts, knowledge, and learning can motivate organizations to apply the information offered by BI systems.

In conclusion, this study has provided a comprehensive and systematic review of BI system adoption, utilization, and success (AUS) research over the period of the last two decades. Following a rigorous guideline for studies' selection, 111 peer-reviewed studies were identified and reviewed. The results obtained from the review indicated that BI research covering three main categories, adoption, utilization and success, made significant progress from 2000 to 2019. The distribution of the selected studies with regard to the different sectors/industries showed that most of the BI system research was conducted in government services, transportation, insurance, communications, health care, banking, agriculture, construction, and professional services sectors. Additionally, the data analysis with regard to the research methodologies revealed that the quantitative methods remained the most-adopted research approach. Furthermore, frameworks such as the DeLone & McLean IS success model, technology acceptance model, and diffusion of innovation theory were the most dominant in BI system research.

Researchers have identified different factors that are critical to BI system AUS. A close examination of the key factors revealed that the majority of studies reported either organizational or IS-related factors as being the most important to AUS, whereas user-related measures have received limited attention. Based on the review of 111 studies, the study also highlighted 1) the challenges facing BI systems, 2) gaps in our knowledge of BI systems AUS and 3) prospects for future research.

ǂ[2] Measuring Business Intelligence Systems Success

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Abstract

Inevitably, business intelligence (BI) systems are becoming extremely important for both public and private sector organizations due to their ability to support managerial decision making. However, academic and practitioner-oriented research suggested that the success of these systems has not yet been fully realized by several organizations. Information system (IS) researchers have evaluated the success of BI system by adopting and proposing different success measures; however, to date, there is no appropriate consensus available for the measurement of BI system success. Using the theoretical groundings of DeLone & McLean's IS success framework, this study reviews the measures used in past research studies and proposes those measures that are indispensable for the BI systems' success. Therefore, the objectives of this study are to; i) understand what is known about evaluating success in the BI system context, and ii) extend knowledge by proposing success metrics to be used for measuring success in the BI system context. To achieve the underlying objectives, this study used a literature review approach and reviewed 92 articles published between the period of 2000-2017 dealing with the success related aspects in BI system research domain. The findings are summarised using the six dimensions of the D&M model. The study reveals an updated and consolidated set of success metrics to evaluate the success of BI systems.

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[2] The paper has been submitted to European conference on Information Systems (ECIS).

1. Introduction

Much attention has been paid to the use of information systems (IS) in many areas of business since the emergence of information technology (IT). Over time, different types of IS have been developed and implemented to address the varying needs of organizations. These systems have evolved according to the new business demands, the nature of decision-making, and end-users' information requirements (Watson, 2009), each providing unique characteristics. In recent times, business intelligence systems (henceforth referred to as BI systems) have attracted significant interest from senior management due to their ability to support managerial decision making (Elbashir et al., 2013). However, the implementation of these systems has been a complex undertaking requiring significant resources and infrastructure (Yeoh & Koronios, 2010) with mixed results.

According to a survey report on IT spending, BI systems have been ranked among the topmost priority of chief information officers (CIOs). About 60% CIOs predicted to prioritize spending on BI systems (Forbes, 2018). By the end of 2020, it is expected that the BI systems market will grow to $22.8 billion (Gartner, 2017). Despite significant spending and growth, the assessment of the success of BI systems is still a problem, and remains both a theoretical and managerial challenge (Gauzelin & Bentz, 2017; Yeoh & Popovič, 2016). More than 87% of organizations have been classified as having a low BI technology maturity (Gartner, 2019), which creates a big hurdle for organizations to increase value of their data assets and exploit implemented technology to its full extent.

The success of a BI system is defined as the positive outcome or the value or the benefits an organization attains from its BI investment (Işık et al., 2013). However, the measurement of the success of BI systems is challenging and complicated for many organizations (Dedić & Stanier, 2016). Contemporary organizations have implemented these systems to achieve different benefits; therefore, BI success varies across organizations and industries depending on the benefits expected from the use of BI systems (Gaardboe & Svarre, 2018; Işık et al., 2013). Some organizations use traditional financial measures to quantify tangible benefits such as return of assets/sales/investment (Hou, 2014a; Lee, Hong, & Katerattanakul, 2004; Owusu, 2017) and increased profitability (Hou, 2016) whereas some use cost-benefit comparisons to assess BI system success (Pirttimäki, Lönnqvist, & Karjaluoto, 2006). BI systems are becoming extremely important for both public and private sector organizations. Therefore, organizations need not to merely rely on the financial benefits and cost versus benefits comparisons (Schieder & Gluchowski, 2011) but also to move beyond the traditional measures to adequately assess the success of BI initiatives.

In IS literature, researchers have derived various models to study the nature and phenomenon of IS success in different contexts. For instance, DeLone & McLean's (D&M) IS framework is one of the most prominent and parsimonious IS success frameworks, that has been adopted by many studies to understand the success of an IS (Tam & Oliveira, 2016; Wu & Wang, 2006). The D&M model proposes six interrelated success dimensions and provides a comprehensive set of success measures for each dimension (DeLone & McLean, 1992, 2003). Following the DeLone and McLean (1992, 2003) framework, researchers have adapted different success measures, based on the nature and type of system being assessed, to evaluate the IS success dimensions as proposed by D&M (Petter, DeLone, & McLean, 2008). In the BI system context, many researchers have attempted to evaluate the success of BI system (Mudzana & Maharaj, 2015; Yeoh & Koronios, 2010); however, they have used many different scales to measure success. A recent literature review has found that the DeLone & McLean IS Success framework was the most frequently applied theory or framework for BI research followed closely by the Technology Acceptance Model (Ain, Vaia, DeLone, & Waheed, 2019). While some studies adopted success measures proposed by D&M, others created their indexes to measure system success, thus reflecting that there is no consensus on the appropriate measures of BI system success (Popovič et al., 2012; Schieder & Gluchowski, 2011; Yeoh & Popovič, 2016). According to DeLone and McLean (1992, 2003), the number of measures used to investigate an IS success should be consolidated so that the findings can be validated and easily compared. In this view, more rigorous research is needed to explore a consistent set of success metrics to measure BI system success (Olszak & Ziemba, 2012).

DeLone & McLean's IS framework provides a concrete foundation to determine the success of an IS. Therefore, this study uses the theoretical groundings of D&M's framework to review the measures indispensable for the success of BI systems. Thus, this study aims to i) *understand what is known about evaluating success in the BI system context, and ii) extend knowledge by proposing success metrics to be used for measuring the success in the BI system context.*

The remainder of the paper is as follows; section two discusses DeLone and McLean's IS success framework. Section 3 represents the research methodology. Section 4 presents the findings organized by the six success dimensions and their measures. Section five discusses the findings, and section 6 covers the implications, recommendations for future research and conclusions.

2. Background: IS success Framework

The IS success framework, proposed by DeLone and McLean (1992), is one of the fundamental and comprehensive frameworks to determine an IS success. DeLone and McLean reviewed various empirical and theoretical studies published during the period of 1981-1987 and proposed six interrelated and interdependent dimensions of IS success; system quality, information quality, user satisfaction, use, organizational, and individual impact. Figure 1 presents the original D&M framework.

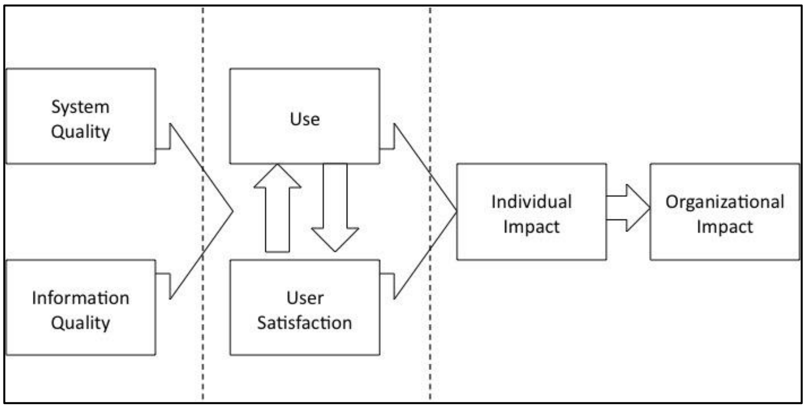

Figure 1. IS success framework (DeLone & McLean, 1992)

After the emergence of IS success framework, researchers called for modifications to the IS success framework. Pitt, Watson, and Kavan (1995) evaluated the SERVQUAL instrument from the IT perspective and argued that IS framework did not incorporate service quality as a dimension of success framework, and it is necessary to incorporate service quality. They asserted that system and information quality, together with service quality influence system use and user satisfaction. Whereas, Seddon (1997) argued that D&M framework is confusing in its original form because both process and variance models (use and success) were combined within the same model. In addition, they argued that the concept of use construct is ambiguous by pointing out that use precedes benefits and impacts, but does not cause them. DeLone and McLean responded to Pitt et al. (1995) argument by adding service quality to the original framework Delone and McLean (2003). However, they responded to Seddon's (1997) arguments that variance and process models together represent the strength of the IS framework, and system use is an appropriate dimension of success, thus retained the 'system use' in extended version of success model. In addition, individual and organizational impact construct was collapsed into one category called "net benefits" (see Figure 2).

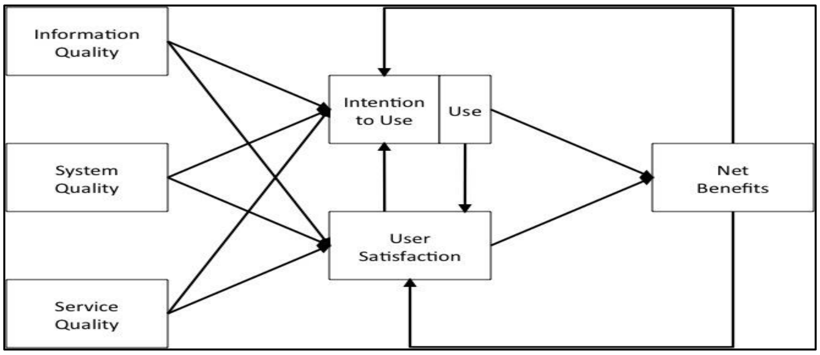

Figure 2. IS success framework (Delone & McLean, 2003)

The six success dimensions reported by DeLone and McLean (1992, 2003) are discussed below:

i) *System quality (SQ)*: SQ captures the desired characteristics of an IS. For instance, system accuracy, flexibility, reliability, efficiency, sophistication, usefulness of system features and functions, response time, ease of use and learning, availability, adaptability, and usability.

ii) *Information quality (IQ)*: IQ focuses on the desirable characteristics of output that an information system produces. For instance, relevance, usefulness, precision, consciousness, timeliness, accuracy, format, clarity, readability, currency, completeness, ease of understanding, security, and personalization.

iii) *Service quality (SerQ)*: SerQ focuses on the support provided to the users by the IS department, developer or vendors. For example, empathy, assurance, and responsiveness.

iv) *Use*: System use referred to as the degree to which individuals use the capabilities of an IS. For instance, duration of use, nature of use, navigation patterns, number of site visits, frequency of use and number of transactions executed.

v) *User Satisfaction (US):* The US focuses on the individuals' satisfaction with an IS. For instance, satisfaction with specifics, overall satisfaction, repeat visits, user surveys and repeat purchase.

vi) Net benefits (NB): NB focuses on the ultimate impact of an IS on groups, individuals, organizations, and industries. Examples include cost savings, time savings, and reduced search costs, etc.

3. Methodology

This study follows a literature review approach to assess the cumulative knowledge of system success in the BI system research domain. The literature review is one of the well-established traditions to thoroughly summarize and integrate findings of past studies to present the knowledge on the topic being studied (Cronin, Ryan, & Coughlan, 2008; Hart, 2018). The approach involves four major steps. The first step selection of the research topic – has been identified and presented in Section 1 – is defined as the success of a BI system. Having a clear picture of the existing knowledge on BI system success will facilitate future studies in this research domain. The remaining literature review steps are discussed below;

3.1. Search the relevant literature

Having selected a research topic, the next step involves searching and identifying the relevant literature in a structured way (Cronin et al., 2008). To achieve the underlying objective, this study followed a structured approach suggested by Webster and Watson (2002) to find relevant articles. Firstly, the literature search was undertaken using a particular search title or keywords in top leading electronic databases such as 'ScienceDirect, Emerald insight, ProQuest, EBSCOhost, Wiley Online Library, JSTOR Archive, Sage Journals, IEEE Xplore, Taylor & Francis Online, ACM digital library, and Springer-Link', covering journals in a broad range of fields as shown in Table 1. The candidate studies were identified by using multiple search titles or keywords such as "business intelligence success", "antecedents of Business intelligence system success", "business intelligence system success", "impact of business intelligence system" and "success factors in business intelligence system context". Since a business intelligence system consists of a combination of technological tools such as a data warehouse, online analytical processing (OLAP), and dashboards, the terms such as data warehouse, online analytical processing, and dashboards were also used to find the relevant literature. In addition, Boolean operators AND/OR were also applied and terms such as "business intelligence system; implementation and/or success, use and/or success, adoption and or success", "data warehouse 'use' and/or 'success'", "OLAP 'use' and/or 'success'", "dashboard 'use' and/or 'success'" etc were used. The search was limited to full-length peer-reviewed articles and proceedings. This circumvented editorials, books, book reviews, trade magazine articles and non-scholarly work to be part of the search. In addition, the year 2000 was selected as the starting year since the first few articles related to BI system research were found in that year (Soliman et al., 2000; Wixom & Watson, 2001). Articles with at least one citation were considered for literature review.

Table 1. Selected electronic databases for literature search

Electronic databases	• ScienceDirect, Emerald insight, ProQuest, EBSCOhost, Wiley Online Library, JSTOR Archive, Sage Journals, IEEE Xplore, Taylor & Francis Online, ACM digital library, Springer-Link, and Web of Science
Area focused	• Information systems, business, and management, management information system, accounting, business, information science, social science interdisciplinary, operation management, finance, information, and management.

As a means to ensure the completeness of the search, a manual search through backward and forward approach (Webster & Watson, 2002) was performed as well. In the first approach, the list of identified studies was triangulated with the reference list of identified studies to find further studies which did not appear in the search list. Secondly, additional references were used to find further related articles.

To perform a literature review, it is important to analyse as much related literature as possible on a research topic (Petter et al., 2008); therefore, along with empirical studies, conceptual studies were also included in this literature review. Taken together, the search result yielded 586 articles relevant to the BI research domain. Upon scanning, studies that did not focus on the BI system were excluded from the review list. Thus, 399 articles were excluded in the first phase. In the next phase, the content of the remaining 187 studies was further reviewed to ensure that study focused on BI system and theoretical construct or dimensions and measures used to examine the success of BI system were provided. The review further excluded 95 studies as some of these studies did not fulfil the criteria, whereas others represented technical perspectives, book reviews/chapters, and no full length. Thus 92 studies from year 2000-2017 were qualified for analysis.

3.2. Synthesizing and reviewing the relevant existing literature

After the collection of relevant articles, the next step was to synthesize and analyse the literature that has been gathered (Cronin et al., 2008). To synthesize the data, firstly, two authors reviewed all retained 92 studies independently and sought answers to the following questions:

i) Is the study conducted in the BI system context?

ii) Are success constructs, dimensions, and measures being available in the study?

iii) What are the constructs, dimensions, and measures fall under the taxonomy of D&M framework?

While reviewing each identified article, the authors coded the data for each article using the Excel sheet according to the proposed research questions and the six dimensions of success from D&M model. The review revealed several success constructs, dimensions, and measures were used in BI system research. Due to the D&M IS success framework, it was easy to organize the data of the studies that were found using its taxonomy. Whereas the data of other studies were quite complicated to organize as several measures were dispersed, some measures have been used under one construct or dimension more than once, yet some did not fit into a construct or dimension under investigation. After the authors finished the coding of data based on their judgments, the data was compared to examine the coding patterns. The coding patterns did not reveal many differences except for few cases which caused disagreement among the authors. The third author, a field expert intervened to facilitate a discussion to provide a consensus for the coding of such cases. In addition, once the coding was completed, the field expert reviewed the coding matrix to provide the final agreement on the appropriate listing of measures under the six IS dimensions, namely system quality, information quality, service quality, use, satisfaction, and net benefits. The following section discuss the analysis and findings in detail.

4. Analysis and findings: Success dimensions and measures

Prior studies have examined BI system and its applications in different environments such as electronic industry (Hou, 2012, 2014a), financial services (Dawson & Van Belle, 2013), banking sector (Owusu, 2017) and corporate sector (Arefin et al., 2015; Gorla, 2003; Popovič et al., 2012). These studies have either adopted different IS theories such as Technology acceptance model (TAM) (Davis, 1989), Unified theory of acceptance and use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003), IS success framework (DeLone & McLean, 1992, 2003) or created their own modified models to evaluate BI system success. Given that, there are many different scales that have been employed to measure the success of BI system. The following section identifies the operationalizations of success measures under each success dimension proposed by DeLone and McLean (1992, 2003).

4.1. Measuring System Quality

System quality – reflects the desired attributes of an IS – has been used by many researchers to evaluate the success of the BI system. To measure BI system quality, researchers proposed and tested numerous measures as exemplified in Table 2 (see Table 9, Appendix D[3]).

Table 2. System Quality Measures

Measures	Frequency (No. of studies used)	Descriptors

[3] Table 9 in Appendix provides a detailed analysis and a complete list of descriptors.

Ease of use	33	• Easy to use • User-friendly • Easy to do what one wants to do • Clear and understandable interaction • Ease of information finding • Easier to gather information • Easy to extract
Usefulness	22	• Provide sufficient information • Provide reports • Provide details on demands • Compatibility
Response time	16	• Speed of execution time for initial BI report or dashboard • Speed of execution time for SQL query • Speed of re-execution time when changing reports • Speed of execution time when drilling down, conditioning, removing or adding columns in reports • Information is processed and delivered rapidly without delay
Easy to learn	15	• Easily comprehend for users
Presence of Features & Functionality	14	• Functionality • Presence of multidimensional tables • Presence of graphics • Capability to redefine dimension • Extract information
Accessibility	13	• Up-to-date information

Among these, ease of use and usefulness were among the most frequently used system quality success criteria because of a significant amount of research relating to the technology acceptance model (Davis, 1989), and Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). The majority of studies reported "ease of use" as a key system quality measure. These studies proposed a variety of characteristics to measure the concept of ease of use; including, easy to use (Gaardboe et al., 2017; Serumaga-Zake, 2017), user friendly (Hart et al., 2007; Hou, 2012), easy to locate data (Hong et al., 2006; Shin, 2003), clear and understandable interaction (Foshay et al., 2014; Hou, 2015), ease of information finding (Kao et al., 2016; Kulkarni & Robles-Flores, 2013), ease to gather and extract information (Hou, 2014b; Visinescu et al., 2017).

Twenty-two (22) studies included the "usefulness" construct characterized by concepts such as compatibility (Ahmad et al., 2016; Grublješič & Jaklič, 2015), sufficient information, reports (Dedić & Stanier, 2017) and details on demand (Chung, Chen, & Nunamaker Jr, 2005) to measure system characteristics. Response time, i.e. quick or timely response of a system to process the requests for information or action, was proposed as a system quality dimension by 16 studies. BI users may perceive the "response time" of BI system in terms of speed of execution time for BI reports or dashboard, SQL query, changing reports and erroneous descriptions, drilling down, and removing or adding columns in reports (Dedić & Stanier, 2017), and getting information in time rapidly and without delay (Hou & Papamichail, 2010; Nelson et al., 2005; Popovič et al., 2012). " Easy to learn" was addressed in fifteen studies and "accessibility" i.e. access to system and information in thirteen studies. Finally, flexibility i.e. adaptability of system to users' needs, and changing conditions, and reliability i.e. dependability or stability of system were both discussed in seven studies each.

Some studies focused on the other measures such as features and functionality of the BI system which were measured as the presence graphics and multidimensional tables, system's capability to redefine dimensions and extract detailed real-time data, query building with click-select feature and query languages, customized report and graphic/chart generation, summarization, navigation and so forth (Deng & Chi, 2012; Gorla, 2003; Kulkarni & Robles-Flores, 2013). The assessment of the literature revealed that fourteen studies highlighted the presence of features and functionalities as important to measure the BI system characteristics. A small number of studies such as that Lautenbach et al. (2017) suggested precision/efficiency and such as Lin, Tsai, Shiang, Kuo, and Tsai (2009), who suggested security of BI system as success criteria which warrant further attention, development, and validation.

