CRITICAL SUCCESS FACTORS FOR BUSINESS INTELLIGENCE SYSTEMS

WILLIAM YEOH
University of South Australia
SA 5095 Australia

ANDY KORONIOS
University of South Australia
SA 5095 Australia

The implementation of a business intelligence (BI) system is a complex undertaking requiring considerable resources. Yet there is a limited authoritative set of critical success factors (CSFs) for management reference because the BI market has been driven mainly by the IT industry and vendors. This research seeks to bridge the gap that exists between academia and practitioners by investigating the CSFs influencing BI systems success. The study followed a two-stage qualitative approach. Firstly, the authors utilised the Delphi method to conduct three rounds of studies. The study develops a CSFs framework crucial for BI systems implementation. Next, the framework and the associated CSFs are delineated through a series of case studies. The empirical findings substantiate the construct and applicability of the framework. More significantly, the research further reveals that those organisations which address the CSFs from a business orientation approach will be more likely to achieve better results.

Keywords: Business intelligence system, Critical success factors, Delphi method, Case study

INTRODUCTION

Recently Business Intelligence (BI) applications have been dominating the technology priority list of many CIOs [11, 12]. According to Reinschmidt and Francoise [22], a BI system is "an integrated set of tools, technologies and programmed products that are used to collect, integrate, analyse and make data available". Stated simply, the main tasks of a BI system include "intelligent exploration, integration, aggregation and a multidimensional analysis of data originating from various information resources" [21]. Implicit in this definition, data is treated as a highly valuable corporate resource, and transformed from quantity to quality [27]. As a result, massive data from many different sources of a large enterprise can be integrated into a coherent body to provide '360 degrees' view of its business [5, 27]. Hence, meaningful information can be delivered at the right time, at the right location, and in the right form [5, 20] to assist individuals, departments, divisions or even larger units to facilitate improved decision-making [15].

While the BI market appears vibrant and the importance of BI systems is more widely accepted, few studies have investigated the critical success factors that affect the implementation success. Although there exist a plethora of guidelines from the IT industry, most rely on anecdotal reports [15]. This is because the study of BI systems is a relatively new area that has been driven primarily by the IT industry and by vendors [15]. Therefore, empirical research to shed more light on those critical success factors (CSFs) influencing the implementation of BI systems is desirable. An understanding of the CSFs enables BI stakeholders to optimise their scarce resources and efforts by focussing on those significant factors that are most likely to aid successful system implementation.

RESEARCH MOTIVATION

The implementation of a BI system is not a conventional application-based IT project (such as an operational or transactional system), which has been the focus of many CSF studies [10]. Instead, it shares similar characteristics with other infrastructural projects such as enterprise resource planning (ERP) systems implementation. That is, implementing a BI system is not a simple activity entailing merely the purchase of a combination of software and hardware; rather, it is a complex undertaking requiring appropriate infrastructure and resources over a lengthy period [10, 19, 28].

Specifically, the key infrastructural foundation for most enterprise level BI systems — a data warehouse — is a subject-oriented, integrated, time-variant and non-volatile collection of data that differ from conventional online transactional processing (OLTP) databases [14]. A complex data structure must be maintained in order to provide an integrated view of the organisation's data so users can query across departmental boundaries for dynamic retrieval of relevant decision-support information. Furthermore, the BI system's architecture is highly complex owing to the back-end systems originating from multiple data sources and to the vast volume of data to be processed. In addition, the implementation of a BI system is often associated with the following challenges: underlying original back-end systems and processes which were not adapted for BI applications; poor data quality derived from source systems that can often go unnoticed until cross-systems analysis is conducted; and the maintenance process that tends to be vague and ill-defined [10, 19, 23].