BI systems are increasingly becoming an integral part of organizational users; therefore, the system quality assessment is crucial to understand the success of the BI system. As the use of system increases, some additional challenges may occur at a deeper level of usage. Failing to address the users' needs will likely decrease the system use (Popovič, 2017). Thus, to create value from the implemented system, system attributes related to ease, usefulness, response time, easy to learn, features and functionality, accessibility, flexibility, reliability, efficiency, and security, etc. (see Appendix C) should be taken into account to ensure the success of the system.

4.2. Measuring Information Quality

Information quality (IQ) is one of the key success dimensions that play a key role in shaping individuals' positive attitudes towards the use of an IS (Tam & Oliveira, 2016). In BI system context, IQ comprises the output (information, report) characteristics such as relevance/usefulness, accuracy, understandability, precise/concise, currency, comprehensiveness as exemplified in Table 3 (see Table 9, Appendix D).

Table 3. Information Quality Measures

Measures	**Frequency (No. of studies used)**	**Descriptors**
Accuracy	19	• Accurate information • Free of error • Appropriate error messages and clear instructions,
Relevance/Usefulness	18	• Relevant information • Provides reports exactly as needed • Provides all required information • Actionable information
Understandability	16	• Information to understand the lineage of data • Useful format/Clear format/understandable format • Easy to interpret
Precise/Concise	10	• Precise information, • Information is to the point
Currency	9	• Up-to-date information,
Comprehensiveness	8	• Comprehensive information, • Sufficient information for decision making

The analysis showed that majority of research suggested relevance/usefulness as critical measure of information quality and proposed attributes such as relevant information (Nelson et al., 2005), reports and information exactly according to need (Popovič et al., 2012; Shin, 2003), actionable and useful information for tasks (Bischoff et al., 2015) to measure relevance/usefulness (of information). Accuracy represents the correctness of the information and has been regarded as the most important measure of IQ in the BI system context (Nelson et al., 2005; Popovič, 2017; Shin, 2003). Most studies reported accuracy characterized as accurate information (Foshay et al., 2014), free of error, appropriate error messages and clear instructions etc (Kao et al., 2016) to measure IQ. Sixteen (16) studies addressed the understandability of output using measures such as information to understand the lineage of data (Foshay et al., 2014), clear and understandable format (Hou, 2012; Kositanurit et al., 2011), and easy interpretation (Visinescu et al., 2017). Preciseness/conciseness of information was applied in 10 studies, and currency i.e. update to date information in nine studies, and comprehensiveness of information in eight studies.

To understand and analyse the effectiveness of the BI system, it is important to understand IQ as a broader concept that may encompass the aspects identified as a consolidated metrics in this study (see Appendix C). It is expected that addressing the quality of information may not only provide a better insight into the association of IQ with other dimensions of IS success but also to the understanding of BI system success.

4.3. Measuring Service Quality

Service quality (SerQ) is important IS success dimension that focuses on the quality of support that users receive when using the BI system (Mudzana & Maharaj, 2015; Schieder & Gluchowski, 2011). In the existing body of BI system literature, few studies focused on the SerQ and measured it through five indicators, such as service level, responsiveness, assurance, effective support, and empathy as shown in Table 4.

Table 4. Service Quality Measures

Measures	Frequency (No. of studies used)	Descriptors
Service level	4	• Better service level • BIS service level is perceived to be high
Responsiveness	4	• Prompt response from supporting staff
Effective Support	3	• Satisfactory support • Effective fix from supporting staff
Assurance	3	• Assurance
Empathy	3	• Empathy

The service level and responsiveness were addressed in four studies each. The service level was characterized by the concepts such as better service level (Han & Farn, 2013) and BI system service level perceived to be high (Bischoff et al., 2015), whereas responsiveness was characterized as the prompt or quick response from the supporting staff (Hong et al., 2006). The other indicators such as effective support, assurance, and empathy were reported by three studies each. The effective support was captured using measures such as effective or satisfactory support from supporting staff (Hong et al., 2006; Soliman et al., 2000). Mudzana and Maharaj (2015) and Serumaga-Zake (2017) tested assurance, i.e., staff's ability to boost users' confidence and empathy, i.e. care and personal attention from the supporting staff, as measure of SerQ in BI system context.

The literature assessment indicated that the service quality has not received much attention in the BI system research. BI systems are complex, and the majority of organizations outsource services to the BI system vendors who are involved in system development and support (Mudzana & Maharaj, 2015). In such scenarios, the SerQ of the vendors will be crucial to measure (Petter et al., 2008) which can often be quite complicated as end users take outsourced services for granted and do not consider them as an important part of the organization (Mudzana & Maharaj, 2015). However, measuring SerQ could be of great importance in the context where the complexity of BI solutions leads end-users to have several questions to the IS department regarding the use of such solutions (Schieder & Gluchowski, 2011). In such cases, measures such as empathy, assurance, effective support and responsiveness of IS staff could be the most important components of SerQ to determine the overall success of the BI system.

4.4. Measuring System Use

Over the past few decades, system use – i.e., individuals' use of system in performing tasks – has been regarded as one of the most critical constructs across various IS research domains (Tam & Oliveira, 2016) including the IS acceptance (Davis, 1989), use (Venkatesh et al., 2003), implementation (Hartwick & Barki, 1994), and success (DeLone & McLean, 1992). Several studies examined the use of the BI system, and the use was measured by frequency of use, duration of use, use as part of routine work, and dependency on the system, etc. as exemplified in table 5 (see Appendix D).

Table 5. System Use Measures

Measures	Frequency (No. of studies used)	Descriptors
Frequency of use	12	• Frequency of use • No. of attempts to access the system
Duration of use	7	• Duration of use • Time spent each day/week • Use all the times
Use as part of routine work	6	• Incorporation of system into regular work schedule • Use of system is normal part
Depend upon the system	3	• Rely on BI system functionality

The most commonly used measure 'frequency of use' was addressed by attributes such as the number of attempts by the users to access and use the system (Hou, 2013; Kohnke et al., 2011). Duration of use, such as time spent each week or the approximate share of work using the BI system (Gaardboe et al., 2017; Hou, 2014a) was used by seven studies to measure the BI system use. In addition, use as part of routine work and dependency was addressed using concepts like incorporation and integration of IT into regular work routine/schedules (X. Li et al., 2013) and dependency on the system functionalities (Visinescu et al., 2017) while performing tasks using the BI system.

Prior studies have stressed the need to investigate use from other perspectives rather than merely focusing on traditional measures, e.g., frequency or duration of use, to better understand the use construct (Grublješič & Jaklič, 2015). In BI system literature, few studies documented other attributes such as embeddedness of use, use for learning, use of system interface, and use of various features, etc., to measure BI system use. The BI system implementation success depends on its embeddedness in an organization, thus understanding embeddedness of use (Grublješič & Jaklič, 2015) as an aspect of system use is important.

Different BI users may access BI systems for different purposes, for instance, to analyse and understand data, expand their knowledge of current market trends, and to create new trends or areas (Visinescu et al., 2017), by using various features of BI systems related to standard/predefined/ad hoc reporting, pivoting tables/graphs, ad-hoc and statistical analysis, mining, intelligent mapping and visualization interaction (Han & Farn, 2013). It is, therefore, crucial to address the attributes related to learning, interface and use of features (Kao et al., 2016; Serumaga-Zake, 2017; Visinescu et al., 2017) for better understanding of BI system use construct.

4.5. Measuring user satisfaction

User satisfaction refers to an individual's net feelings resulting from a variety of benefits that an individual expects to get from the interaction with an IS (Seddon, 1997). User satisfaction is one of the most widely studied constructs to measure IS success (Wu & Wang, 2006). Few researchers attempt to measure satisfaction in the BI system context and developed multi-attribute satisfaction measures. Table 6 exemplifies the grouping of satisfaction measures adopted in BI system research.

Table 6. User satisfaction Measures

Measures	Frequency (No. of studies used)	Descriptors
Satisfaction with the use of BIS	11	• Satisfied in using BIS • Pleased with the experience of using BIS • User satisfaction
Satisfaction with the overall performance	9	• Satisfaction with overall performance • Satisfied with performance of BIS • Need fulfilment
Satisfaction with the overall quality of information	6	• Satisfaction with overall quality of information • Information very satisfying • Meets information needs
Satisfaction with the accuracy of the system	4	• Satisfied with the accuracy of system • Acceptable level of reliability and accuracy of analysis

The first category named as 'satisfaction with the use of BIS' presents the measures frequently used to examine the user satisfaction with the system such as satisfied in using BIS (Hou, 2013), pleased with the experience of using BIS (Han et al., 2016), and user satisfaction

(B. H. Wixom & Watson, 2001) as shown in Table 6. Next, most studied measures were found related to the satisfaction with the performance of the BI systems. Shin (2003) reported satisfaction with overall performance of data warehouse, Han et al. (2016) addressed satisfaction with performance of BI system, whereas Kulkarni and Robles-Flores (2013) measure satisfaction as need fulfilment as a result of using BI system. The key function of the BI system is to provide information to the decision-makers; therefore, satisfaction with the quality of information produced by BI system is critical for the quality decision making (Visinescu et al., 2017). In this respect, Nelson et al. (2005), Shin (2003), and Mudzana and Maharaj (2015) measured the satisfaction with the quality of information produced by BI system, as shown in table 6. Other studies have found satisfaction is associated with accuracy of the system and included measures such as acceptable level of reliability and accuracy of analysis (Rouhani, Ashrafi, Zare Ravasan, & Afshari, 2016).

The overall assessment of literature has revealed nine measures for assessing user satisfaction in the BI system context, as shown in Appendix D. Some measures have been studied more, while others received little attention. In organizations, most of the employees rely on BI systems to fulfil their information processing, and decision-making needs these days (Isik, Jones, & Sidorova, 2011). Therefore, along with system and information satisfaction, measuring users' satisfaction towards clarity of information (Kohnke et al., 2011), speed of interacting with the system (Kositanurit et al., 2011), functions and abilities (Kao et al., 2016) and decision-making (Audzeyeva & Hudson, 2016; Visinescu et al., 2017) are important. Further research should employ this comprehensive set of user satisfaction measures to understand the success of the BI system.

4.6. Measuring Net benefits

The implementation of BI systems has become critical for contemporary organizations due to their ability to provide a number of benefits to the organizations (Işık et al., 2013). Many researchers assessed the impact of these systems at individual and organizational levels and proposed multiple measures to report the net benefits at each level. The assessment of these measures revealed 16 categories of benefits in total (see Appendix D). Table 7 presents a few of the more popular categories that exemplify measures used to capture the impact of the BI system.

Table 7. Net benefits measures

Measures	Frequency (No. of studies used)	Descriptors
Improved Job Performance	26	• Changed job significantly • Make my reports effectively • Quicker tasks • Accomplish tasks more quickly
Improved strategic performance	25	• Improved competitive advantage • Improved coordination with business partners/suppliers • Increased organizational efficiency and productivity
Increased individuals Productivity	24	• Increase my/users/staff productivity • Reduced effort
Improved decision making	23	• Better decision making • Enhanced effectiveness in decision making • Right decisions and right actions • Decision resulted in desired outcome
Effective operations management	21	• More effective management • Supplier management • Risk management • Business process management
Marketing & Sales effectiveness	16	• Sales promotions • Marketing • Entering new markets • Enabled real time identification of trends
Increased Profitability & Returns	16	• Increase return on sales • Increase return on investment • Increase revenues • Profit maximization
Improved Products & Services	9	• Creating new products & services • Value-added good/services to customers • Improve product and service quality

At the individual level, a variety of measures are employed, but job performance and productivity measurements seem to be preferred to assess the impact. The individuals' performance impact is the actual performance of the individuals using a system (Tam & Oliveira, 2016); as such, the performance improves with the use of a system (Hou, 2012). The improvements in one's job performance and productivity using BI system was captured in terms of significant change in job (Wixom & Watson, 2001), effective report making

(Gaardboe et al., 2017), and tasks accomplishment (Grublješič et al., 2014), increased productivity (Arefin et al., 2015), and reduced effort (Wixom & Watson, 2001) etc, as shown in Table 7. While BI systems are 'special purpose information system', and the purpose is to support and improve managerial decision-making (Wieder et al., 2012). Out of total, 23 studies examined the impact associated with individuals' decision-making and proposed measures such as better decision making (Hong, 2006), right decisions and right actions (Puklavec et al., 2017), effective decisions (Işık et al., 2013) and so forth.

An extensive amount of studies reported organizational-level benefits as a result of using the BI system. BI system creates economic value by increasing organizational productivity and efficiency, (Dedić & Stanier, 2017), and improving competitive advantage (Elbashir et al., 2008). In addition, analytical information produced by BI system enables organizations to have real-time identification of trends (Fink et al., 2017), creation of new products and services (Elbashir et al., 2011), and improvement in product and service quality and functionality (Hou, 2014b, 2016). Other benefits reported were the effective management (Baars & Kemper, 2008), supplier management e.g. purchasing or inbound logistics (Elbashir et al., 2011), risk management (Ravasan & Savoji, 2014), business process management (Richards et al., 2017), increased return on sales and investment (Elbashir et al., 2008; Hou, 2016) as shown in Table 7.

The impact of BI system could also be measured in terms of improved planning efficiency (Lin et al., 2009), forecasting (Arefin et al., 2015), improved efficiency of internal processes (Elbashir et al., 2008), and flexible manufacturing/operations processes (Elbashir et al., 2011), effective change management (Wixom & Watson, 2001). In addition, some studies suggested measures such BI system identify potential problems faster, increase the understanding of problems, enhance awareness, and protect against unauthorized access (Hou & Papamichail, 2010; Popovič et al., 2012). While other few suggested BI systems improve employee skills and know-how capabilities of employees to perform job such as project management, data analysis and interpretation (Hou, 2014b, 2016), senior/middle management coordination and interaction (Peters et al., 2016), however, these measures need further research validation.

The overall analysis revealed many measures at both individual and organizational levels; however, multiple measures make it difficult to interpret the findings and select the measure for future research. Therefore, all the identified measures are collapsed under 16 categories to provide future research a direction to measure net benefits in BI system context specifically and IS in general. While taking into an account of success measures related to improved job performance, individual productivity, decision making, profitability, and returns, etc. studies should consider the measures related to system efficiency, faster problem detection, improved security, individual growth, and improved forecasting to provides better understanding of net benefits associated with BI system.

5. Discussion

The overall analysis of 92 peer-reviewed articles allowed us to analyse the success measurement in BI system research. Over the past two decades, BI systems have been rapidly adopted and implemented in multinational companies and small & medium enterprises, and, hence, the issue of BI systems' effectiveness and success has largely been part of many practitioners and academicians' debate (Richards et al., 2019). Given that, academic researchers adopted various research methods such as Delphi technique, case studies, empirical analysis, surveys, and interviews to identify that lead to success or enhance BI system effectiveness. These researchers validated various success measurement instruments; some measured and accounted for few success dimensions proposed by DeLone and McLean (1992, 2003) such as system quality, system use, benefits, some focused on multiple dimensions of success, whereas others identified or created their indices to measure the impact or success of

BI systems. As a result, the BI system research is plagued with inconsistent instruments and an inability to generalize the results. Therefore, based on success dimensions proposed by DeLone and McLean (1992, 2003), this study attempted to provide consolidated success metrics by reducing the myriad of measures for the success measurement in BI system context.

The analysed measures were captured under six IS dimensions; system quality, information quality, service quality, use, satisfaction and net benefits (Appendix D). BI systems are well known for their analytic capabilities to provide real-time information to the decision-makers (Hou, 2016; Peters et al., 2016). In this view, a well-designed implemented BI system void of technical failures is necessary prerequisite to fully realized its benefits (Deng & Chi, 2012; Gorla, Somers, & Wong, 2010). A well-designed BI system should not only have required feature and functionalities (Gorla, 2003) but it should also be easy to use and learn (Foshay et al., 2014; Hart & Porter, 2004), flexible (Wixom & Watson, 2001), accessible (Hong et al., 2006), reliable (Nelson et al., 2005), efficient (Lautenbach et al., 2017), available (Deng & Chi, 2012), and secure (Lin et al., 2009). In addition, the information produced by the BI system is used for decision making, thus information quality is critical aspect of BI system success. The system requires to deliver output which represent precise (Kositanurit et al., 2011), comprehensive (Nelson et al., 2005), current (Bischoff et al., 2015), reliable (Hou & Papamichail, 2010), accurate (Shin, 2003), relevance/useful (Bischoff et al., 2015; Hart et al., 2007), understandable (Popovič et al., 2012) information. In addition, the output content (e.g. standard, customized, or interactive reports) should be timely and readily available (Mudzana & Maharaj, 2015) in a representational form (Bach et al., 2016).

The analysis revealed that service quality has been scantly discussed in the BI system context. One possible reason might be that the service quality of BI system involves support from external system developers rather than IS department (Mudzana & Maharaj, 2015). Delone and McLean (2003) suggested that system quality or information quality might be the most important dimensions when measuring the success of a single system. On the other hand, service quality may also be an important component for or measuring the overall success of an IS department (Delone & McLean, 2003). Thus, when the 'IS department' is the context of the study, characteristics such as empathy, assurance (Serumaga-Zake, 2017), effective support, and responsiveness (Hong et al., 2006) of IS staff could be employed to determine the success.

Prior studies have reported the end-users' use of the BI system is one of the critical problems that organizations are facing (Popovič, 2017). Thus, measuring the system use should not merely be dependent on traditional measures such as frequency or duration of use (Grublješič & Jaklič, 2015), more should be incorporated to measure the system use (Petter et al., 2008). Researchers should include other measures related to embeddedness of use, learning, interface, and use of features (Kao et al., 2016; Serumaga-Zake, 2017; Visinescu et al., 2017) etc, as identified (Appendix C), to understand the use in BI system context. In addition, while assessing the user satisfaction towards BI system, measuring users' satisfaction towards functions and abilities (Kao et al., 2016), clarity of information (Kohnke et al., 2011) and speed of interacting with the system (Kositanurit et al., 2011) has been documented. In addition, measuring user satisfaction with the decision-making (Audzeyeva & Hudson, 2016; Visinescu et al., 2017) would increase the understanding of the success of BI system in pre and post system adoption context. Achieving benefits such as improved efficiency (Gorla, 2003), reduced cost (Elbashir et al., 2008), improved performance (Grublješič et al., 2014) and profitability (Wieder et al., 2012) is the ultimate goal of the use of BI system, The analysis revealed 16 net benefits measures at both individual and organizational levels (Appendix C) which can be used to evaluate the success of BI system

6. Implications, Future Research, and Conclusions

The study provides a theoretical and practical contribution to both academicians and practitioners. Firstly, this study provides a more coherent body of knowledge for researchers and provides a direction for future research to evaluate the BI system's success. Secondly, this study provides an updated and consolidated success metrics based on D&M success dimensions. However, the choice of success dimensions is contingent upon the objective of the study (DeLone & McLean, 1992). Therefore, depending on the objective of the study, future studies could employ and validate few or multiple dimensions of D&M IS framework or the complete framework using the proposed set of measures to assess the success of BI system. In addition, there are dramatic changes in IS practices due to the rapid growth of technology. Thus, the identified set of measures could be useful for IS researchers to measure the effectiveness of IS in other contexts.

For practitioners, this research could serve as a guide to measure success of implemented BI system. Although contemporary organizations continue to increase their spending on BI system, however, achieving value using these systems to its full extent is still challenging. Given that, practitioners acknowledge the importance of evaluating the value of their investments and are making an effort to find out the ways to enhance the effectiveness of BI system. However, their IS-effectiveness evaluation methods are often too simplified focusing on only the value of benefits of implemented BI systems. They fail to consider other aspects such as information, system or service quality and use of BI systems. Thus, considering these aspects along with net benefits could provide insights on the success of BI system to the practitioners.

The study also provides prospects for future research. This study conducted a literature review in the context of BI system research to shed light on the success measurement of the BI system. Future research could adopt IS success framework using the proposed comprehensive measurement instruments to provide empirical validation of the instrument in the BI system context. Secondly, future research could conduct a meta-analysis to take into account the relationships between the success dimensions at individual and organizational levels to provide more extensive knowledge on the interrelationships among success dimensions in BI system context. In addition, future research could conduct research on less explored success dimensions such as service quality to provide deeper insights on BI system success.

Overall, through an extensive literature review of 92 peer-reviewed articles, this study reflected upon the measurement instruments used to enhance/attain BI system effectiveness or success in the existing body of literature and proposed success metrics to be used for measuring the success of BI system. An extensive amount of research has examined the success of IS using DeLone & McLean's multidimensional IS success framework. Being one of the most well-known and parsimonious frameworks to measure IS success, this study employed the theoretical groundings of IS framework and provide a consolidated success metric using the taxonomy of D&M framework i.e. system quality, information quality, system quality, use, satisfaction, and net benefits.

ǂ [4]Achieving effective decisions using business intelligence system: Reflections on the role of system and human factors

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Abstract

Business intelligence (BI) systems are being used by organizations to transform a massive amount of data on customers, markets, and environments into relevant information to fulfil their needs for faster and better decision making. However, the success of these systems is still questionable. Literature shows that organizations have largely failed to exploit BI systems effectively due to underutilization. As a result, BI systems have not only failed to improve managerial decision-making but also failed to deliver the expected returns. Much attention has been paid to the decision-making benefits of BI systems, and limited research has paid attention to investigate factors that affect BI system use and decision-making performance. Therefore, this study proposed a framework that combines system and human factors to assess BI system use and decision-making performance. To validate the research framework, the quantitative approach was employed to collect data from the employees of Pakistani telecom companies. Findings revealed that system factors, i.e. system quality and information quality, and the human factor, i.e. user competence significantly influence BI system use. Furthermore, system use and user competence significantly influence decision making performance. The study suggests that by understanding the system and human-related factors during the post-implementation phase, organizations can minimize the risk of system failure and increase the

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potential for success. As a result, organizations will be able to attain more value from implemented BI systems.

1. Introduction

Inevitably, the ever increasing market pressures and environmental uncertainty have impelled contemporary organizations to use information systems' (IS) capabilities to attain valuable information for effective decision making (Peters, Popovič, Isik, & Weigand, 2014; Puklavec et al., 2017). Recognized as one of the most important technological trends for past two decades, business intelligence systems (henceforth referred to as BI systems) have consistently been ranked among the top agenda items of business executives and analysts (Işık et al., 2013). BI systems – commonly identified as a collection of technological solutions – are used to collect, store, analyze, report, and disseminate data (Arnott et al., 2017; Grublješič & Jaklič, 2015) to improve decision-making performance and firm performance (Hou, 2013; Puklavec et al., 2014).

In recent years, organizations are spending heavily to implement these systems successfully (Owusu, 2017). According to statistics, the spending on the BI system will grow to $22.8 billion by the end of 2020 (Gartner, 2017). However, the praxis demonstrates that the success of these systems is still questionable. In many instances, BI systems fail to deliver expected benefits due to users' rejection, underutilization of system, infrastructural issues, information quality issues, system errors, lack of system knowledge and technical skills (Boonsiritomachai et al., 2016; Işık et al., 2013; Olszak, 2016; Popovič, 2017). System issues and poor content lead to inappropriate system use (Popovič, 2017; Popovič et al., 2012). In addition, organizations handle an enormous amount of data on their businesses, customers, markets and environments using BI system these days. Without having a quality system and quality information, the improvements in organizational decision-making performance as a result of using the BI system could be hampered (Ghasemaghaei, Ebrahimi, & Hassanein, 2018). Valid, correct, timely information and right means – to transform relevant information for improved decision making – are essential for successful implementation of BI systems (Zeng, Xu, Shi, Wang, & Wu, 2006); therefore quality aspects should be taken into account (Bischoff et al., 2015).

Wang and Haggerty (2011) argued that organizations need to align users with IS to attain optimal performance. Such alignment can only be achieved by understanding individuals, more specifically, individuals' characteristics of coping with IT for performing different tasks. Given that, many researchers have pointed out user's competence (i.e., user's IS knowledge and skills) for effective deployment of IS (Li, Yang, Klein, & Chen, 2011; Yoon, 2009). In recent times, organizational members have heavy reliance on BI systems to perform different tasks such as exploring, mapping, analyzing and correlating data elements to facilitate decision making (Kao et al., 2016; Lee & Widener, 2015); therefore, it is important to understand users' competence, i.e., IS knowledge and skills in BI system context. Lack of users' competence in using BI system would not only futile users' system use (Arnott et al., 2017) but also impede improvements in their decision-making performance (Waller & Fawcett, 2013). In the BI system context, literature stresses on the importance of user's competence for the effective utilization of system (Richards et al., 2017; Yeoh & Popovič, 2016) in order to enhance decision making performance, but none of the studies has explicitly conceptualized, operationalized and validated the concept of user competence.

The majority of prior empirical studies have mainly discussed factors such as perceived usefulness, ease of use, organizational BI capabilities and scope, and benefits (Bischoff et al., 2015; Hart et al., 2007; Kokin & Wang, 2014). Little research has focused on system and human-related factors to understand improvements in system use and employee's decision-making performance. This is important to consider as employees make decisions by relying on BI systems, without evaluating the system factors and the human factor, it is difficult to assess system use and employees' decision-making performance. In recognition of above-mentioned gaps, this study tries to seek answer for the following research question;

(1) What are the factors that impact BI system use and employees' decision-making performance?

The rest of the paper is structured as follows: first, this study outlined the theoretical background. Secondly, it outlined a conceptual framework and research hypotheses. Thirdly, it presents the research methodology. Fourth, it outlined the study's findings. Fifth, it highlights the discussion. Next, it tapped the theoretical and practical implications. Lastly, it provided the conclusion and limitations of the study.

2. Theoretical Background

To address the research gaps and to build the foundation for the conceptual framework, this study synthesized concepts from information system (IS) and management research – IS success (system quality and information quality) and human resource attributes – especially users' competence. Hence, this study used the IS success model (Delone & McLean, 2003) and social cognitive theory (Bandura, 1986b) as a theoretical foundation.

2.1. IS success framework

The DeLone and McLean (1992) IS success model is one of the most cited IS success framework that proposed six major interdependent dimensions of IS success; information quality, system quality, use, user satisfaction, individual and organizational impact. These dimensions cover the whole spectra of information flows from the original production, through consumption, and to influence organizational and individual performance. In 2003, the IS framework was updated with an addition of service quality and net benefits (after collapsing individual and organizational impact into single construct) (Delone & McLean, 2003). IS success framework has been used by many researchers to measure system success. For instance, Shin (2003) adapted IS framework to identify success in the data warehouse context and reported poor data quality as one of the major constraints in the effective use of data warehouse. More recently, Mudzana and Maharaj (2015) and Serumaga-Zake (2017) used IS framework and highlighted the importance of system and information quality for effective BI system use.

2.2. Social cognitive theory

Social cognitive theory (SCT), proposed by Bandura (1986b)**,** is one of the fundamental theories that represents a broad approach to predict and understand an individual's behaviour. SCT suggested that individuals' behaviours and performances occur because of three tightly intertwined aspects: environmental changes, individuals' cognitions, and behaviours (Bandura, 1986a). This study uses this causal flow as a guideline to support the theorization of the empirical framework as follows. As, within the external economic environment, data transformation through BI systems has become extremely important phenomena for the organizations to assist timely decision making to gain competitive advantage. The more the data transformation, the better will be the decision making. Therefore, many small and large organizations have implemented BI systems to facilitate management's decision making (Han et al., 2016). Given that, the environmental change, organizations are struggling to get employees fully involved with the BI system by making them adopt new ways of performing work (Deng & Chi, 2012) as it ebbs and flows between the traditional legacy system environment and advanced BI system environment that allows mapping of data, correlating data elements, conducting ad hoc and statistical analysis, and preparing proactive reports (Kao et al., 2016; Lee & Widener, 2015), etc.

Following the SCT, researchers have reported that individuals develop new behavioural routines, cognitive structures, and competencies to cope with the changes in the environment (Wan, Wang, & Haggerty, 2008; Wang & Haggerty, 2011), which subsequently enhance their behavioural actions and performance outcomes. Thus, consistent with the SCT and prior research, this study focuses on individuals' competencies to understand individuals' knowledge, skills and abilities (KSAs) that enable them to perform their work effectively using BI system which is increasingly becoming an integral part of the several contemporary organization's routine works.

2.2.1. User Competence in BI system context

In management and IS literature, competence has been regarded as an important precursor to performance outcomes, technology use, and success (Blili, Raymond, & Rivard, 1998; Huang & Wong, 2010; Shih, 2006; Yoon, 2008). Competence, in general, is construed as a set of necessary abilities, skills, motivations, and knowledge that guides an individual's action to perform an explicit, familiar or new task effectively in his/her workplace (Parolia, Jiang, & Klein, 2013; Spencer & Spencer, 1993; Wang & Haggerty, 2011).

According to Marcolin, Compeau, Munro, and Huff (2000), competence, by nature, is context-specific, as different contexts may require individuals to exhibit a different set of abilities, skills, motivations, and knowledge. Thereby, competence has been theorized in management and IS studies in a myriad way – defining relevant contexts and type of competence that adds to the 'choice set' (Wang & Haggerty, 2011) – to explain the phenomenon of individuals' behaviour and job outcomes. Examples include two-dimensional managerial IT competence – IT-related tacit knowledge and explicit knowledge (Genevieve Bassellier, Reich, & Benbasat, 2001), three dimensional organizational IT competence – IT knowledge, IT operations and IT objects (Tippins & Sohi, 2003), virtual competence – virtual self-efficacy, virtual media skill, virtual social skill (Wang & Haggerty, 2011) and generic and technical skills among IT professionals (Colomo-Palacios, Casado-Lumbreras, Soto-Acosta, GarcíA-PeñAlvo, & Tovar-Caro, 2013).

Keeping in view the notion of competence and its context-specific nature (Marcolin et al., 2000; Wang & Haggerty, 2011), this study theorizes user's competence as a multidimensional construct in the BI system context comprising two dimensions IS knowledge and skills**.** Knowledge has been regarded as a key part of competence, but as competence is grounded in an individual's everyday practice, therefore knowledge on its own is insufficient to represent competence. Given that, competence is not only dependent on knowledge possessed by individuals (Geneviève Bassellier, Benbasat, & Reich, 2003) and also on their skill level. Hence, expertise in an IS domain is dependent on individuals' IS knowledge and skill levels (Koo, Chung, & Kim, 2015). Given that, this study focused on both knowledge and skills. Table 1 (see Appendix E) provides a list of studies that highlight the importance of each dimension selected for this study.

Knowledge represents the basic knowledge of IS, system applications, and solutions (Cegarra-Navarro, Garcia-Perez, & Moreno-Cegarra, 2014; Tippins & Sohi, 2003; Yoon, 2009). This involves specialized knowledge that an individual possesses for understanding the system, and for effectively applying system applications and solutions to his/her tasks. In BI system context, IS knowledge gauges an individual's knowledge of BI system and its tools (e.g. reporting, query and analytics), and knowledge about how to apply these tools to accomplish various tasks such as data management, data modelling, reports and documents creation and interpretation etc. (Lee & Widener, 2015; Nelson et al., 2005; Olszak, 2016). Studies suggested that user's knowledge of BI system is crucial (Grublješič & Jaklič, 2015), lack of knowledge of system's functionalities, and reported data lead to unsuccessful system use (Deng & Chi, 2012). Having sufficient BI system knowledge enables users to use technological infrastructure effectively (Geneviève Bassellier et al., 2003; Cegarra-Navarro, Cepeda-Carrion, & Eldridge, 2011), perform correct sequence of actions (Tippins & Sohi, 2003) to recombine resources and information to generate productive outcomes (Siegel & Renko, 2012). Given that, IS knowledge has been considered as important in a technology use context; therefore, this study theorized it as a dimension of user competence in the BI system context.

Skills represent an individual's ability (or skill level) in handling an IS, using the system's basics, and applying system and solutions to given tasks, and to manage business information to his/her full potential (Yoon, 2009; Yu, Lin, & Liao, 2017). In the BI system context, skills involves the capability of an individual to use the BI system's basics such as profiling, mapping, and planning of data, apply system functions to perform cube, ad hoc query analysis and statistical analysis, to report and interpret data (Beckerle, 2008; Lee & Widener, 2015). Having the right skills for performing data analysis and interpretations are considered as important for the use of the BI system (Yu et al., 2017), which subsequently leads to enhanced decision-making performance. When users lack required skills, e.g. skills to execute a regular or complex ad hoc query using BI system to obtain data to answer a business question, they will not be able to accomplish the tasks timely (Wang & Haggerty, 2011) or make mistakes (Ghasemaghaei et al., 2018). Furthermore, lack of skills also leads to ineffective utilization of BI system (Boonsiritomachai et al., 2016); this will eventually lead to incorrect decisions, loss of opportunities, and revenue (Hou, 2016). Having the right set of skills is crucial in BI system context; therefore, skill is considered as a dimension of user competence in the BI system context.

A combination of both IS knowledge and skills, i.e. user competence provides individuals with the potential to perform given tasks (Ghasemaghaei et al., 2018) and use the given medium effectively (Yu et al., 2017). Contemporary organizations have implemented BI systems to transform data to gain business insights. To do so, the human resource and their competencies are required; however, these aspects have not received sufficient attention (Grublješič & Jaklič, 2015; Richards et al., 2017; Skyrius et al., 2016) in BI system research domain. The acquisition of relevant knowledge and skills is critical for the successful assimilation of the BI system (Elbashir et al., 2011). Hence, this study takes into account users' competence, i.e. IS knowledge and skills as a critical factor of BI system use and improved decision-making performance.

3. Conceptual framework and Hypotheses

Considering the rationale of this study and a need to identify the underlying proxies that improve the BI practitioners' system use and decision-making performance, the theoretical groundings of IS Success framework (Delone & McLean, 2003) is utilized. Wherein, achieving the decision-making performance is taken as net benefits – that are being influenced by system-related factors (system quality and information quality). The mapping of proposed BI system framework to the building blocks of Delone and McLean's (2003) IS success model is presented in Figure 1 below.

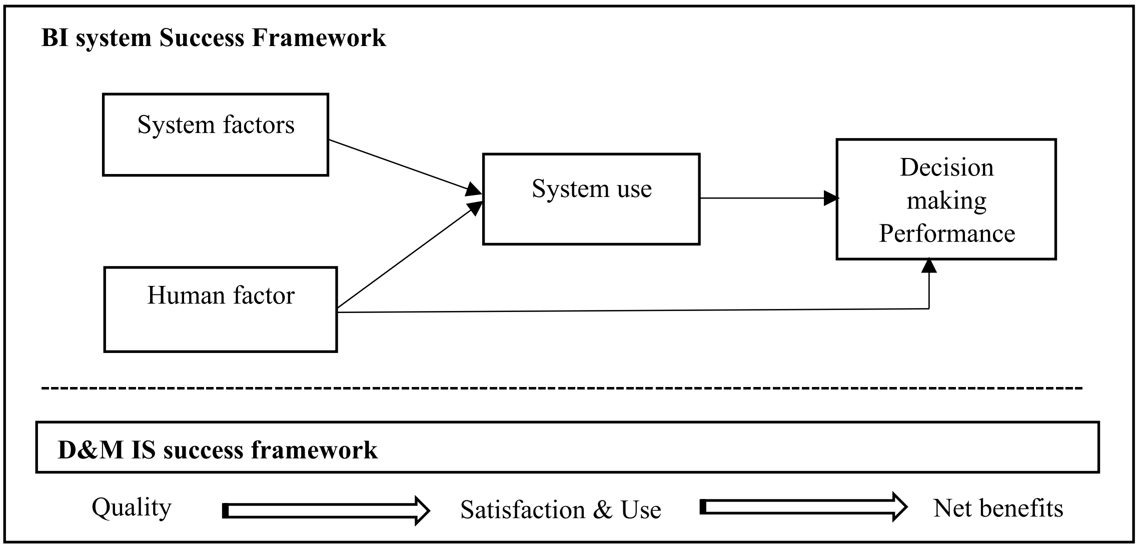

Figure 1. BI success framework mapped to building blocks of Delone and McLean (2003) IS success model

Along with the system factors (i.e., system quality and information quality), the BI success framework also incorporated the human factor (i.e., user competence). Consistent with prior research, this study argues that two dimensions of user competence (i.e., knowledge and skills) are pivotal, whereby they both have an impact on individuals' BI system use and their performance in an organization. Together knowledge and skills are considered as dimensions forming user competence, each dimension reflecting a unique contribution to user competence. User competence is, therefore, operationalized as a multidimensional, formative construct. A formative construct represents an aggregate construct that is formed based on its respective dimensions i.e. first-order constructs which complement each other and fulfil the purpose of the higher-order formative construct. Moreover, a change in one first-order construct does not necessarily cause an equal change in other dimensions. Thus, formative constructs seem appropriate for the study. In addition, consistent with Ghasemaghaei et al. (2018), decision-making performance is taken as a dependent variable with two dimensions, i.e. decision quality and decision efficiency. The further decomposition of the mapped framework is presented in figure 2 below.

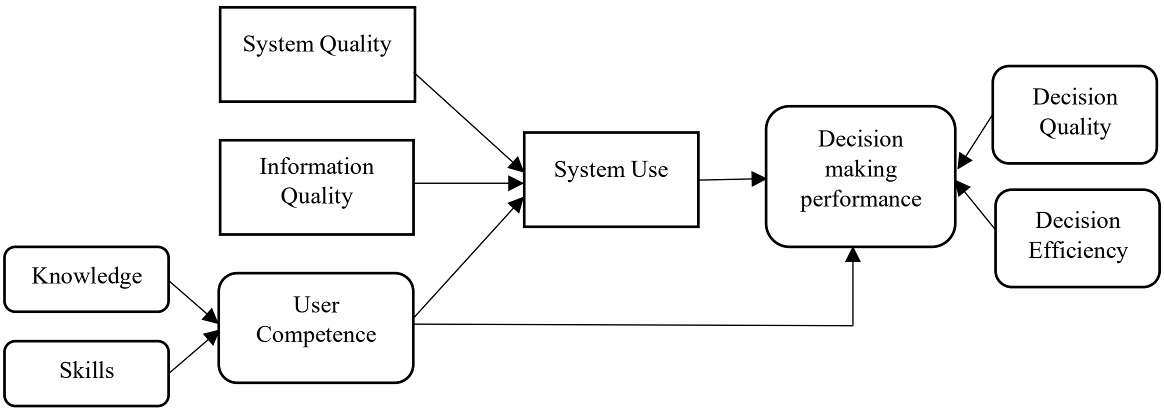

Figure 2. Proposed conceptual framework

The proposed hypothetical relationships between system quality (SQ), information quality (IQ), user competence (UC), system use, and decision-making performance (DMP) are discussed in the following sections.

3.1. System Quality

System quality (SQ) represents the desired characteristics of an information system (Delone & McLean, 2003) such as key functionality (Urbach, Smolnik, & Riempp, 2010), information processing (Zheng, Zhao, & Stylianou, 2013), consistency (Roca, Chiu, &

Martínez, 2006), accessibility, integration (Nelson et al., 2005), documentation quality (Hou & Papamichail, 2010), and timely response (Ahn, Ryu, & Han, 2007) among others. Accordingly, others regarded SQ as the degree to which an information system is easy to understand and easy to use (Zheng et al., 2013). In the context of this study, SQ measures the attributes (such as reliability, ease of use, accessibility, reporting, and timely response) of the BI system (Delone & McLean, 2003; Hou & Papamichail, 2010; Nelson et al., 2005). Prior research found a positive association between system quality and system use (Gaardboe et al., 2017; Tam & Oliveira, 2016). In line with previous studies, this study assumes that higher the overall system quality (e.g. reliability, ease of use, accessibility, reporting, and timely response) of BI system, the more the users tend to use it. Thus, this study postulates the following hypothesis:

Hypothesis 1: System quality is positively associated with BI system use.

3.2. Information Quality

Information quality (IQ) represents an aggregate measure to capture the content aspects of an information system (DeLone & McLean, 1992) and has been attributed as a key success factor (Nelson et al., 2005). Existing IS/IT research suggested a positive direct or indirect relationship between IQ and information system use (Chen, 2010; Saeed & Abdinnour-Helm, 2008; Wang & Liao, 2008). In this study, IQ represents the desirable attributes (e.g., accuracy, completeness, comprehensiveness, understandability, current and format) (Nelson et al., 2005; Petter, DeLone, & McLean, 2013; Xu, Benbasat, & Cenfetelli, 2013) of BI system's outputs. Guaranteeing sufficient IQ is essential for the success of both the design and operation of BI systems (Popovic & Jaklic, 2010). Given that, if the information provided by BI system conforms users' needs, provides accurate, complete, up to date, understandable, and interpretable content (Nelson et al., 2005), then users are more likely to use the BI system.

Keeping this notion in view, this study expects IQ to exhibit a positive effect on system use. Thus, this study postulates the following hypothesis;

Hypothesis 2: Information quality is positively associated with BI system use.