Despite the complexities in implementing BI systems, there has been little empirical research about the CSFs impacting the implementation of BI systems. The gap in the literature is reflected in the low level of contributions to international conferences and journals. More importantly, the value of previous CSF studies will obviously decline with age [16]. The rapid advancement of technological innovation and the pace at which new technologies are being adopted will apparently influence the state of criticality for research into CSFs [16]. Furthermore, CSFs applicable to other types of information systems may not necessarily apply to a contemporary BI system. Therefore, the increased rate of adoption of BI systems, the complexities of implementing a contemporary BI system, the scarcity of academic research, and

Received: June 11, 2009 Revised: August 6, 2009 Accepted: September 14, 2009

the far-reaching business implications justify a more focused examination of CSFs as well as the associated contextual issues required for implementing BI systems. This paper describes an exploration of an important and topical area of interest — the CSFs impacting the implementation of BI systems. It is expected that this research will make a contribution to both theory and practice. In theoretical terms, this research:

- adds to knowledge and contributes to the literature of an emerging area of interest — the implementation of BI systems, in particular, the CSFs that affect the implementation effort;
- identifies the criteria which determine the success of BI systems implementation; and
- validates current CSFs understandings, and extends our knowledge of contemporary BI systems.

In practical terms, the research project:

- identifies the CSFs that impact on BI systems implementation, so enabling stakeholders to better use their scarce resources by focussing on those key areas that are most likely to have a greater impact.

The remainder of this article has been structured as follows. The next section describes the two-stage research methodology in this study. The later section presents and discusses the research findings. In the last section the authors conclude the overall study and then state their contributions.

RESEARCH DESIGN

This research adopted an interpretivist paradigm and followed a two-stage qualitative approach. Based on extensive literature review, a research framework and associated interview questions were developed for use in the Stage 1 exploratory Delphi study. This research framework was refined with the data gathered from 15 Delphi participants. In the second stage, the preliminary CSFs framework derived from the Delphi study was further verified in five case studies of large and complex organisations. Each case study involved interviews with the BI stakeholders, and the collection of project documents. Cross-case analysis was done to examine the CSFs. As a result, a refined CSF framework was developed.

Stage One — Delphi Study

In the absence of much useful literature on BI system, this stage one of research seeks to explore and identify a set of CSFs that are jointly agreed by a group of BI system experts. The Delphi method was deemed to be the most appropriate method for this study because it allows the gathering of subjective judgements which are moderated through group consensus [17]. Moreover, this research assumes that expert opinion can be of significant value in situations where knowledge or theory is incomplete [17]. For this study, a Delphi panel composed of fifteen BI systems experts was established. Ziglio and Adler [34] assert that useful results can be obtained from small group of 10-15 experts. Beyond this number, further increases in understandings are small and not worth the cost or the time spent in additional interviewing. Thus, the size of such a Delphi panel is deemed suitably representative.

The Delphi study comprised three rounds. During the first round the authors conducted face-to-face interviews with each participant. After the interview, further clarifications (if any) were made by follow-up phone calls and email communications. Subsequently, the data gathered from the first round of interviews were analysed thoroughly by content analysis technique, a constant comparison technique, to identify major themes [18]. In other words, the qualitative data were examined thematically and emergent themes were ranked by their frequency and later categorised.

In the second round, the suggested factors of all the participants were consolidated into a single list. The list was then distributed among the participants to facilitate comparison of the expert's perceptual differences. During the third round, the list of candidate CSFs was surveyed by the Delphi participants using a structured questionnaire survey approach. Specifically, a 5-point Likert scale (i.e. from 1 'not important' to 5 'critically important') was applied to rate the importance of the candidate CSFs in the process of seeking consensus from the BI experts. From the survey feedback, only those factors with standard deviations (SD) of 1.0 or less, and average ratings of 3.5 and above, were short-listed as CSFs because 1 SD from the mean contains 68% of all scores. These criteria (i.e. SD<1.0 and Mean >3.5/5.0) offer a working definition of a threshold for stability, and hence the resultant CSFs are considered legitimate. Therefore, the existence of CSFs within this definition in round three is considered to be a critical point for terminating the Delphi study. The details of the results are discussed below.