3.3. User Competence

In this study, the user's competence (UC), cumulatively, indicates an individual's IS knowledge and skills to understand and use the BI system's tools and functionalities that are needed to manage and analyse business information. Prior studies have emphasized on the importance of UC in an information system use (Koo et al., 2015). According to Marcolin et al. (2000), the assessment of the UC is crucial in maximizing the effectiveness of IS use. If individuals are competent to execute/perform a task in a given context using an IS, then they are more likely to expect positive outcomes associated with their job performance (Hsu, Ju, Yen, & Chang, 2007; Rezvani, Khosravi, & Dong, 2017). BI systems are typically configured to help end-users in deriving useful knowledge and meaningful information from a larger quantity of data to help decision making. Therefore, the effective utilization of BI system requires end-users to possess knowledge and skills to understand the available data sources, data integration and analysis, to interpret reports and information produced by the system (Deng & Chi, 2012; Nofal & Yusof, 2016), and to leverage information to make informed decisions (Trieu, 2013). Lack of users' competence in using BI system would not only diminishes users' system use (Arnott et al., 2017) but also impede improvements in their decision-making performance (Waller & Fawcett, 2013). Prior research has reported that UC (i.e. knowledge and skills) play a significant role in affecting user's system use (Deng & Chi, 2012) and their performance outcomes (Ghasemaghaei et al., 2018; Wang & Haggerty, 2011). In the BI system context, this study argues that users with greater competence will more likely to use the BI system and produce positive job outcomes, i.e. improved decision-making performance than those with lower competence. Moreover, this study expects IUC to exhibit a positive effect on system use and decision-making performance. Thus, this study hypothesized as following;

Hypothesis 3: User competence is positively associated with BI system use.

Hypothesis 3a: User competence is positively associated with decision making performance.

3.4. System Use and decision-making performance

System use is the extent of employing an IS in completing tasks at the workplace (Hou, 2016; Yuthas & Eining, 1995). Over the past two decades, system use has been attributed as critical to the success of an IS (Hong et al., 2006; Hou, 2016). A system needs to be used effectively to attain maximum benefits out of it (Trieu, 2017). Prior studies have widely discussed the impact of system use on individuals' job performance (Rai & Hornyak, 2013). Yuthas and Eining (1995) argued that if the goal of an information system is to enhance managerial decision making then decision making performance (DMP) would be relevant to evaluate the effectiveness of IS in a given context. In the context of this study, the BI system has been recognized as a key tool to manage big data and assist in effective, fast, and informed decision making (Schieder & Gluchowski, 2011; Wieder & Ossimitz, 2015). Therefore, DMP is the most relevant to measure performance achieved as a result of using the BI system. Following Ghasemaghaei et al. (2018), DMP, as a multidimensional construct, is defined as the 'users' evaluation of decision quality and efficiency in their decision-making process'. Decision quality is concerned with the quality of decision outcomes that are high in terms of precision, accuracy, and reliability, whereas decision efficiency focuses on goal attainment, such as arriving at decisions quickly (Ghasemaghaei et al., 2018; Jarupathirun, 2007; Trieu, 2013). Hou and Papamichail (2010) in a study exploring the effect of the ERPBI system use on DMP of senior managers, found a significant relationship between the two constructs. Keeping this in view, this study expects BI system use to exhibit a positive impact on employees' DMP.

Hypothesis 4: BI system's use is positively associated with employees' decision-making performance.

4. Research Methodology

To address the underlying research objectives and validate the proposed research hypotheses, a quantitative research approach primarily based on a survey questionnaire was used for this study. In the following sections, a detailed view of the targeted subject, instrument design, and development, sampling, data collection is presented.

4.1. Instrument development and design

The measures for all constructs were drawn from the existing literature. As such, to measure the SQ which demonstrates the desired characteristics of BI systems, items were adapted from Delone and McLean (2003), Nelson et al. (2005), and Hou and Papamichail (2010). The IQ items that measure users' perception of understandability, comprehensiveness, accuracy, currency, and format were adapted from Delone and McLean (2003), Nelson et al. (2005), and Saeed and Abdinnour-Helm (2008). The items for IS knowledge and skills which are the sub-dimension of UC were sourced from existing studies. Eight items utilized by Gholamreza Torkzadeh and Lee (2003), Yoon (2009), Lee, Trauth, and Farwell (1995) and Pérez-López and Alegre (2012) were adapted to measure the knowledge. Nine items were drawn from existing research (Johnson & Marakas, 2000; Lee et al., 1995; Gholamreza Torkzadeh & Lee, 2003) to measure the skills. In addition, BI system use was measured by three items adapted from Foshay et al. (2014), Puklavec et al. (2017), Ain, Kaur, and Waheed (2016) and Mudzana and Maharaj (2015). Finally, DMP has two sub-dimensions decision quality and decision efficiency, items for decision quality were adapted from Ghasemaghaei et al. (2018), DeLone and McLean (1992) and Wieder and Ossimitz (2015), whereas items for decision quality were adapted from Ghasemaghaei et al. (2018) and (Hou, 2012). The survey contained 40 items which were measured on a five-point Likert scale with responses ranging from “Strongly disagree” to “Strongly agree”. The reliability of the scale, as a result of the pilot study, is presented in section 4.3.

4.2. Targeted Subject

This study focuses on the telecommunication (henceforth referred to as telecom) industry which has widely been recognized as the most dynamic sector and the key driver of economic growth for past few decades (Madden & Savage, 2000; Pradhan, Arvin, Bahmani, & Norman, 2014). Pakistan’s telecom industry provides telecom services and solutions such as mobile telecommunications, telephony, and internet (3G, 4G, and broadband) to its customers. According to recent statistics, there are 159 million cellular subscribers, 68 million broadband subscribers, 66 million 3G/4G subscribers, and 3 million basic telephony subscribers (PTA, 2019) distributed among six telecom companies. Telecom companies depend on their subscriber bases such as several active customers, caller programs, duration of calls, services, prices compared to other companies, and customers’ retention (Normile, 2008; Olszak, 2016) to gain a competitive position. Therefore, telecom companies have adopted BI systems to handle such data attributes properly. The implementation of BI system has not only enhanced the data storage and analysis capabilities of these companies but also improved their timely decision-making to enhance the competitive position in the market (Hou, 2012; Ishaya & Folarin, 2012). Pakistan’s telecom industry is one of the major clients of BI industry in Pakistan and representative of the large sector with a large number of BI users (Khan, Amin, & Lambrou, 2010), thus offered the best available data source for this study. In addition, for this study, we limited the geographic scope to control for the impact of different cultures and other environmental factors. Thus, the telecom industry of one country is likely to be a fruitful ground to address this study’s research objectives.

4.3. Sampling and Data Collection

Out of six multinational telecom companies, four agreed to participate in the paper-based survey. Initially, the survey was pilot-tested by fifteen managers from the telecom to identify the possible problems with the content and format of the questionnaire. Each pilot participant was asked to complete and evaluate the survey and comment on the content clarity. The result of the pilot revealed that the Cronbach's alpha values for each construct were higher than the suggested threshold 0.6 (Churchill Jr, 1979), thus indicating the satisfactory reliability of the scale. In addition, feedback from the pilot participants was taken into account in the final version of the survey questionnaire. In the next phase, data was collected from randomly selected BI users. Firstly, a contact person was identified in each company, typically from the IT department, who had an important role, experience, and knowledge of implemented BI systems and potential users. The contact person was asked to provide a list of potential BI users. Due to the privacy issue, the contact persons in each company refused to provide the list but choose to distribute the survey to the potential respondents themselves. However, the contact persons provided brief information about the use of the BI system and BI users at different management levels. There was first-level management (CEO and CFO, etc.), second-level management (General manager, divisional manager, regional manager, plant manager), and third-level management (Department manager, office manager, and supervisor), consultant, data analysts, and executives. These respondents were from 9 functional departments, including accounting and finance, information technology, human resource, marketing and sales, customer support, research and development, production/supply chain management, legal department, and revenue assurance. In total, 400 survey questionnaires, ensuring respondents' confidentiality, were distributed. Out of the total, 215 questionnaires were returned. The returned questionnaires were further assessed for erroneous data and missing values. Four responses were discarded due to a lot of missing data, leaving 211 responses with a response rate of 52%, which were further analysed using SPSS and SmartPLS.

4.4. Data Analysis method

The Partial Least Squares (PLS) – a structural modeling technique that is well suited for highly complex predictive models – was used to test the proposed research model and hypotheses. The PLS deemed appropriate due to several reasons, including its ability to deal with the reflective as well as formative constructs, minimal restrictions on normality, and relatively small sample requirement (Chin & Newsted, 1999; Hair, Anderson, Babin, & Black, 2010). Since the proposed model of this study consists of both formative and reflective constructs and the sample size is fairly small i.e. 211; therefore, PLS was an appropriate choice for this study. In addition, following the existing research, this study adopted two-step structural equation modeling approach and created two PLS models (Afthanorhan, 2014; Gaskin & Godfrey, 2014; Wang & Haggerty, 2011). According to this approach, in the first step, latent constructs scores of first-order constructs are derived by creating paths between first-order constructs and other constructs as theorized. For instance, for user competence, the latent constructs scores for knowledge and skills were derived, whereas, for decision making performance, the latent constructs scores for decision quality and decision efficiency were derived. In the second step, all the derived latent constructs scores are used as the indicators of their respective second-order constructs. To do so, SmartPLS 2.0 software (Ringle, Wende, & Will, 2005) was used.

5. Data Analysis

5.1. Descriptive statistics

The analysis of individual's profiles revealed that there were 163 males (77.3%) and 48 females (22.7%) across the age groups 22-27 (23.2%), 28-34 (52.6%), and 35 and above

(24.2%), as depicted in Table 2. There were 3 (1.4%) respondents from first-level management, 36 (17.1%) from second-level management, 124 (58.8%) from third-level management, whereas 48 (22.7%) respondents were executives, data analysts, and consultant. The use of the BI system was divided into three main categories such as predefined reports (28.2%), query tools (32.8%) and analysis tools (37.3%).

Table 2. Demographic characteristics of the sample

Demographics	Frequency	Percentage	Demographics	Frequency	Percentage
Gender			**Duration of BIS use per week**		
Male	163	77.3%	< 10 mins.	3	1.4%
Female	48	22.7%	10-20 mins.	4	1.9%
Age			20-40 mins.	2	.9%
22-27	49	23.2%	40-60 mins.	7	3.3%
28-34	111	52.6%	1-1.5 hr	6	2.8%
35 and Above	51	24.2%	1.5-2 hr	15	7.1%
			More than 2 hrs	174	82.5%
Job Title			**Frequency of BIS usage per week**		
First-level management (CEO/CFO/CIO/President/VP)	3	1.4%	About once a day	18	8.5%
Second-level management (General Manager/Regional manager/Divisional Manager/Plant Manager)	36	17.1%	More than 4 times a day	128	60.7%
Third-level management (Department Manager/Office Manager/Supervisor)	124	58.8%	About once a week	11	5.2%
Others	48	22.7%	2 or 4 times a week	54	25.6%
BIS use by functionality			**BIS Operated in Organization**		
Predefined reports	115	28.2%	<1 year	3	1.4%
Query tools	134	32.8%	1-3 years	22	10.4%
Analysis tools	152	37.3%	3-5 years	44	20.9%
Others	7	1.7%	Over 5 years	142	67.3%
Number of Employees			**Annual Revenue**		
<250	3	1.4%	100-1000	1	.5%
250-1000	3	1.4%	1001-5000	5	2.4%
1000-3000	5	2.4%	5001-10000	2	.9%
More than 3000	200	94.8%	Over 10,000	203	96.2%

It can be noted from Table 2 that the BI system has been operated in telecom organizations for more than five years (67.3%). The majority of respondents, i.e. 174 (82.5%) reported that they spend more than two hours per week to use the BI system. 128 (60.7%) used a BI system more than four times a day, whereas 1.4% of respondents used it less than 10 minutes.

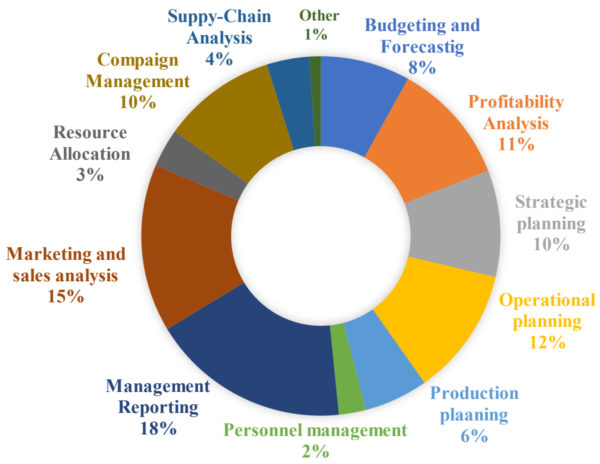

Figure 3. Purpose of BI system use

In addition, more than 18% used a BI system for management reporting, 15% used it for marketing and sales analysis, 12 % operational planning, 11% profitability analysis, 10% campaign management and strategic planning, 8% budgeting and forecasting, while only 3% used it for resource allocation and 2% for personnel management, as shown in Figure 3.

Prior to performing confirmatory factor analysis, the quality of scale and 40 measurement items were assessed by exploratory factor analysis using principal component analysis with varimax rotation and Kaiser normalization. Table 3 revealed the factor loadings for all variables indicating that the 36 measurement items significantly loaded on each component with the loading > .50 except for the four items (i.e. SQ6, IQ6, SK8, SK9), whose loading was less than 0.50 (Hair et al., 2010), thus eliminated from the scale.

Table 3. Factor Loadings

Measurement Items	System Quality	Information Quality	Knowledge	Skills	System Use	Decision Quality	Decision Efficiency
SQ1	.730						
SQ2	.727						
SQ3	.725						
SQ4	.757						
SQ5	.777						
IQ1		.807					
IQ2		.688					
IQ3		.714					
IQ4		.767					
IQ5		.808					
K1			.668				
K2			.821				
K3			.783				
K4			.747				

K5			.741				
K6			.802				
K7			.783				
K8			.771				
SK1				.737			
SK2				.730			
SK3				.701			
SK4				.746			
SK5				.750			
SK6				.685			
SK7				.637			
SU1					.880		
SU2					.886		
SU3					.573		
DQ1						.648	
DQ2						.812	
DQ3						.790	
DQ4						.713	
DQ5						.709	
DE1							.767
DE2							.778
DE3							.827

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

In addition, Bartlett's test of sphericity was statistically significant, whereas Kaiser Meyer-Olkin measure of sampling adequacy was .87, above the threshold value of .06 (Kaiser, 1974), thus showed sampling adequacy. Next, the multicollinearity diagnostic was performed to determine whether the independent variables are highly correlated. Two separate regression models were examined (Premkumar, Ramamurthy, & Liu, 2008). In the first regression model, system use was selected as a dependent variable, whereas SQ, IQ, and UC were selected as an independent variable. In the second model, DMP was selected as the dependent variable and system use and UC was selected as the dependent variable. The statistics indicated that variance inflation factor (VIF) values were between the range of 1.00 to 1.03, and tolerance was ranged from .96 to .99, thus within acceptable threshold values, i.e. VIF <10 and tolerance > .1 (Howitt & Cramer, 2011). Thus, multicollinearity was not an issue in this study.

5.2. Measurement Model

To examine the measurement model, reliabilities, items loadings, convergent validity, and discriminant validity were assessed. Firstly, the internal consistency of the scale was estimated using Cronbach's alpha and composite reliability, as indicated in Table 4. The Cronbach's alpha values for all the constructs were higher than the suggested threshold 0.60 (Fornell & Larcker, 1981), ranging from 0.76 to .93. In addition, composite reliability values were also within the suggested benchmark 0.70 (Fornell & Larcker, 1981) ranging from 0.86 to 0.94, hence indicating adequate internal consistency. In addition, the standardized loadings of all items were above the acceptable value of .5 (Hair et al., 2010) as shown in Table 4.

Table 4. Reliabilities, AVE and Standardized item Loadings

Items	Coefficient Alpha	Composite Reliability	AVE	Standardized Loading
System Quality	**.80**	**0.86**	**0.55**	
BI system…				
Performs reliably				0.776
Is easy to use				0.620
Provides information in a timely fashion				0.774
Allows information to be readily accessible to me				0.762
Supports my need of/in reporting completely				0.779
Information Quality	**.82**	**0.87**	**0.58**	
Information provided by BI system is…				
Easily understandable				0.768
A comprehensive set of information				0.668
Up-to-date				0.771
Well formatted				0.778
Available				0.828
User Competence (second-order formative construct)				
Knowledge	**.93**	**0.94**	**0.67**	
I have…				
Knowledge of mainframe, operating systems and networks				0.631
Knowledge of the capabilities of the BI system				0.860
Knowledge on how to use BI system tools (e.g. data warehouse, ETL, OLAP, OTL, Dashboard, Interactive visualization tools etc.)				0.851
Knowledge of databases (e.g. relational database, in-memory database (IMDB), NoSQL etc.)				0.793
Knowledge on how to use BI system for (e.g. data management, data modelling, mapping, and reporting, ad-hoc reporting, analysing, alerting, predictive modelling, operationalizing, optimization, activating etc.)				0.846
Ability on how to interpret business problems & develop appropriate solutions using BI system				0.855
Analytical knowledge (e.g. statistical, ad hoc query and predictive analysis)				0.844
Overall, I am knowledgeable when it comes to BI systems				0.862
Skill	**.92**	**0.94**	**0.68**	
I have ability to…				
Use BI system to display numbers and information as graphs				0.805
Use BI system to summarize numeric information				0.871
Use BI system to plan and organize clear, concise, effective reports, and documentations				0.834
Use BI system to accomplish assignments				0.825
Use BI system to develop and deliver effective, informative, and persuasive information				0.874
Plan, organize and lead BI projects				0.763
Overall, I have ability to use BI system effectively				0.822
System use	**.77**	**0.87**	**0.69**	
I frequently use BI system to complete tasks (e.g. analyses, reporting, planning, dashboard, forecasting, alerting, benchmarking etc.)				0.918
I use many functions of BI system				0.913
I depend upon BI system to complete tasks (e.g. analyses, reporting, planning, dashboard, forecasting, alerting, benchmarking etc.)				0.644
Decision making performance ***(second-order formative construct)***				
Decision Quality	**.89**	**0.92**	**0.70**	
The decisions I made as a result of using BI system are …				
Precise				0.798
Reliable				0.877
Rational and informed				0.874
Dependable				0.806

The decisions I made as a result of using BI system improve organizational outcomes				0.847
Decision Efficiency	**.82**	**0.89**	**0.74**	
Using BI system…				
The time to arrive at decisions is fast				0.807
The speed of arriving at decisions is high				0.891
Helps me to make decisions quicker				0.881

Convergent validity – the degree to which measures of the scale are related – was assessed based on the average variance extracted (AVE). Table 4 presents that AVE values of all the constructs with reflective measures were higher than the recommended value 0.50 (Hair et al., 2010), suggesting adequate convergent validity. To evaluate the discriminant validity, the square root of AVE values for each construct should be higher than any pair of correlation. Table 5 presents that the square root of AVE (bold on diagonal elements) is greater than any pair of correlation among constructs, thus suggesting satisfactory validity (Fornell & Larcker, 1981).

Table 5. Inter-construct Correlation

Constructs	Mean	Std.Dev	SQ	IQ	UC	SU	DMP
System Quality (SQ)	3.31	.67	**0.74**				
Information quality (IQ)	3.70	.82	.039	**0.76**			
***UserCompetence (UC)**	3.72	.75	-.052	.021	**n/a**		
System Use (SU)	3.77	.69	.224**	.299**	.177**	**0.83**	
***Decision making performance (DMP)**	3.98	.68	.059	.032	.587**	.216**	**n/a**

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

Note: n/a= Not available. Constructs with an asterisk (*) are formative constructs. Such constructs do not reflect the underlying measures but are formed based on them. The concept of the average degree to which items correlate with the construct does not apply to the formative constructs, therefore, it is not appropriate to calculate AVE for such constructs.

As noted, there are two second-order constructs – user competence and decision-making performance – in the proposed framework of this study. Since the second-order constructs' indicators do not reflect the underlying constructs but are form based on them. Therefore, the concept of the average degree to which items correlate with the construct does not apply to the formative constructs; therefore, it is not a necessary requirement to calculate the internal consistency reliability, convergent, and discriminant validity for such constructs (Jarvis, MacKenzie, & Podsakoff, 2003).

5.3. Structural Model

The SmartPLS 2.0 software (Ringle et al., 2005) was used to examine the structural model and underlying hypotheses. The examination of proposed relationships includes bootstrapping analysis, estimation of path coefficients, and R^2. Bootstrapping analysis (with 1000 samples) was used to examine the statistical significance of the paths (i.e., the strength of the relationship between independent and dependent variables) using t-values. Following Hair, Hult, Ringle, and Sarstedt (2016) recommendation, *t*-statistics i.e. values > 1.96 ($p < .05$), > 2.58 ($p < .01$) and, > 3.29 ($p < .001$) were used as an indication of significance level. Next, the $R^{2,}$ which represents the amount of variance in endogenous variables explained by exogenous variables was used to determine the predictive power of the framework. Together, path coefficients and R^2 determine how well the proposed framework is performing. The findings of the proposed structural model have shown in Figure 4.

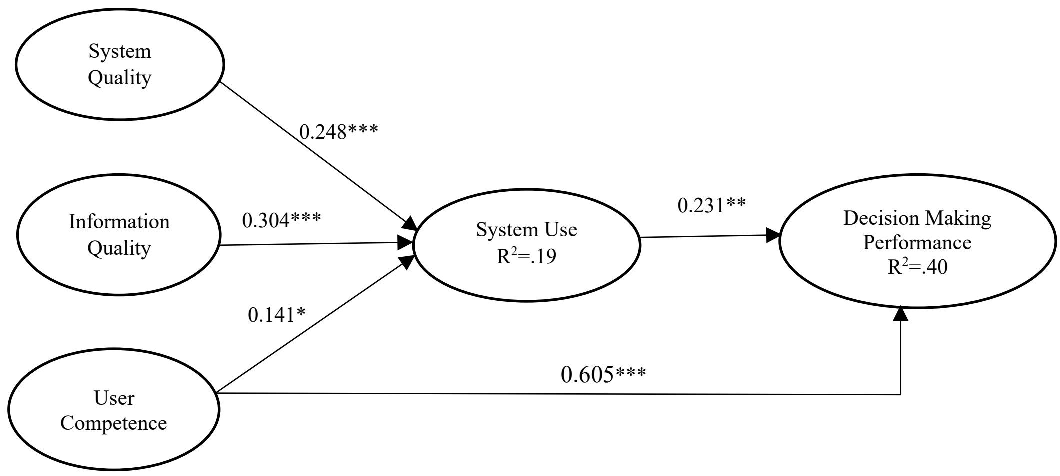

Figure 4. Results of proposed structural models (significance level at p < .05*, < .01**, <.001***)

Table 6 represents a summary of proposed hypothetical relationships and the structural model results. The results revealed that all the hypothesized relationships between SQ, IQ, UC, system use and DMP were supported.

Table 6. Statistical findings for the structural model

Relationship	Hypotheses	St. Weights	Std. Error	t-values	Results
SQ -> SU	System quality positively influences BI system use	0.248	0.073	3.43***	Supported
IQ -> SU	Information quality positively influences BI system use	0.304	0.072	4.22***	Supported
UC -> SU	User competence positively influences BI system use	0.141	0.067	2.02*	Supported

UC -> DMP	User competence positively influences decision making performance	0.605	0.050	11.98***	Supported
SU ->DMP	System use positively influences decision making performance	0.231	0.072	3.12**	Supported

Furthermore, all independent variables, i.e. SQ, IQ, and UC explained 19% of the variance in system use, which subsequently, along with UC explained 40% of the variance DMP, as shown in Figure 4.

6. Discussion

The key objective of the study was to investigate the effect of the system (i.e., system quality and information quality) and human (i.e., user competence) factors on business intelligence system use and employee's decision-making performance. The DeLone and McLean's IS framework was extended in the BI system context by incorporating user competence as an independent, explanatory variable. The proposed framework represented five hypothesized relationships, which all were supported, as shown in Table 5. The regression weights indicated a significant association between SQ and SU at the path coefficient at β= 0.248, p=<.001, thus supporting H1. A positive relationship between SQ and BI system use suggests that if BI system is reliable, accessible, easy to use, provides information in a timely fashion, and supports their reporting needs completely, they are more likely to use it to perform their tasks. The finding of this study is in line with prior studies conducted in the context of m-banking (Tam & Oliveira, 2016) and healthcare (Gaardboe et al., 2017). The path analysis between IQ and system use produced a statistically significant result at β= 0.304, p=<.001, thus supporting H2. This shows that as the IQ increases so does the BI system usage level. Previous studies have emphasized that the BI system enabled information use depends on the quality of the BI system enabled information (Popovič et al., 2014). Thus, the more the complete, comprehensive, up to date, available, understandable and well-formatted information produced by the BI system, the more the users likely to use the BI system. The results are consistent with prior research that supported IQ and system use relationships in BI system context (Mudzana & Maharaj, 2015).

Next to the line was a relationship between UC and system use, which was found significant at β= 0.141, p=<.05, thus H3 was supported. This explains that users who possess the required competence for the BI system will be more likely to use the BI system to execute their tasks and activities. These findings are relatively different from the existing research results as few researchers such as Huang and Wong (2010) and Marcolin et al. (2000) suggested a similar association and it was asserted that user competence might have a direct role in predicting the human behaviour such as usage of information technology. The finding of this study confirms the claim and provide a positive association between UC and system use. Furthermore, the hypothetical relationship between UC and DMP showed strong support at β= 0.605, p=<.001, thus supporting H3a. This explains that possession of particular system knowledge and skills not only help users to understand the information but also aid them to interpret it to improve their decision-making performance. The finding of this study is consistent with previous studies which found a significant relationship between UC and individuals' job performance in virtual setting (Wang, 2011), the end-user computing environment (Yoon, 2009), and analytics context (Ghasemaghaei et al., 2018). Finally, hypothesis 4 on the relationship between BI system use and DMP was supported at β= 0.231, p=<.01. Since, BI system is an effective tool for improving decision making (Olszak, 2016), the finding of this study shows that employees who made more use of BI system made higher quality decisions in terms of precise, reliable, dependable and rational decisions with more improved outcomes and improved their decision efficiency by shortening the time frame for making decisions. The result of this study was consistent with Hou and Papamichail (2010) who found a significant relationship between system use and DMP.

7. Theoretical and practical implications

As change occurs rapidly, whether internal or external, organizations cannot rely on old information and informal way of transferring and gaining knowledge. Organizations need new knowledge and tools to perform their activities and make appropriate decisions. In this view, BI systems have received much attention from the practitioners as a source of gaining access to new data and transform it into the relevant information to improve DMP (Hou & Papamichail, 2010). However, few empirical studies have taken into account the impact of BI system use on the decision-making performance or investigated the relationship between system factors (i.e. SQ & IQ), UC, system use, and DMP. This study took a novel step and empirically tested a research framework and made following theoretical and practical contributions.

From a theoretical point of view, firstly, this study makes a major contribution by operationalizing and validating the UC construct in the context of the BI system. This study provided strong evidence that UC is a multifaceted construct that consists of two dimensions: knowledge and skills. Also, the measures of UC showed satisfactory reliability, discriminant, and convergent validity, whereas the findings indicated UC as a significant determinant of BI system use and DMP. Hence, the empirical validation of this study enables other researchers to use the UC construct and its instrument with increased confidence to study various phenomena regarding the end-users in the future BI research. Secondly, this study provides a contribution by extending the Delone and McLean (2003) IS success framework by incorporating UC in BI system context. Thus, this study suggests a framework that synthesizes concepts from IS and human resource literature to provide a more comprehensive framework of technology use for IS success in general and BI system success in particular. Thirdly, the positive relationship between SQ, IQ, system use and individuals' DMP further validates the applicability of Delone and McLean's (2003) IS success framework in the BI system use context. The study highlights the importance of SQ and IQ in the effective utilization of BI system use. Moreover, it suggested that the BI system use leads to improved individuals' performance in making high quality and efficient decisions with improved organizational outcomes.

From a practical point of view, this study provides some useful insights for the system designers, management, and BI practitioners engaged in developing and using the BI system. Firstly, the development and validation of a framework linking quality antecedents to system use may allow system designers to have a better understanding of system use. For instance, the findings of this study revealed that designers should be focusing on creating an easy to use, reliable, accessible, and supporting system that fulfils reporting needs, and offer timely information in their quest to improve SQ. With respect to IQ, designers may focus on producing understandable, up-to-date, available, well-formatted, and comprehensive information to enhance IQ. Secondly, improving DMP through the use of the BI system is the key motivation of contemporary organizations making significant investments in these technological tools (Ghasemaghaei et al., 2018). This study should enable managers and BI practitioners to gain a better understanding of the relationships between SQ, IQ, UC, system use and DMP to understand the benefits of BI systems implementation. The results indicated that SQ and IQ play an important role in effective BI system usage. This notifies managers and BI practitioners on the importance of system and information quality aspects. As such, addressing the users' needs on appropriate system features and improved information output will increase the chances of the use of BI system which is prerequisite to improved DMP. In addition, management can assist users by providing consistent support in terms of technical assistance to overcome user resistance towards a system and to reduce the risk of system failure in post-usage scenarios. Thirdly, to improve system use and DMP, management could focus on employee training to improve employees' competence, i.e. knowledge and skills. Management needs to ensure that employees who are using BI system and making decisions through the use of BI system should have sufficient knowledge and skills to use the system appropriately and to interpret the obtained information correctly (Richards et al., 2017; Waller & Fawcett, 2013).

8. Conclusions, Limitations, and Future Research

This study investigated the impact of SQ, IQ, and UC on system use and employees DMP in BI system context. The Delone and McLean (2003) IS framework was extended by incorporating user competence. The explicit integration of UC along with system factors have largely been overlooked in a prior stream of BI research (Hart & Porter, 2004; Hou, 2012; Kohnke et al., 2011). Therefore, the UC construct was operationalized to understand the effective and successful use of the BI system and individual performance. The findings paint an insightful picture of determinants influencing BI system use and employee's DMP. Data analysis revealed that SQ, IQ, UC do impact BI system use and employees' DMP.

Although this research provides a fresh insight to understand the role of system and human factors in improving system use and decision-making performance in the BI system context, but it has some limitations. However, these limitations provide prospects for future research. Firstly, the study has taken a single industry, i.e. telecom industry, as its targeted scope; therefore, the generalisability of findings to other industries is questionable. Future studies should examine the applicability of this study's findings to other industries. Secondly, this study focused on user's competence i.e. knowledge and skills to address the knowledge gaps related to individual users within the existing BI research domain. Future research, focusing on the team/group work in BI context or BI project teams, may take into an account of users social (Parolia et al., 2013), problem-solving (Li et al., 2011) other relevant characteristics/competencies to address the success of BI system implementation. This could be important, as when individuals work in a team, they tend to adopt a mental model shared by all team members, which aids them to communicate, coordinate, predict and describe problems, and adapt each other's actions (Deng & Chi, 2012). Therefore, along with individuals' analytical knowledge and skills, understanding of team level competencies would be insightful to address the success of BI system. Thirdly, this study examined the users' perception at one point in time and did not account for the time-lag effects of measuring the BI systems' pay off. Hence, a longitudinal approach could be taken into account in future studies. Fourth, this study was conducted in Pakistan, and the findings might not apply to other countries' contexts due to environmental and cultural differences. Therefore, future research should examine the associations studied in this study, in other countries context.

ii. Thesis Conclusion

This thesis focuses on the success of BI systems, which, nowadays, have become critical for both public and private organizations to make sense of constantly increasing volume of internal and external data. To fill out the existing gaps, three studies have been conducted. In the first study, an attempt was made to understand the current state of BI system adoption, utilization, and success (AUS) research domain. None of prior studies attempted to synthesize the existing knowledge on the adoption, utilization, and success of BI systems as a means to provide comprehensive knowledge of BI system AUS research. The results of systematic literature review provided useful knowledge on key areas of investigation, key theoretical frameworks and factors, research methodologies, challenges faced by organizations, and knowledge gaps within the existing BI system AUS research. The second study aimed to provide knowledge on the success measures and proposed a success metrics by reducing the myriad of measures to assess the success in the BI system context, whereas third study focused on the identification of factors i.e. system (system quality, information quality) and human (user competence) that can contribute to the success of BI system.

The research has both theoretical and practical implications. From a theoretical point of view, the major contribution of the research is following: Firstly, the research provides detailed knowledge on BI system AUS research, highlights knowledge gaps, and provides suggestions to scholars and academicians. Secondly, it provides updated and consolidated success metrics to measure the success of BI system. Researchers may use the suggested measures to evaluate the success of BI system rather than adopting the dispersed instruments present in the existing literature. Thirdly, the research conceptualized and validate user competence construct in the BI system context. The empirical validation of user competence construct enables future BIS researchers to use this construct to better understand the individuals' system/technology use. From practical point of view, the research enables practitioners to have useful insights such as the analysis of systematic literature review revealed that organizational and information system perspectives had received more attention while user perspective received less. Although, both organizational and information system perspectives are important to consider, but it is equally important to pay attention to users and user-centric issues to increase the chances of system success. Secondly, organizations strive for finding best solutions to assess and enhance the effectiveness of these costly systems. An insight of consolidated view of success aspects could help practitioners to understand the attributes important for the success of BI system. Thirdly, the research may provide practitioners an understanding of the relationship between system, human/user, and decision-making performance, and understanding of required system features, users' knowledge, and skills to realized value from BI system investments.

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Extended table 3: Quality Assessment Criteria						
Study ID	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Total**
B1	1	1	0.5	1	0.5	4
B2	1	1	1	1	1	5
B3	0.5	1	0.5	0.5	1	3.5
B4	1	1	0.5	1	0	3.5
B5	1	1	1	1	1	5
B6	1	1	1	1	1	5
B7	1	0.5	1	1	0.5	4
B8	1	1	0.5	1	1	4.5
B9	1	1	0.5	1	1	4.5
B10	0.5	0.5	0.5	1	0.5	3
B11	1	0.5	1	1	1	4.5
B12	1	0.5	0.5	0.5	1	3.5
B13	1	0.5	0.5	0.5	0.5	3
B14	1	1	1	1	1	5
B15	1	1	1	1	1	5
B16	0.5	0.5	0	0	1	2
B17	1	1	1	0.5	1	4.5
B18	0.5	0.5	1	0.5	0.5	3
B19	1	1	0.5	0.5	0.5	3.5
B20	1	1	0	0	0	2
B21	1	1	1	1	1	5
B22	1	1	1	0.5	0.5	4
B23	0.5	1	1	0.5	1	4
B24	1	1	0.5	1	0.5	4
B25	1	1	0.5	0.5	1	4
B26	1	1	0	0	0	2
B27	0.5	1	1	1	1	4.5
B28	0.5	0.5	1	1	0.5	3.5
B29	1	1	0.5	1	1	4.5
B30	0.5	1	1	1	1	4.5
B31	1	1	0	0	0	2
B32	1	1	0.5	0.5	1	4
B33	1	1	0.5	1	1	4.5
B34	1	1	1	1	1	5
B35	0.5	1	0.5	0.5	1	3.5
B36	1	1	1	0.5	1	4.5
B37	1	1	0	0	0	2
B38	1	1	1	1	1	5
B39	0.5	0.5	1	1	1	4
B40	1	1	0.5	1	1	4.5
B41	0.5	0.5	1	1	1	4
B42	1	1	1	1	1	5
B43	1	1	0.5	0.5	0.5	3.5
B44	1	1	1	1	1	5
B45	1	1	0.5	1	1	4.5
B46	1	1	0.5	1	1	4.5
B47	1	1	0.5	1	1	4.5
B48	1	1	0	0	0	2
B49	1	1	0.5	1	0.5	4
B50	1	1	0.5	0.5	0.5	3.5
B51	1	1	0	0	0	2
B52	1	1	1	1	1	5
B53	1	1	0.5	0.5	1	4
B54	0.5	1	0.5	1	1	4
B55	1	1	0.5	1	1	4.5
B56	1	1	1	1	1	5
B57	1	1	0.5	0.5	0.5	3.5
B58	1	1	0.5	1	1	4.5

B59	1	1	0.5	0.5	0.5	3.5
B60	1	0.5	0.5	0.5	0	2.5
B61	1	1	0.5	0.5	1	4
B62	1	1	0.5	1	0.5	4
B63	1	1	0.5	0.5	1	4
B64	1	1	1	1	1	5
B65	1	1	0.5	0.5	0.5	3.5
B66	1	1	0.5	1	1	4.5
B67	1	1	0	1	1	4
B68	1	1	1	0.5	1	4.5
B69	1	1	1	1	0.5	4.5
B70	0.5	1	1	1	1	4.5
B71	1	1	0.5	1	1	4.5
B72	1	1	0.5	1	1	4.5
B73	1	1	0	0	0	2
B74	1	1	0.5	0	0.5	3
B75	1	1	0	0	0	2
B76	1	1	1	1	1	5
B77	1	1	0.5	1	1	4.5
B78	0.5	1	0.5	0.5	1	3.5
B79	1	1	0	0	0	2
B80	1	1	0.5	1	1	4.5
B81	1	1	0.5	1	1	4.5
B82	1	1	0.5	1	0.5	4
B83	1	1	0.5	1	1	4.5
B84	1	1	0.5	1	1	4.5
B85	1	1	1	1	1	5
B86	1	1	0	0	0	2
B87	1	1	0.5	0.5	1	4
B88	1	1	0	0.5	1	3.5
B89	1	1	1	1	1	5
B90	1	1	0.5	1	1	4.5
B91	1	1	0.5	1	1	4.5
B92	1	1	1	1	1	5
B93	0.5	1	0.5	1	1	4
B94	1	1	0	0	0	2
B95	1	1	0.5	1	1	4.5
B96	1	1	0.5	1	1	4.5
B97	1	1	0.5	1	1	4.5
B98	1	1	0.5	0.5	0.5	3.5
B99	1	0.5	0.5	0.5	1	3.5
B100	1	1	0.5	0.5	0.5	3.5
B101	1	1	1	1	0.5	4.5
B102	1	1	0.5	1	1	4.5
B103	1	1	0.5	0	0	2.5
B104	1	1	0.5	1	1	4.5
B105	1	1	0.5	1	1	4.5
B106	1	1	0.5	0.5	1	4
B107	1	1	1	1	1	5
B108	1	1	0.5	1	1	4.5
B109	1	1	1	1	1	5
B110	1	0.5	0.5	1	1	4
B111	1	1	1	1	1	5