Stage Two — Case Study

Due to limited academic literature, the Stage 1 Delphi study was used to narrow the CSFs focus of this research. However, reliance on the Delphi study alone was not sufficient for the collection of data needed to rigorously address the research objective. Therefore, a case study methodology was used for Stage 2 of the theory-building process. That is, this second stage sought to corroborate the CSFs findings of Stage 1. The case study methodology provides better explanations and understandings on the examined phenomenon which would otherwise be lost in other quantitative designs [18, 33]. For this study, in contrast to sampling logic, a case study is an empirical investigation following replication logic that leads to analytic generalisation [33]. Thus multiple case studies in this research should be regarded as multiple experiments and not multiple respondents in a survey [33]. That is, *relevance* rather than *representativeness* is prioritised in case selection. Given that the objective of this study was to build theory, a case study process with multiple-case design was the appropriate approach, and the use of the case study methodology is justified on these grounds.

Data collection for this study entailed semi-structured interviews with key stakeholders of BI projects. To facilitate data triangulation, data were also gathered from a number of sources including relevant documents. A cross case analysis approach was used in this study to gain better understandings and increase the generalisability of the findings [18]. In searching for patterns, the authors examined similarities and differences about relationships within the data. Hence, varying the order in which case data are arrayed enables patterns to become more obvious [24]. This research did not produce quantitative data. In all cases, the authors were examining the presence or absence of a particular CSF (e.g., were adequate resources provided?), while at the same time ascertaining whether that characteristic

was fulfilled in a meaningful way. To assess the importance of the seven previously-identified CSFs, the authors studied five organisations that had implemented BI systems, including rail corporations, energy utilities, water utilities, and a ship-builder.

STAGE ONE CSF FINDINGS AND DISCUSSIONS

This section presents the findings and interpretation of the stage one Delphi study. As illustrated in Figure 1, this CSFs framework outlines how a set of critical factors contributes to the success of a BI system implementation. Following Ariyachandra and Watson [2], the implementation success criteria of this research take into account two key dimensions: process performance (i.e. how well the process of a BI system implementation went), and infrastructure performance (i.e. the quality of the system and the standard of output). The infrastructure performance has parallels with the three major IS success variables described by Delone and McLean [7, 8], namely system quality, information quality, and system use, whereas process performance can be assessed in terms of time-schedule and budgetary considerations [2]. Specifically, system quality is concerned with the performance characteristics of the information processing system itself, in which the system should be flexible, scalable and able to integrate data [2, 7, 8]. Information quality refers to accuracy, completeness, timeliness, relevance, consistency, and usefulness of information generated by the system [2, 7, 8]. System use is defined as "recipient consumption of the output of an information system" [7, 8]. Subsequently, individual users and their respective organisations would assess the benefits of the BI system implementation [13]. This perception of the benefits would then become part of an interactive, business-driven evolutionary continuum to further support evolving business needs for improved BI systems [3, 4]. That is, a BI system implementation is viewed as an organic cycle that evolves over time. Based on constant evaluation of the information, as well as user feedback, the system resembles a loop that requires re-evaluation of existing BI solutions, and subsequently the system will be modified, optimised and improved accordingly. In other words, completion of the system implementation does not mean that all BI related problems are resolved [21]. The system will succeed only when business users keep identifying and modelling knowledge, as well as monitoring and modifying data repositories on an ongoing basis [21]. Hence, the entire process is cyclical, but with a series of interrelated steps [25].

In brief, this framework treats the CSFs as necessary for implementation success of a BI system, whereas the absence of the CSFs would lead to failure of the system. The Delphi participants provided detail and justification to those critical factors. The CSF framework details the CSFs identified in the first stage of this study, and they are presented according to the major dimensions of interest proposed by Wixom and Watson [32], namely organisation, process, and technology. For each CSF description, the primary data came from the findings of the third-round consensus amongst the Delphi participants. The secondary data came from the first two rounds of qualitative interviews with individual participants. Additional data from published literature were also used to support the arguments of the participants.