Extended Table 5. Data Extraction Form										
SID	**Author(s)**	**Study type**	**Objective(s)**	**Topics**	**Tool/System**	**Theory/Framework/Model adopted**	**Key Factors**	**Sample**	**DC method**	**Country**
B1	(Soliman et al., 2000)	Journal (I&M)	Identified factors of end-user satisfaction with data warehouses	Adoption	Data warehouse	NA	Support provided to end-users, Accuracy, Format and preciseness, Fulfillment of end-user needs	42 business managers	Survey	United States
B2	(B. H. Wixom & Watson, 2001)	Journal (MISQ)	Examined the factors that influence data warehousing success	Success	Data warehouse	DeLone & McLean IS success model	Management Support, Champion, Resources, User Participation, Team Skills, Source Systems, Development technology	225 data warehousing managers, staff members and other employees (IS managers, CIO)	Survey	United States, South Africa, Canada, Austria
B3	(Rouibah & Ould-Ali, 2002)	Journal (JSIS)	Described a BI system (PUZZLE) and validated it by designing a prototype	Use	BI system	NA	NA	28 MBA students and professors	Mixed Methods	France & Netherlands
B4	(Gorla, 2003)	Journal (CACM)	Investigation of the effect of OLAP features on PEOU and PU	Adoption	OLAP	Technology Acceptance Model (TAM)	Visualization, Summarization, Navigation, Sophisticated Analysis, Dimensionality	58 ROLAP and MOLAP software users	Survey	Hong Kong
B5	(Shin, 2003)	Journal (JAIS)	Investigated the technological and non-technological factors affecting data warehouse users' satisfaction	Success	Data warehouse	DeLone & McLean IS success model	Information Quality, system quality, Service quality	64 first line managers, middle managers, contracted consultants	Mixed Methods	North America
B6	(M. Hart & Porter, 2004)	Journal (JCIS)	Identified the influence of users' cognitive processes on the perceived usefulness of OLAP	Use	OLAP	TAM	Result demonstrability, Output quality, Job relevance, Perceived ease of use	56 respondents	Mixed Methods	South Africa
B7	(S. M. Lee et al., 2004)	Journal (IJITDM)	Investigated the relationship between data warehouse implementation and organizational performance	Success	Data warehouse	NA	Data Warehousing, Business factor, Market level factor	85 marketing directors or vice presidents	Survey	United States
B8	(Hwang et al., 2004)	Journal (DSS)	Explored the influence of critical success factors on data warehouse adoption	Adoption	Data warehouse, OLAP	NA	Size of bank scale, Champion, Top management support, Internal needs, Skills of project team, Coordination of organizational resources, Participation of users, Assistance of information consultants, Degree of business competition, selection of vendors	50 CIOs	Survey	Taiwan
B9	(Nelson et al., 2005)	Journal (JMIS)	Developed a framework consisting of nine	Adoption	Data warehouse	NA	Accuracy, Completeness, Currency, and Format, Accessibility, Reliability,	465 data warehouse users	Survey	United States

			determinants of quality in an information system context				Response time, Flexibility, and Integration			
B10	(Chung et al., 2005)	Journal (JMIS)	Proposed a model for knowledge discovery on the Web and developed a BI explorer to browse other business websites	Adoption	NA	NA	NA	NA	Secondary data	United States
B11	(Gargeya & Brady, 2005)	Journal (BPMJ)	Explored the factors affecting the success of SAP software adoption	Success	BI system	NA	NA	NA	Secondary data	United States
B12	(Hong et al., 2006)	Journal (IJITDM)	Identified the factors affecting the data warehouse usage and end-users' perceived impact	Use	Data warehouse	DeLone & McLean IS success model, TAM	Data Quality, Accessibility, Response time, Support and training	123 data warehousing users	Survey	Korea
B13	(M. Hart et al., 2007)	Journal (IISIT)	Examined students' acceptance of OLAP software products	Use	OLAP	TAM2	Job relevance, Output Quality, Result demonstrability, Anxiety, Facilitating Conditions	53 students	Survey	South Africa
B14	(Ramamurthy et al., 2008)	Journal (DSS)	Examined the technological and organizational factors of data warehouse adoption	Adoption	Data warehouse	Diffusion of innovation (DOI), TAM	Organization Size	276 executives	Survey	United States
B15	(Elbashir et al., 2008)	Journal (IJAIS)	Examined the performance effects of BIS use at the business process and organizational levels and developed a business process performance measure	Use	BI system	Porter's value-chain activities framework	Business process performance – Customer intelligence, Supplier relation, Internal efficiency	1873 managers in 612 organizations	Survey	Australia
B16	(Baars & Kemper, 2008)	Journal (ISM)	Discussed three approaches to the integration of structured and unstructured data for management support and mapped them in an integrated BI framework	Adoption	OLAP	NA	NA	NA	NA	Germany
B17	(Lin et al., 2009)	Journal (ESA)	Constructed an analytic network process-based performance assessment model	Success	BI system	NA	NA	12 consultants, IT persons and end users	Case study	United States
B18	(Cheng, Lu, & Sheu, 2009)	Journal (ESA)	Presented an ontology-based approach for BI applications such as data mining and statistical analysis	Use	BI system	NA	NA	NA	NA	Taiwan
B19	(Candal-Vicente, 2009)	Conference (ICCGI)	Identified the key determinants to understand data warehouse implementation	Success	Data warehouse	DeLone & McLean IS success model	Strategic Alignment, Management support, External environment, Champion, Training operational and technical support, Prototype	56 executives and experts	Survey	Puerto Rico
B20	(Jiang, 2009)	Conference (CCCM)	Conceptualized a framework of users' BI adoption	Adoption	E-BI	Theory of Reasoned action (TRA), TAM, Motivational theory, DOI	Gender/Age	NA	NA	China
B21	(Yeoh & Koronios, 2010)	Journal (JCIS)	Investigated the critical success factors (CSFs) that influence BI system success	Success	BI system	NA	Organization (Vision & business case, Management & Championship), Process (Team, Project management &	15 Delphi Participants (BI system experts)	Case study	Australia

							methodology, change management), Technology (Data, infrastructure) Infrastructure performance (System quality, information quality, system use), Process performance (Budget, Time schedule)			
B22	(Seah et al., 2010)	Journal (IJIM)	Identified the role of indigenous leadership in the successful implementation of BI systems	Success	BI system	NA	NA	15 CEO, Vice president, Senior branch manager, sales team, Engineering Team, Business integration managers	Case study	China
B23	(Phan & Vogel, 2010)	Journal (I&M)	Developed a framework of CRM and BI systems for catalogue and online retailers	Success	BI system	NA	Price Discrimination, Switching cost, BI and CRM systems	6 executives and employees	Interviews	United States
B24	(Hou & Papamichail, 2010)	Journal (IJTPM)	Examined the influence of the ERPBI system on decision-making performance	Use	ERPBI system	NA	ERPBI Usage	108 top, middle and low-level management	Survey	Taiwan
B25	(Kohnke et al., 2011)	Journal (IJISCM)	Tested a framework for the evaluation of management activities in the BI system context	Use	BI system	TAM	Quality of information, System performance, User information, User training, Top management support	258 BI users	Survey	Brazil
B26	(Schieder & Gluchowski, 2011)	Conference (ECIS)	Presented an instrument to measure BI system success	Success	BI system	DeLone & McLean IS success model	Functional coverage, Technical sustainability, Organizational maturity	NA	NA	Germany
B27	(Kositanurit et al., 2011)	Journal (ESA)	Identified information systems' characteristics	Use	BI system	Technology to Performance Chain (TPC) model	System Quality, Information Quality	385 users	NA	United States, Thailand
B28	(Ghazanfari, Jafari, & Rouhani, 2011)	Journal (SI)	Proposed an expert tool to evaluate the BI competencies of enterprise systems	Adoption	BI system	NA	NA	185 CIOs, IT managers, IT project managers	Survey	Iran
B29	(Elbashir et al., 2011)	Journal (TAR)	Examined the impact of organizational controls (resource development and knowledge management) on BI system assimilation	Use	BI system	NA	Absorptive capacity (TMT level)	347 Senior executives, operational managers and IT users	Survey	Australia
B30	(B. H. Wixom et al., 2011)	Journal (MISQE)	Described the BI journey of Norfolk Southern Railways	Use	BI system	NA	Business strategy, Data quality, Usable, Integrated, Business value, BI tools queries, reporting application	30 business and IT leaders	Case study	United States
B31	(Ferrari, Rossignoli, & Zardini, 2011)	Journal (ITITO)	Proposed a conceptual framework to identify factors of adoption of the SaaS model for BI systems	Adoption	SaaS BI system	NA	NA	NA	Case study	Italy
B32	(Karim, 2011)	Journal (IJBSS)	Explored the influence of key determinants of BI systems on organization performance	Success	BI system	NA	BI strategic plan, Cooperation among business units, Expertise, Information and analysis usage, Effective decision-	69 respondents	Survey	NA (different countries)

							making process, Technical readiness of BI			
B33	(Popovič et al., 2012)	Journal (DSS)	Proposed a framework to understand the relationship between BIS dimensions	Success	BI system	DeLone & McLean IS success model	BI system maturity	141 senior managers and CIOs in 181 medium and large organizations	Survey	Slovenia
B34	(Hou, 2012)	Journal (IJIM)	Tested a framework to identify relationships between end-user computing satisfaction, system usage and individual performance	Use	BI system	Igbaria and Tan's (1997) nomological net model, DeLone & McLean IS success model	End user computing Satisfaction – Content, Accuracy, Format, Ease of use, Timeliness	330 end users of BI from Taiwanese electronics industry	Survey	Taiwan
B35	(Zhao et al., 2012)	Conference (AMCIS)	Identified the critical success factors of open-source BI tools' adoption	Adoption	BI system	TAM	Organizational factors (Industry, Size, Resources, Process of selecting and implementing IT), Project factors (Team size, cost), Provider factors (Vendor recognition, size, Quality of customer support, quality of user training, offering maturity, administration and deployment, ease of evaluating capabilities), System factors (completeness of BI offering, quality of software code, testing, data quality, user community functionality, ease of use, documentation quality)	NA	Interviews	United States
B36	(Mathew, 2012)	Journal (IJBIS)	Explored the factors affecting BI system adoption	Adoption	BI system	Gatignon and Robertson's (1989) technology adoption model	Task Characteristics (Decision support, Task complexity), Retailer Category (Size, Management), BIS Provider Characteristics (Access, Affordability), Decision maker Characteristics (Technology familiarity, Quantitative skills)	NA	Case study	India
B37	(Brockmann et al., 2012)	Conference (NBIS)	Reviewed common mobile trends and different users' acceptance frameworks to derive success factors for mobile BI systems	Use	MBI	TAM	Perceived value, Perceived ease of use, Trust, Perceived ease of adoption	NA	NA	Germany
B38	(Deng & Chi, 2012)	Journal (JMIS)	Developed a comprehensive view of the BI system use problem in organizations	Use	BI system	NA	NA	NA	Secondary data, observation, Interviews	United States
B39	(Ramakrishnan et al., 2012)	Journal (DSS)	Examined the relationship between external pressure and BI data collection strategies	Use	BI system	Institutional theory	Institutional Isomorphism, Competitive pressure	63 BI developers	Survey	United States

B40	(Wieder et al., 2012)	Journal (IJESAR)	Investigated the factors that define the benefits associated with BI tools' deployment	Success	BI system	DeLone & McLean IS success model	Data Quality, User Satisfaction, BI scope, Decision quality	33 respondents	Survey	Australia
B41	(Ishaya & Folarin, 2012)	Journal (TI)	Provided an overview of BI technologies in the telecom industry and developed an architecture and prototype for service-oriented business intelligence (SOBI)	Adoption	BI system	NA	NA	2 telecom analysts and 42 customers	Mixed Methods	Nigeria and United Kingdom
B42	(X. Li et al., 2013)	Journal (ISR)	Identified two post-acceptance BIS usage behaviours	Use	BI systems	Motivation Theory	Perceived usefulness, Intrinsic motivation towards accomplishment, Intrinsic motivation to know, Intrinsic motivation to experience stimulation	217 Senior managers	Mixed Methods	China
B43	(Dawson & Van Belle, 2013)	Journal (SAJIS)	Examined the critical success factors for BI in the South African financial services sector	Success	BI system	Wixom & Watson framework	Management support, Champion, Resources, User participation, Data Quality	26 project stakeholders	Delphi technique	South Africa
B44	(Işık et al., 2013)	Journal (I&M)	Examined the role of BI capabilities in BI success	Success	BI system	Gorry and Scott Morton framework of management information system	Technological capabilities – Data quality, Integration with other systems, user access, Organizational BI – Flexibility, Risk Management support)	300 BI professionals	Survey	United States
B45	(Hou, 2013)	Journal (IJTPM)	Investigated the factors affecting BI system adoption	Adoption	BI system	TAM, Decomposed TPB	Perceived usefulness, Perceived ease of use, Compatibility, Peers influence, Superior influence, Self-efficacy, Facilitating Conditions	339 IS executives or senior managers	Survey	Taiwan
B46	(Kulkarni & Robles-Flores, 2013)	Conference (AMCIS)	Proposed and tested a BI success framework	Success	BI system	DeLone & McLean IS success model	Analytical culture, Leadership Commitment, User Involvement	299 BI professionals	Survey	India, Peru, United States and Vietnam
B47	(Elbashir et al., 2013)	Journal (JIS)	Examined the impact of BI assimilation on the value creation process	Use	BI system	NA	CIO business knowledge, TMT strategic IT knowledge	347 senior business and IT executives, middle managers, and IT users.	Survey	Australia
B48	(T. Trieu, 2013)	Conference (ICIS)	Explored the relationship between IT enterprise maturity stages and decision-making performance	Use	BI system	Theory of effective use (TEU)	Data integration, Learning system	NA	NA	Australia
B49	(Y. Han & Farn, 2013)	Conference (HICSS)	Developed a framework to explain the continuous usage of a pervasive BI system	Use	BI system	Limayem et al.'s IS continuance model	Confirmation, Comprehensiveness of usage, Structural empowerment	117 managers, staff and clerks	Survey	Taiwan
B50	(Mungree, Rudra, & Morien, 2013)	Conference (ACIS)	Investigated the factors affecting BI system implementation success	Success	BI system	NA	NA	16 BI consultants	NA	Australia

B51	(Chu, 2013)	Journal (IJEBM)	Presented an implementation model for manufacturing management using BI tools	Use	BI system	NA	Manufacturing management process, IT (data management), BI (Statistical analysis)	NA	Case study	Taiwan
B52	(Hou, 2014a)	Journal (IJIEM)	Investigated the determinants that influence users' behavioural intention to use BI systems and the moderating role of age, gender, experience and voluntariness	Use	BI system	UTAUT	Performance expectancy, effort expectancy, social influence, facilitating conditions, computer self-efficacy, computer anxiety, attitude towards BI	330 respondents from electronic industry	Survey	Taiwan
B53	(Hou, 2014b)	Journal (IJTPM)	Examined the influence of integrated ERP and BI systems on organizational performance	Use	BI system	NA	ERPBI system usage	139 senior managers, supervisors, non-managers/IT professional	Survey	Taiwan
B54	(Popovič et al., 2014)	Journal (JSIS)	Examined how information sharing influences information use and BIS use	Success	BI system	NA	Business Intelligence system quality, Information quality, Information sharing values	123 respondents from medium and large sized firms	Survey	Slovenia
B55	(H.-C. Wang, 2014)	Journal (BIT)	Distinguished managers' BI adoption intentions from organizational BI implementation intentions	Adoption	BI system	NA	Personal innovativeness in the domain of information technology, Personal involvement towards BI system	62 senior managers	Survey	Taiwan
B56	(Foshay et al., 2014)	Journal (ISM)	Examined the influence of metadata on BI adoption	Use	BI system	DeLone & McLean IS success model, TAM	Definitional metadata quality, Data quality metadata quality, Navigational metadata quality, Lineage metadata quality	455 BI users and recruiters	Survey	United States
B57	(T. E. Yoon et al., 2014)	Conference (SS)	Identified the determinants that influence individuals' decision to accept BI application	Adoption	BI system	Diffusion of innovation theory (DOI), Motivation theory (MT) and theory of planned behavior (TPB)	Relative advantage, Complexity, Compatibility, Intrinsic motivation, Extrinsic motivation, Social Influence (supervisor, co-worker support), Requisite skills & resources, Organizational learning climate	47 SAP users	NA	United States
B58	(Chang et al., 2014)	Journal (CTW)	Investigated managers' intention to read and create reports	Adoption	BI system	TAM	Perceived ease of use to read, Perceived ease of use to create reports	271 managers	Survey	China & Taiwan
B59	(Puklavec et al., 2014)	Journal (EBR)	Identified the determinants of BI system adoption in SMEs	Adoption	BI system	Diffusion of innovation (DOI) and Technology, Organization, Environment (TOE)	Expected benefits, Perception of strategic value, Cost, BIS is part of ERP, Management support, Organizational culture, Project champion, Organizational data environment, organizational readiness, Size, External support	10 BI adopters and professionals	Interviews	NA

B60	(Kokin & Wang, 2014)	Journal (AMM)	Conceptualized a framework to measure BI success	Success	BI system	NA	Technological BI capabilities (Data source, Data type, Data reliability, interaction with other systems, User access), Organizational BI capabilities (Flexibility, Intuition involved in analysis, Risk level)	NA	NA	China
B61	(Grublješič et al., 2014)	Journal (IIS)	Proposed a framework to understand BI system use better	Use	BI system	TAM, UTAUT, TAM3	Effort perceptions, Performance perception, Social influence, Result demonstrability, facilitating conditions, focus on customer	195 Top management and IS managers	Survey	Slovenia
B62	(Ravasan & Savoji, 2014)	Journal (IJBIR)	Identified the critical success factors affecting BI system implementation	Success	BI system	NA	Organizational (Ensure senior management support, well defined vision and goals, Adequate resources, BI & business strategy alignment), Human Resources (User support, change management, Participation end users, User training, managing users' expectation), Project Management (Strong project management, risk management, project team management, IT knowledge and technical skills), Technical (Data management, Adequate and reliable technical architecture, Select the appropriate architecture)	122 Project team members	Survey	Iran
B63	(Chang et al., 2015)	Journal (BIT)	Examined the role of motivations in employees' acceptance and use of BI	Use	BI system	Expectancy Theory, Social exchange theory and BDB (Bagozzi, Dholakia, and Basuroy) model	Tangible rewards, Intangible Rewards, Organizational rewards, Reputation, Reciprocity	271 Managers	Survey	Taiwan
B64	(Arefin et al., 2015)	Journal (JSIS)	Examined the impact of organizational structure, strategy, process and culture on organizational effectiveness and the mediating role of BIS effectiveness	Success	BI system	Venkatraman's Strategic orientation of business enterprise (STROBE) framework, Barney's resource-based view	Organizational factors – strategy, structure, process, culture	228 managers from 154 organizational	Survey	Bangladesh
B65	(Mudzana & Maharaj, 2015)	Journal (SAJIS)	Identified post-implementation factors to measure BIS success	Success	BI system	DeLone & McLean IS success model	Information Quality, Service Quality, System Quality	102 BI users	Survey	South Africa
B66	(Hou, 2015)	Journal (ID)	Investigated the factors affecting users' continuous intention to use a BI system	Use	BI system	Expectation-confirmation Model of IS, TAM	Perceived usefulness, Confirmation of expectation, Perceived ease of use	330 senior managers and executives	Survey	Taiwan

B67	(Grublješič & Jaklič, 2015)	Journal (JCIS)	Investigated post-adoptive use behaviour	Use	BI system	Burton-Jones and Straub dimensions	Individual characteristics, BIS quality characteristics, Organizational factors, Macro environmental characteristics	-	Case study	Slovenia
B68	(Bischoff et al., 2015)	Journal (JITTA)	Explored the factors affecting the continuous use of a BI system	Use	BI system	NA	Influence of peer, Information Quality, Governance, Coverage of user requirements, User support, Influence of organization	138 BI Practitioners	Mixed Methods	Switzerland and Germany
B69	(Wieder & Ossimitz, 2015)	Conference (PCS)	Examined the influence of BI management on decision making	Success	BI system	DeLone & McLean IS success model	BI management	33 senior IT managers	Survey	Australia
B70	(Kowalczyk & Buxmann, 2015)	Journal (DSS)	Investigated data-centric decision support using ambidexterity	Success	BI system	NA	NA	11 BI Analysts	Case study	Germany
B71	(M. T. Lee & Widener, 2015)	Journal (JIS)	Developed a framework to understand the connection between information systems, organizational learning and performance effects	Use	BI systems	NA	BI systems (Extent of use of QAR and DV)	343 directors, managers, business analysts, vice presidents	Survey	United States
B72	(R. Gonzales et al., 2015)	Journal (JGITM)	Examined the influence of data warehouses and BI on organizational performance	Success	Data Warehouse	DeLone and McLean IS success	Information Quality, System Quality, Service Quality	133 DW and BI managers	Mixed Methods	Peru
B73	(Zellal & Zaouia, 2015)	Conference (WCCS)	Examined the factors that influence data quality	Success	Data Warehouse	NA	Source Data Quality	NA	NA	Morocco
B74	(Bouchana & Idrissi, 2015)	Conference (SITA)	Assessed user satisfaction in BI system context	Adoption	BI system	NA	Ease of use, Ease of learning, information quality, System quality, trust	NA	Case study	NA
B75	(Nofal & Yusof, 2016)	Journal (IJBIM)	Proposed a framework based on critical success factors to examine the relationship between ERPBI and organizational performance	Use	BI system	NA	Organization (Clear Vision & Planning, Top management support, effective communication), Process (Effective project management, change management, teamwork & composition, Training), Technology (Data quality and IT infrastructure)	NA	NA	Malaysia
B76	(Y.-M. Han et al., 2016)	Journal (ID)	Explained the pervasive continued usage of BIS	Use	BI system	Expectation- confirmation model (ECM)	Confirmation, Comprehensiveness of usage, Perceived usefulness, Structural empowerment	117 Respondents	Survey	Taiwan
B77	(Hou, 2016)	Journal (ID)	Examined the influence of BI system usage on organizational performance	Use	BI system	NA	BI System Usage	139 respondents	Survey	Taiwan
B78	(Rouhani et al., 2016)	Journal (JEIS)	Studied the relationship between business intelligence functions, decision support benefits and organizational benefits	Use	BI system	NA	Analytical and intelligent decision-support, enhanced decision-making tools, Reasoning, Optimization and recommendation, Providing experiments and environmental information	228 CIOs	Survey	Middle East

B79	(Bach et al., 2016)	Conference (PCS)	Discussed a framework to investigate BIS adoption	Adoption	BI system	TAM	Change Management, Knowledge sharing, Information quality, Technology driven strategy	NA	NA	United States
B80	(Chee, Yeoh, Tan, & Ee, 2016)	Journal (JCIS)	Developed an automatic weight assignment for evaluating critical dimensions of data quality	Adoption	Dashboard	NA	NA	10 BI users	Mixed Methods	Malaysia
B81	(M. D. Peters et al., 2016)	Journal (IJAIS)	Developed a framework to understand the impact of BI systems on organizational performance	Success	BI system	NA	BI infrastructure integration	324 CEOs and CFOs	Survey	Australia
B82	(Kao et al., 2016)	Journal (CHB)	Described the development of a hospital-based BI system by using the design research methodology	Adoption	BI system	NA	NA	5 respondents (vice-superintendent, CIO, Director and other staff)	Mixed Methods	Taiwan
B83	(Shollo & Galliers, 2016)	Journal (ISJ)	Examined the role of BI systems in organizational knowing	Success	BI system	NA	NA	10 interviews	Interviews	Scandinavia
B84	(Ahmad et al., 2016)	Journal (JTAIT)	Examined the innovation traits for the successful deployment of BI	Success	BI system	Diffusion of Innovation (DOI)	Relative advantage, Complexity, Compatibility, Triability, Observability	310 Business analysts and executives	Survey	Malaysia
B85	(Boonsiritomachai et al., 2016)	Journal (CBM)	Proposed a BI maturity framework for small and medium enterprises	Adoption	BI system	Diffusion of Innovation (DOI)	Relative advantage, Complexity, Compatibility, absorptive capacity, Organizational resource availability, Competitive pressure, vendor selection, Owner-managers' innovativeness, Owner-managers' IT knowledge	427 employees	Survey	Thailand
B86	(Skyrius et al., 2016)	Journal (IIS&IT)	Examined the driving forces affecting BI adoption	Adoption	BI system	NA	Data driven BI, BI agility/maturity, BI acceptance	NA	NA	Lithuania
B87	(Audzeyeva & Hudson, 2016)	Journal (EJIS)	Discussed the process of maximizing the strategic benefits from BI application	Success	BI system	NA	NA	16 managers and specialists	Case study	UK
B88	(Yeoh & Popovič, 2016)	Journal (JAIST)	Investigated the critical success factors affecting BI system implementation	Success	BI system	NA	Organization (Committed management support & sponsorship, Clear vision & well-established business case), Process (Business-centric championship & balanced team composition, Business-driven & iterative development approach, User-oriented change management), Technology (Business driven, scalable & flexible technical framework, Sustainable data quality & integrity)	NA	Interviews	Australia

B89	(Serumaga-Zake, 2017)	Journal (SAJIS)	Identified BIS success factors	Success	BI system	DeLone & McLean IS success model	Information quality, system quality, Service quality	250 BI users	Survey	South Africa
B90	(Visinescu et al., 2017)	Journal (JCIS)	Examined the antecedents affecting decision quality in the BI context	Use	BI system	Clark's model	Level of BI use, Problem space complexity, Information quality	61 BI users	Survey	USA
B91	(Richards et al., 2017)	Journal (JCIS)	Explored the influence of BI system implementation effectiveness on corporate management practices that subsequently affect organizational process effectiveness	Success	BI system	NA	BIS Effectiveness	337 managers	Survey	Taiwan
B92	(Owusu, 2017)	Journal (CBM)	Examined the influence of BI system adoption on organizational performance	Adoption	BI system	NA	BI systems adoption	130 CIO, IT/IS managers	Survey	China, Japan, US
B93	(Brichni, Dupuy-Chessa, Gzara, Mandran, & Jeannet, 2017)	Journal (ESA)	Developed an automated system (BI4BI) for BI evaluation	Adoption	BI system	NA	NA	26 BI experts, business users and end users	Mixed Methods	Ghana
B94	(Popovič, 2017)	Journal (ER)	Examined corporate-, technology- and individual-related factors to understand users' resistance to BIS	Use	BI system	NA	Information culture, Communication, Service quality, Training, System issues, loss of power, Changes in decision-making approach, Job/skills change	NA	NA	France
B95	(Chang et al., 2017)	Journal (MJLIS)	Investigated the effects of personality traits on BI usage intentions	Use	BI system	Bagozzi, Dholakia and Basuroy (BDB) model	Conscientiousness, emotional stability, agreeable, extraversion, openness to experience	354 managers	Survey	Slovenia
B96	(Fink et al., 2017)	Journal (I&M)	Developed a framework for BI value creation	Success	BI system	Resource Based View (RBV)	BI team	178 BI managers, expert, CIO, executives	Mixed Methods	China and Taiwan
B97	(Puklavec et al., 2017)	Journal (IMDS)	Developed a framework to assess BIS adoption, evaluation and use	Adoption	BI system	Diffusion of innovation (DOI) and Technology, Organization, Environment (TOE)	Relative advantage, Cost, BIS is part of ERP, Management support, Relational decision-making culture, Project champion, Organizational data environment, organizational readiness, External support	181 CIO, other management, or senior IS personnel	Survey	Israel
B98	(Arnott et al., 2017)	Journal (DSS)	Explored the patterns of BI use in organizations	Use	BI system	Gorry and Scott Morton (GSM) framework	NA	142 BI users and developers	Interviews	NA
B98	(Gaardboe et al., 2017)	Conference (PCS)	Explored the factors affecting individuals' system use	Success	BI system	DeLone & McLean IS success model	Information Quality, System Quality	746 end users	Survey	Australia, China
B100	(Dedić & Stanier, 2017)	Journal (JMA)	Developed an evaluation tool to measure BI solutions' success	Success	Data warehouse	DeLone & McLean IS success model	NA	30 BI users	Survey	Denmark
B101	(Gauzelin & Bentz, 2017)	Journal (JISB)	Explored the impact of BI systems on SMEs' business	Success	BI system	NA	NA	200 members	Interviews	Europe
B102	(Lautenbach et al., 2017)	Journal (SAJIS)	Examined the factors affecting the BI & A use within organizations	Use	BI system	DOI, TOE	Data Infrastructure capabilities, Data management challenges, Top management support, Talent management	72 CIO's, IT and BI managers	Survey	France

							challenges, External market influence, Regulatory compliance			
B103	(V.-H. T. Trieu et al., 2018)	ECIS	Examined the factors that influence the actual use of BI systems.	Success	BI system	NA	BIS dependence, BIS infusion, Fact-based decision-making culture, Data quality of source systems	BI users	Survey	North America
B104	(Torres et al., 2018)	I&M	Examined the impact of BI&A on organization performance	Success	BI &Analytics	Information processing theory, Resource-based view (RBV)	BI&A technical infrastructure quality, BI&A management capability, BI&A personnel expertise, BI&A sensing capability, BI&A seizing capability, business process change capability, functional performance	137 C-level executives, vice-presidents, directors, and senior managers	Survey	NA
B105	(Popovič et al., 2019)	IM&DS	Examined the impact of BI system use on organization performance	Success	BI system	Resource based view, diffusion of innovation theory	Routine use, Innovative use, Impact on marketing & Sales, Impact on management and internal operations, Impact on procurement	181 CIO, other management, or senior IS personnel	Survey	NA
B106	(Masa'Deh et al., 2018)	IJH&TA	Examined the influence of BIS on organizational effectiveness	Success	BI system	NA	Definitional metadata quality, Data quality metadata quality, Navigational Metadata quality, Lineage Metadata quality, Perceived ease of use, perceived usefulness, BI system effectiveness	225 hotel staff	Survey	Jordon
B108	(Batra, 2018)	TJSS	Assessment of the success of DW, BI & analytics projects development	Success	DW, BI system	NA	Technological capability, Shared understanding, Top management commitment, Agile values, Plan driven aspects	124 DW analyst, manager, administration, consultant, developer, systems analyst & other	Survey	NA
B107	(Jaklič et al., 2018)	IJIM	Assessment of the compatibility in predicting BI & analytics use intentions	Adoption	BI system	IDT, UTAUT	Performance perceptions, Results demonstrability, Social influence, Compatibility	195 top management, head of department and divisions, IS managers	Survey	Slovenia
B109	(M. L. Gonzales et al., 2019)	Int. J. BIS	Examined the factors that provide BI enabled success	Success	DW, BI system	NA	BI Leadership, BI infrastructure, BI financial commitment	1,054 corporations and organisations representative and BI consultant	Survey	Africa, Asia, Australia, Canada, Europe, Mexico/Central/South America, Middle East, USA or other
B110	(Božič & Dimovski, 2019)	IJIM	Examined how BI& Analytics triggered insights	Success	BI system	NA	NA	14 CEO positions, IT	Semi-structured interviews	Europe

			transformed into valuable knowledge					managers, CIO, Heads of R&D, Market Managers		
B111	(Richards et al., 2019)	JCIS	Investigated the relationship between BI system effectiveness and the effectiveness of corporate level management practices.	Success	BI system	Integrative Model of IT Value, Information Processing Theory	BIS effectiveness, planning effectiveness, BA effectiveness, Measurement effectiveness	337 senior managers, executives, and board members	Survey	America, Asia & Others

Note *DC = Data collection, **NA**= Not Available.

Table 8. Comprehensive BI system success metrics					
System Quality	**Information Quality**	**Service Quality**	**System Use**	**Satisfaction**	**Net benefits**
Ease of use	Precise/Concise	Effective support	Frequency of use	Satisfaction with overall quality of information	Improved Job Performance
Usefulness	Timeliness	Service level	Duration of use	Satisfaction with overall performance	Efficiency
Easy to learn	Comprehensiveness	Assurance	Use as part of routine work	Satisfaction with clarity of information	Effective change Management
Presence of feature & functionality	Relevance/Usefulness	Empathy	Embeddedness of use	Satisfaction with accuracy of information	Faster problem detection
Flexibility	Accuracy	Responsiveness	Depend upon the system	Satisfaction with the speed of interacting with the system	Increased individuals Productivity
Reliability	Currency		Use system for learning	Satisfaction with the amount of support provided by vendor or other sources	Improved decision making
Response time	Understandability		Like to use system interface	Satisfaction with the use of BI system	Marketing & Sales effectiveness
Precision/Efficiency	Representational		Use various features of BI	Satisfaction with system functions and features	Planning Efficiency
Availability	Reliable/Consistency			Satisfaction with decision making	Improved Products & Services
Accessibility	Content				Increased Profitability & Returns
Security	Availability				Improved strategic performance
					Improved business processes
					Effective operations management
					Individuals Growth
					Improved security
					Improved Forecasting

Table 9. Assessment of measures used in BI system research		
Measures	**Descriptors**	**References**
System Quality		
Ease of use	• Easy to use • User friendly • Easy to do what one wants to do • Difficult to understand, implement and use • Cumbersome to implement and use • Easy to locate data • Utilization of mature functionality for content storage and distribution • Exploration • Assist managers and users in generating dynamic reports • Clear and understandable interaction • Ease of information finding • Easier to gather information • Easy to extract	Baars and Kemper (2008); Bischoff et al. (2015); Chang et al. (2014); Chung et al. (2005); Dedić and Stanier (2017); Foshay et al. (2014); Gaardboe et al. (2017); Gorla (2003); Grublješič et al. (2014); Grublješič and Jaklič (2015); M. Hart et al. (2007); M. Hart and Porter (2004); Hong et al. (2006); Hou (2012, 2013, 2014b, 2015); Hou and Papamichail (2010); Kao et al. (2016); Kohnke et al. (2011); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); X. Li et al. (2013); Lin et al. (2009); Mudzana and Maharaj (2015); M. D. Peters et al. (2016); Ramamurthy et al. (2008); Serumaga-Zake (2017); Shin (2003); Soliman et al. (2000); Visinescu et al. (2017); B. H. Wixom et al. (2011); Yeoh and Koronios (2010)
Usefulness	• Compatible with all aspects of my work • Compatibility • Provide sufficient information • Provide reports • Provides information that helps finish projects effectively • Providing details on demands	Ahmad et al. (2016); Bach et al. (2016); Bischoff et al. (2015); Boonsiritomachai et al. (2016); Chung et al. (2005); Dedić and Stanier (2017); Grublješič et al. (2014); Grublješič and Jaklič (2015); Y.-M. Han et al. (2016); Y. Han and Farn (2013); M. Hart and Porter (2004); Hou (2013, 2014b, 2015); Işık et al. (2013); Kao et al. (2016); Kokin and Wang (2014); Kulkarni and Robles-Flores (2013); X. Li et al. (2013); Mudzana and Maharaj (2015); Serumaga-Zake (2017); T. E. Yoon et al. (2014)
Response time	• Information in a timely fashion • Time for data refresh after redefinition • On time delivery of assets • Get the information I need in time • Faster analysis • Actual update speed • Forecast speed • Speed of execution time for initial BI report or dashboard • Speed of execution time for SQL query • Speed of re-execution time when changing reports • Currency or unit • Speed of execution time when drilling down, conditioning, removing or adding columns in reports • Amount of time required to change erroneous descriptions, Change of descriptive content fast • Information is processed and delivered rapidly without delay	Dedić and Stanier (2017); Fink et al. (2017); R. Gonzales et al. (2015); Gorla (2003); Hong et al. (2006); Hou (2012); Hou and Papamichail (2010); Işık et al. (2013); Kohnke et al. (2011); Kositanurit et al. (2011); Lin et al. (2009); Nelson et al. (2005); M. D. Peters et al. (2016); Popovič et al. (2012); Shin (2003); Yeoh and Koronios (2010)
Accessibility	• Easy system access • Convenient to access • Accessibility • Retrieval of information at any time • Authorization to access useful data • Access control • Accessibility	Audzeyeva and Hudson (2016); Bischoff et al. (2015); Fink et al. (2017); Grublješič and Jaklič (2015); M. Hart and Porter (2004); Hong et al. (2006); Hou and Papamichail (2010); Işık et al. (2013); Kositanurit et al. (2011); Mudzana and Maharaj (2015); Serumaga-Zake (2017); Wieder and Ossimitz (2015); B. H. Wixom et al. (2011)

Presence of features and functionality	• Functionality • Presence of multidimensional tables • Presence of graphics • Number of hierarchies allowed • Capability to swap between summarized and detailed levels • Data navigability • Number of allowable dimensions • Capability to redefine dimension • Preconstructed query capability • Simple query building with click-select feature • Query building with query languages • Concurrent run of queries • Ability to extract detailed and real time data • Recall • Supports your needs in reporting functionality completely • System provides complete features I need • Report navigation • Report bookmarking • Report export • Report customization, • Customizable • Reporting errors • DW improves on-line analytical processing (OLAP)/data mining operations • Data integration from data sources • Integration • Level of detail • Extract information • Summarization • Standard report generation • Customized report generation • Graphic/chart generation	Candal-Vicente (2009); Chung et al. (2005); Dedić and Stanier (2017); Deng and Chi (2012); Gorla (2003); Hou and Papamichail (2010); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); Nelson et al. (2005); Ramamurthy et al. (2008); Rouhani et al. (2016); Shin (2003); B. H. Wixom and Watson (2001); Yeoh and Koronios (2010)
Flexibility	• Versatility • Shareability • Interoperability	Candal-Vicente (2009); Dedić and Stanier (2017); Foshay et al. (2014); Gorla (2003); Nelson et al. (2005); B. H. Wixom and Watson (2001); Yeoh and Koronios (2010)
Easy to learn	• Easily comprehend for users • Easy for me to become skillful	Bischoff et al. (2015); Chang et al. (2014); Foshay et al. (2014); Gaardboe et al. (2017); Grublješič et al. (2014); M. Hart et al. (2007); M. Hart and Porter (2004); Hong et al. (2006); Hou (2013, 2014a, 2015); Hou and Papamichail (2010); Kao et al. (2016); Kositanurit et al. (2011); X. Li et al. (2013)
Reliability	• Stability	Bischoff et al. (2015); Hou and Papamichail (2010); Mudzana and Maharaj (2015); Nelson et al. (2005); Popovič (2017); Serumaga-Zake (2017); Yeoh and Koronios (2010)
Precision/Efficiency	• Quick finding results • Efficient reporting • Precision	Chung et al. (2005); Lautenbach et al. (2017)
Availability	• Report Availability • BI tools available • Availability	Deng and Chi (2012); Mudzana and Maharaj (2015); Serumaga-Zake (2017); Wieder et al. (2012)
Information Quality		

Relevance/Usefulness	• Relevant information • Provision of information corresponds to users' needs and habits • Provides reports exactly as needed • Provides all required information • Content meet needs • Applicability • Actionable information • Appropriateness • Information provided is useful for tasks • Output useful • Easy to interpret, • Knowledge or information provided is important and helpful, • Information is critical to my work, • Information or knowledge received is meaningful	Bach et al. (2016); Bischoff et al. (2015); Chee et al. (2016); Dedić and Stanier (2017); Grublješič and Jaklič (2015); M. Hart et al. (2007); Hong et al. (2006); Hou (2012); Hou and Papamichail (2010); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); Mudzana and Maharaj (2015); Nelson et al. (2005); Popovič et al. (2012); Shin (2003); Soliman et al. (2000); Visinescu et al. (2017); Wieder and Ossimitz (2015)
Accuracy	• Accurate information • Accuracy • Free of error • Distortation, bias • Provides appropriate error messages and clear instructions • Believable	Bischoff et al. (2015); Brichni et al. (2017); Chung et al. (2005); Dedić and Stanier (2017); Foshay et al. (2014); Gauzelin and Bentz (2017); Ghazanfari et al. (2011); Hou and Papamichail (2010); Kao et al. (2016); Kohnke et al. (2011); Lautenbach et al. (2017); Lin et al. (2009); Mudzana and Maharaj (2015); Nelson et al. (2005); Popovič (2017); Popovič et al. (2012); Shin (2003); Visinescu et al. (2017); Yeoh and Koronios (2010)
Understandability	• Understandability • Get all the information to understand lineage of data • Useful format/Clear format/understandable format • Information transparency • Clear information • Easy to interpret	Bach et al. (2016); Bischoff et al. (2015); Chung et al. (2005); Dedić and Stanier (2017); Foshay et al. (2014); Gaardboe et al. (2017); Hou (2012); Kao et al. (2016); Kositanurit et al. (2011); Mudzana and Maharaj (2015); Nelson et al. (2005); M. D. Peters et al. (2016); Popovič (2017); Popovič et al. (2012); Soliman et al. (2000); Visinescu et al. (2017)
Precise/Concise	• Precise information • Precision • Information is to the point, void of unnecessary elements • Conciseness • Filter information	Bischoff et al. (2015); Chung et al. (2005); Dedić and Stanier (2017); Gauzelin and Bentz (2017); Hou (2012); Hou and Papamichail (2010); Kositanurit et al. (2011); Mudzana and Maharaj (2015); Popovič et al. (2012); Soliman et al. (2000)
Currency	• Current information • Up-to-date information	Bischoff et al. (2015); Dedić and Stanier (2017); R. Gonzales et al. (2015); Hou (2012); Hou and Papamichail (2010); Nelson et al. (2005); Popovič (2017); Popovič et al. (2012); Wieder and Ossimitz (2015)
Comprehensiveness	• Comprehensive information • Sufficient information for decision making • Provides sufficient information • Scope of information is adequate • Completeness	Hou (2012); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); Nelson et al. (2005); Popovič (2017); Popovič et al. (2012); Soliman et al. (2000); Wieder and Ossimitz (2015)
Content	• Customized reporting • Content, Volume • Interactive reporting • Customer demographics • Abstraction of analytics details	Brichni et al. (2017); Kowalczyk and Buxmann (2015); S. M. Lee et al. (2004); (Mudzana & Maharaj, 2015); M. D. Peters et al. (2016); Serumaga-Zake (2017); Wieder and Ossimitz (2015); B. H. Wixom et al. (2011)
Availability	• Availability of information • Information readily accessible	Bach et al. (2016); Foshay et al. (2014); Mudzana and Maharaj (2015); Nelson et al. (2005); Popovič et al. (2012); Serumaga-Zake (2017); Skyrius et al. (2016); Visinescu et al. (2017)
Timeliness	• Timely information	Bischoff et al. (2015); Işık et al. (2013); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); Mudzana and Maharaj (2015); Soliman et al. (2000)
Reliable/Consistency	• High reliable information • Reliability of analysis • Consistency	Bischoff et al. (2015); Ghazanfari et al. (2011); Hou and Papamichail (2010); Kulkarni and Robles-Flores (2013); Yeoh and Koronios (2010)

Representational	• Representational, • Presentation of information on errors and failures • Content representation of information is logical • Labeling	Bach et al. (2016); Chung et al. (2005); Grublješič and Jaklič (2015); Yeoh and Koronios (2010)
Service Quality		
Effective Support	• Satisfactory support • Effective fix from supporting staff • Technical support for effective use	Hong et al. (2006); Puklavec et al. (2017); Soliman et al. (2000)
Service level	• Better service level, • Service level provided by the BI system was better, • BIS service level is perceived to be high	Bischoff et al. (2015); Y. Han and Farn (2013); Hou (2015)
Responsiveness	• Responsiveness • Prompt response from supporting staff	Hong et al. (2006); Mudzana and Maharaj (2015); Popovič (2017); Serumaga-Zake (2017)
Assurance	• Assurance	Mudzana and Maharaj (2015); Popovič (2017); Serumaga-Zake (2017)
Empathy	• Empathy	Mudzana and Maharaj (2015); Popovič (2017); Serumaga-Zake (2017)
System Use		
Frequency of use	• Frequency of use • Number of attempts to access the system over a period of twelve months • How often use BIS	Bischoff et al. (2015); Foshay et al. (2014); Grublješič et al. (2014); Grublješič and Jaklič (2015); Hong et al. (2006); Hou (2012, 2013, 2014a); Kohnke et al. (2011); Mudzana and Maharaj (2015); Nofal and Yusof (2016); Owusu (2017)
Duration of use	• Duration of use: time spend each week, • How much time spend each week using BIS? • In the last 7 days, often using BIS, • In the last 7 days, spend a long time on BIS usage, • What is the approximate share of your total work have you used [BI] to solve for the past month? • Uses BIS at all times	Gaardboe et al. (2017); Y. Han and Farn (2013); Hou (2012, 2013, 2014a, 2016); Owusu (2017)
Use as part of routine work	• Incorporated IT into regular work schedule • Integrated as part of normal work routine • Use of IT is normal part • Use system to track performance • Use system to monitor variations • Use system to focus on critical success factors • Top management regularly uses information from system • Our company uses BIS technology/solution of (Analyses, Reporting, Planning, Dashboard, Data mining • Use BIS for answering complex questions • Using BI was critical	Bischoff et al. (2015); M. T. Lee and Widener (2015); X. Li et al. (2013); Owusu (2017); Puklavec et al. (2017); Visinescu et al. (2017)
Continue to use	• For future, would use BIS, • Plan to continue use in future	Foshay et al. (2014); Hou (2013)
Embeddedness of use	• Embeddedness of use	Grublješič et al. (2014); Grublješič and Jaklič (2015)
Depend upon the system	• Depend upon the system • Relied on BI functionality	Mudzana and Maharaj (2015); Serumaga-Zake (2017); Visinescu et al. (2017)
Use system for learning	• Use the system when necessary for learning	Mudzana and Maharaj (2015); Serumaga-Zake (2017)
Like to use system interface	• Like to use system interface	Kao et al. (2016)
Use various features of BI	• Use various features of BI	Visinescu et al. (2017)
Satisfaction		
Satisfaction with overall quality of information	• Satisfaction with overall quality of information • Information very satisfying	Ghazanfari et al. (2011); Kulkarni and Robles-Flores (2013); Mudzana and Maharaj (2015); Nelson et al. (2005); Shin (2003); Wieder et al. (2012)

	• Satisfied with the information • Stakeholders' satisfaction • Information needs satisfaction • Suitability/task relevance of BI info. ¨ • Meets information need	
Satisfaction with overall performance	• Satisfaction with overall performance • Effectiveness & efficiency of BI system • General end-user satisfaction with BI system • Satisfied with performance of BIS • Need fulfilment • Acceptable satisfaction between stakeholders • System is very helpful	Y.-M. Han et al. (2016); Y. Han and Farn (2013); Kulkarni and Robles-Flores (2013); Mudzana and Maharaj (2015); Rouhani et al. (2016); Serumaga-Zake (2017); Shin (2003); Wieder et al. (2012)
Satisfaction with clarity of information	• Satisfied with clarity of information	Kohnke et al. (2011)
Satisfaction with the accuracy of system	• Satisfied with the accuracy of system • Satisfaction with system accuracy • Acceptable level of reliability and accuracy of analysis • Satisfied with the accuracy	Dedić and Stanier (2017); Hou (2012); Kositanurit et al. (2011); Rouhani et al. (2016)
Satisfaction with the speed of interacting with the system	• Satisfied with the speed of interacting with the system • Personal satisfaction while mastering certain difficult job skills	Kositanurit et al. (2011); X. Li et al. (2013)
Satisfaction with the amount of support provided by vendor or other sources	• Satisfied with the amount of support provided by vendor or other sources	Kositanurit et al. (2011)
Satisfaction with use of BIS	• Satisfied in using BIS • Pleased with the experience of using BIS • Very dissatisfied/ Very satisfied • Very displeased/ Very pleased • Very frustrated/ Very contented • Absolutely terrible/ Absolutely delighted • Overall, satisfied with the system • Satisfy, Overall, how satisfied are you with BI? • Decision to use BIS was wise • Would recommend BI, User satisfaction	Ahmad et al. (2016); Candal-Vicente (2009); Gaardboe et al. (2017); Y.-M. Han et al. (2016); Y. Han and Farn (2013); Hou (2013, 2015); Kao et al. (2016); Mudzana and Maharaj (2015); Serumaga-Zake (2017); B. H. Wixom and Watson (2001)
Satisfaction with system functions and abilities	• System had all expected functions and abilities • Has all the functions and capabilities I expect it to have	Gaardboe et al. (2017); Kao et al. (2016)
Satisfaction with Decision-making	• Decision-making satisfaction	Audzeyeva and Hudson (2016); Visinescu et al. (2017)
Net Benefits		
Improved Job Performance	• Changed job significantly • Project deadline met (roll out deadline, initial development deadline) • Results apparent • Effectiveness • More effective • Enhances effectiveness in my job • More innovative • Improve quality of work • Quality management effectiveness • Enables a complete and comprehensive presentation • Make my reports effectively • Improve job performance	Ahmad et al. (2016); Arefin et al. (2015); Bischoff et al. (2015); Boonsiritomachai et al. (2016); Candal-Vicente (2009); Fink et al. (2017); Gaardboe et al. (2017); Grublješič et al. (2014); Y.-M. Han et al. (2016); Y. Han and Farn (2013); M. Hart et al. (2007); M. Hart and Porter (2004); Hong et al. (2006); Hou (2012, 2013, 2015); Hou and Papamichail (2010); Kao et al. (2016); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); X. Li et al. (2013); Mudzana and Maharaj (2015); Richards et al. (2017); Serumaga-Zake (2017); B. H. Wixom and Watson (2001); T. E. Yoon et al. (2014)

	• Quicker tasks • Improves performance • Enables to accomplish tasks more quickly • Accomplish tasks more quickly • Helps to complete work efficiently • Complete my reports • Engage in more in-depth analysis • Positive impact on work • Improved task outcomes • Improvement of some of weak points on the job • Job easiness	
Efficiency	• Reduced time • Improves working efficiency • Complete my reports quickly	Candal-Vicente (2009); Gaardboe et al. (2017); Gorla (2003); B. H. Wixom and Watson (2001)
Effective change Management	• Dealing Political resistance effectively • Change management effectively • Change management	Grublješič and Jaklič (2015); Ravasan and Savoji (2014); B. H. Wixom and Watson (2001)
Faster problem detection	• Transforming weak signs into intelligence • Allows better understanding the concept of weak signs and orients environmental scanning • Identify potential problems and notice before serious problems • Identify potential problems faster • Increase the understanding of the problem • Exposes the problematic aspects of current • business processes and make awareness • Identify potential problems faster • Notices me potential problems	Hou (2012); Hou and Papamichail (2010); Popovič et al. (2012); Rouibah and Ould-Ali (2002)
Increased individuals Productivity	• Increase my/users/staff productivity • Reduced effort • Spend significantly more time analyzing data before making a decision • Positive impact on my productivity	Ahmad et al. (2016); Arefin et al. (2015); Bach et al. (2016); Bischoff et al. (2015); Candal-Vicente (2009); Elbashir et al. (2008); Fink et al. (2017); Gorla (2003); Grublješič et al. (2014); Y.-M. Han et al. (2016); Y. Han and Farn (2013); M. Hart et al. (2007); M. Hart and Porter (2004); Hou (2012, 2013, 2015); Hou and Papamichail (2010); Kositanurit et al. (2011); Kulkarni and Robles-Flores (2013); X. Li et al. (2013); Owusu (2017); Shin (2003); B. H. Wixom and Watson (2001); B. H. Wixom et al. (2011)
Improved decision making	• Improves decision making • Making better decisions • DW improves decision-support operations • Use more sources of information in DM • Better decision making • Effective decision-making support • Provides support to decision-making • Decision-taken success • Good decision • Improved decision-making processes • Right decisions and right actions • Enhances effectiveness in decision making • Improve the quality of decisions and actions • Improves my decision-making performance • Clear and specified conclusion • Make decisions quicker • Spend less time in meetings • Shorten the time frame for making decisions • Enhance communications among participant • Quicker decisions	Chang et al. (2014); Chu (2013); Dedić and Stanier (2017); Fink et al. (2017); Foshay et al. (2014); R. Gonzales et al. (2015); Gorla (2003); Hong et al. (2006); Hou (2012, 2013, 2014b, 2016); Hou and Papamichail (2010); Işık et al. (2013); Popovič et al. (2012); Puklavec et al. (2017); Ramamurthy et al. (2008); Rouhani et al. (2016); Visinescu et al. (2017); Wieder and Ossimitz (2015); Wieder et al. (2012); B. H. Wixom et al. (2011); T. E. Yoon et al. (2014)

	• Shorten the time frame for DM • Less time spending in meeting • Decision effectiveness • Timeless/Speed of decision making • Increase communication by sharing of knowledge • Enables to make decisions more quickly • Make a timely decision • Improve reliability of decision processes or outcome • Identify past similar solutions and recommend an appropriate solution • Reduces uncertainty in the decision-making process enhances confidence and improves operational effectiveness • Accuracy/Correctness of decision making • Making rationale/Informed decisions • Informed decision making • Improve the quality of decisions • Easier to make decisions • Decision resulted in desired outcome • Improve the quality of decisions and actions • Reliable information to make informed and strategic decisions	
Marketing & Sales effectiveness	• Sales Promotion • Pricing programs • Measurement of promotions • Knowledge of purchasing patterns • Year to year percent change in sales • Increased geographic distribution of sales • Vendor negotiations • Predict buyer patterns, Exploit the market • Determine products customers are likely to purchase • Price discrimination among channels • Identify potential opportunity, provide alternatives • Examine more alternative solutions • Marketing e.g., targeting customers and tailoring offers • Sales e.g., sales force automation, revenue management, • Entering new markets • Promote image and reputation • Customers-segmentation • Commercial campaigns • Accurate impact assessment of new products • Enables real-time identification of trends • Identify trends, opportunities, and threats • Scan market and forecast events • Identify changing trends and emerging threats • Increase market share • Customer services e.g., improving customer satisfaction • Enhancing customer relations • Customer loyalty • Enhancing customer linkages • Anticipate new requirements of existing customers or new costumers • Reduce customers complaints • Customer satisfaction • Better understanding of customers • Enhancement in customer satisfaction	Audzeyeva and Hudson (2016); Dedić and Stanier (2017); Elbashir et al. (2008); Elbashir et al. (2011); Elbashir et al. (2013); Fink et al. (2017); R. Gonzales et al. (2015); Grublješič and Jaklič (2015); Hou (2014b, 2016); Hou and Papamichail (2010); S. M. Lee et al. (2004); Owusu (2017); M. D. Peters et al. (2016); Phan and Vogel (2010); Wieder et al. (2012)

	• An enhancement in customer loyalty • Increase recognition rate of corporate brand	
Increased Profitability & Returns	• Increase Return on sales (ROS) • Increased revenues • Reduction of lost sales • Increased return on investment (ROI) • Enhanced profit margin • Profitability • Revenue growth, Return on asset (ROA) • Return on investment (ROI) improvements • Speed the return on investment (ROI) • Increase return on asset (ROA) • Increase profit margin • More profitable • Profit maximization • Increase sales revenue • Increased profits • Increased revenues • Increased return on investment • Impact return on investments	Arefin et al. (2015); Chu (2013); Dawson and Van Belle (2013); Dedić and Stanier (2017); Elbashir et al. (2008); Elbashir et al. (2013); Fink et al. (2017); R. Gonzales et al. (2015); Hou (2014b, 2016); Işık et al. (2013); (S. M. Lee et al., 2004); Nofal and Yusof (2016); Owusu (2017); M. D. Peters et al. (2016); Wieder et al. (2012)
Improved strategic performance	• Improved competitive advantage • Improved coordination with business partners/suppliers • Improved responsiveness to/from suppliers • Reduced inventory levels • Reduced time-to-market products/services • Business policy implemented and execution • Lock in customers • Delivery of products/services • Improved business performance • Performance (improved performance of org) • Future competitive edge • Shorten customer response time • Workplace achieved its operational process goals • Workplace achieved its customer relationship process • Workplace achieved customer expectations on timely product and/or service deliveries • Financial performance • Market performance • Improved organizational efficiency • Financial performance • Increase in the rate of timely delivery of products and services • Products are delivered on time, Bring efficiency to business • Increased organizational efficiency and productivity • Improved company performance • Enhanced overall organizational performance • Entering new markets • Growth • Market share • Development (growth of org.) • Sales growth • Market value • Growth control	Arefin et al. (2015); Audzeyeva and Hudson (2016); Bach et al. (2016); Cheng et al. (2009); Dawson and Van Belle (2013); Dedić and Stanier (2017); Elbashir et al. (2008); Elbashir et al. (2011); Elbashir et al. (2013); Fink et al. (2017); R. Gonzales et al. (2015); Hou (2014b, 2016); Karim (2011); Krumm, Kanthak, Hartmann, and Hertel (2016); M. T. Lee and Widener (2015); Nofal and Yusof (2016); Owusu (2017); M. D. Peters et al. (2016); Phan and Vogel (2010); Popovič et al. (2012); Puklavec et al. (2014); Richards et al. (2017); Wieder et al. (2012); Zhao et al. (2012)

	• Seeking new opportunities • Greater market share • Faster growth • Geographic distribution of sales/service activities expanding • Using information provided to make changes to cooperate strategies and plans, • Modify existing KPIs and analyse newer KPIs • Reducing risks • Improve awareness of share vision, objectives, and value • Risk control	
Improved business processes	• Improved efficiency of internal processes • Creating flexible manufacturing/operations processes • Improved business processes • Improve efficiency in operational process in your organization • Improve the quality of operational process • Enhance delivery dependability of operational process • Improve firm's customer process to facilitate target customer selection • Improve firm's customer process to facilitate customer acquisition • Improve firm's customer process to facilitate customer retention • Improving production/service processes • Internal processes are efficient in terms of time and cost • Overall process effectiveness • Process management effectiveness • Shorten the duration of data processing	Elbashir et al. (2008); Elbashir et al. (2011); Fink et al. (2017); Hou (2014b, 2016); Lin et al. (2009); Richards et al. (2017); B. H. Wixom et al. (2011)
Effective operations management	• More effective management, • Supplier management e.g., inbound logistics or purchasing, • Manufacturing and/or internal operations, • Inventory management, Management of fuel use, • Management of assets turns • Management of strategic planning, • Quality management • Planning and buyer management • Provide support to logistics management • Easier management • Better management • Risk management • Data management • Enabled customer centered strategy • Business process management • Increased inventory turnover • Reduction in the cost of transactions with business partners/suppliers • Reduced operational cost • Reduction in the cost of effective decision-making • Reduced customer return handling costs • Reduced marketing costs • Reduces the threats of price, cost transparency and disintermediation, • Being a low-cost producer/provider • Reducing costs • Reduce the cost of production • Reduce operating cost • Lower transaction costs • Reduction in the cost of effective decision-making • Reduction of our operational cost	Arefin et al. (2015); Audzeyeva and Hudson (2016); Baars and Kemper (2008); Chu (2013); Dedić and Stanier (2017); Elbashir et al. (2008); Elbashir et al. (2011); Elbashir et al. (2013); Fink et al. (2017); R. Gonzales et al. (2015); Hou (2014b, 2016); Işık et al. (2013); Owusu (2017); Phan and Vogel (2010); Popovič et al. (2012); Puklavec et al. (2014); Ravasan and Savoji (2014); Richards et al. (2017); Wieder et al. (2012); B. H. Wixom et al. (2011)

	• Corporate cost reduction • Operating costs reducing • Allow to realize operational efficiency • Enhancing supplier relations • Operational efficiency • Developing supplier linkages • Developing manufacturing/operations flexibility • Ensure sufficient supplies • Increase asset utilization	
Planning Efficiency	• Improve the planning efficiency • Analysis of train trips plans for every shipment • Graphical depiction of actual performance • Trip/operational planning • Rapidly react to business events and proactive business planning	Lin et al. (2009); Popovič et al. (2012); B. H. Wixom et al. (2011)
Improved Products & Services	• Creating new products/services • Enhancing existing products/services • Providing value-added goods/services to customers • Predictable service • Improved customer service • Reduced rail car time • Scheduled railroad • Service expansion to customers • Adding value to the services • Enhancing existing products • Providing value-added services • Creating new products • Reduce the cycle time • Improve product or service quality • Enhance product or service functionality • Identify the opportunities to develop new products or services • Develop new products or services more effectively • Reduce the cycle time of new product development • Extend product portfolio through collaboration, • Increase effective production of new products • Product development • Product portfolio segmentation • Customer service	Chu (2013); Elbashir et al. (2011); Elbashir et al. (2013); Hou (2014b, 2016); Kowalczyk and Buxmann (2015); Popovič et al. (2012); Richards et al. (2017); B. H. Wixom et al. (2011)
Individuals Growth	• Improve employee skills such as project management, • Improve know-how capabilities of employees to perform job • Improve capabilities of data analysis and interpretation • Improve coordination • Senior management interaction • Senior/middle management interaction • Improvement in employees 'BIS related skills and proficiency	Arefin et al. (2015); Hou (2014b, 2016); Owusu (2017); M. D. Peters et al. (2016)
Improved security	• Protected against unauthorized access	Hou and Papamichail (2010)
Improved Forecasting	• Forecast the future consequences of using various alternatives, • Forecasting • Driver based forecasts	Arefin et al. (2015); Hou and Papamichail (2010); Richards et al. (2017)

Table 1. Prior research on user competence

Studies	Research aim	Dimensions	Inclusion of knowledge	Inclusion of Skill	Results
Lee et al. (1995)	Assessment of knowledge and skills requirement for IS professionals	-	√	√	Revealed critical IS knowledge and skills for IS managers
Rehman, Baker, and Majid (1997)	Examination of set of competencies of library and information professionals	Multidimensional	√	√	Provided set of competencies needed for informational professional
Blili et al. (1998)	Assessment of the use and success of end user computing	Multidimensional	-	√	End-user computing competence influences EUC success
Marcolin et al. (2000)	Assessment of user competence in software packages domain	Multidimensional	√	-	User competence is a multifaceted construct that is measured differently through different measurement
Genevieve Bassellier et al. (2001)	Investigation of influence of IT competence on proactive behaviours of IT	Multidimensional	√	-	IT competence of business managers on its own is not sufficient to predict their IT leadership, other factors (such as attitude, perceived behavioural control, subjective norm), are also required
Geneviève Bassellier et al. (2003)	Assessment of IT competence as a contributor to business managers' intention to champion IT within organization	Multidimensional	√	-	IT competence explained 34% of the variance in business managers intention to champion IT
Bassellier and Benbasat (2004)	Investigation of business competence of IT professionals	Multidimensional	√	-	Business competence has a positive effect on the intentions of IT professionals to develop partnerships with business clients
Tippins and Sohi (2003)	Investigation of impact of IT competency on firm performance	Multidimensional	√	-	IT competency plays a significant role in firm performance
Wu, Chen, and Chang (2007)	Investigated the perceived importance of knowledge and skills for information system managers	-	√	√	Identified number of different skills and/or knowledge required to carry out critical IS activities at different management levels
Yoon (2009)	Assessment of factors affecting individual task performance	-	√	√	End-user computing competency affect user performance
Huang and Wong (2010)	Assessment of information technology use	Multidimensional	√	√	IT competencies shape individuals' actions such as using an information
Wang and Haggerty (2011)	Developed competence construct and examined its effect on individual performance and satisfaction in virtual work setting	Multidimensional	-	√	Virtual competence positively influences individuals' satisfaction and performance
Pérez-López and Alegre (2012)	Analysed the influence of IT competency on knowledge management process and firm performance	Multidimensional	√	-	IT competency has significant effect on knowledge management process, whereas insignificant effect on firm performance
Colomo-Palacios et al. (2013)	Explored the competencies gaps among software practitioners	-	-	√	Technical competencies presented greater gaps than generic competencies
Kang and Ritzhaupt (2015)	Identified the core competencies of technology professionals	-	√	√	Provided key competencies needed for technology professionals
Krumm et al. (2016)	Focused on differences in Knowledge, skills, abilities and other characteristics (KSAOs) requirement for virtual teams	-	√	√	KSAOs are essential for leading, deciding, analysing and interpreting.

List of Publications

- Ain, N., Vaia, G., DeLone, W. H., & Waheed, M. (2019). Two decades of research on business intelligence system adoption, utilization and success–A systematic literature review. *Decision Support Systems, 125*, 113113.