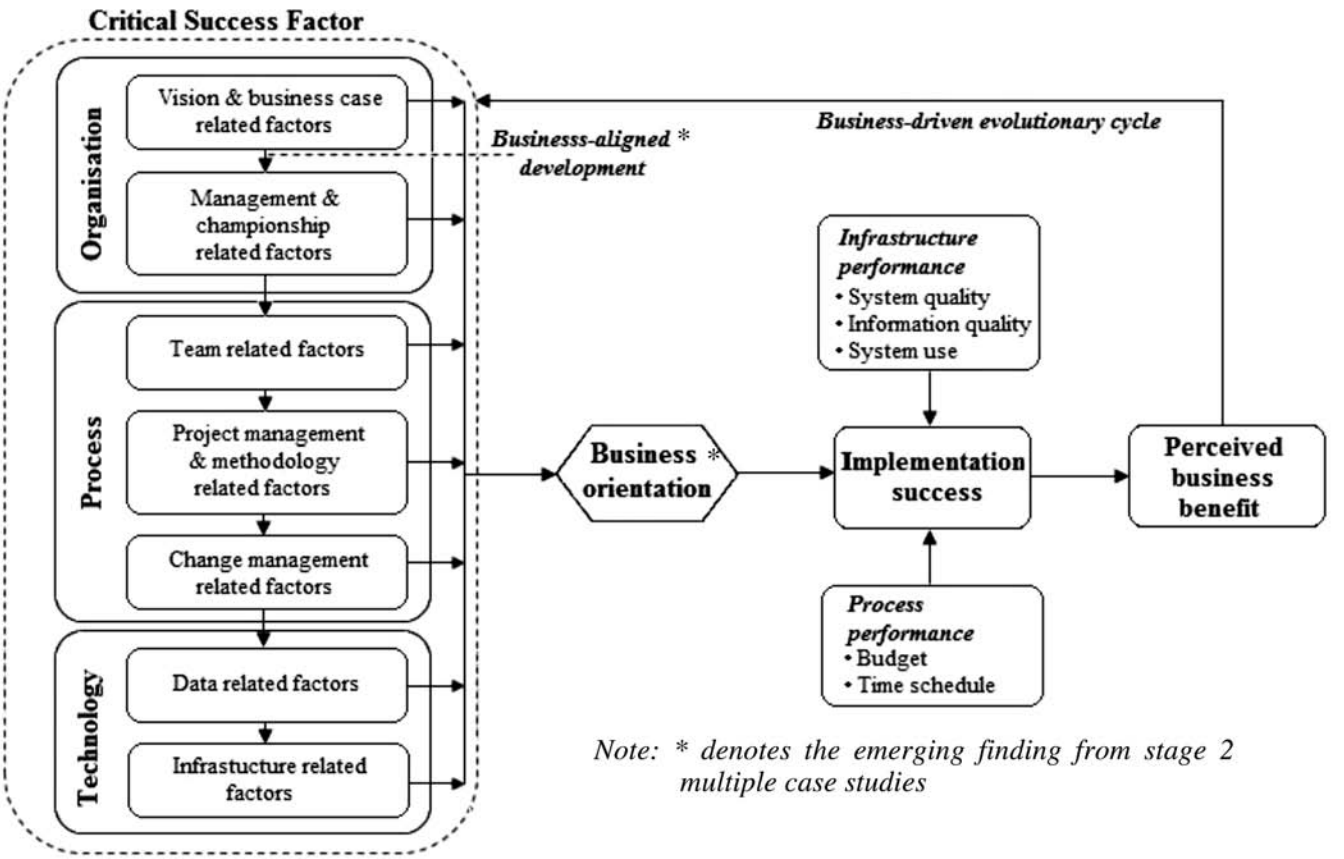

FIGURE 1 — CSFs Framework for Implementation of BI Systems

Organisational dimension

Committed management support and sponsorship. Committed management support and sponsorship has been widely acknowledged as the most important factor for BI system implementation. All Delphi participants agreed that consistent support and sponsorship from business executives make it easier to secure the necessary operating resources such as funding, human skills, and other requirements. One interviewee stated firmly, "*If you don't have top level sponsorship — it is doomed!*" Another participant explained the situation this way,

> "*Project Sponsorship has been shown to be the single most important determinant of IT project success or failure. A BI project is no different to any other IT project in this respect . . . Maintaining the commitment and support of the projects sponsor throughout the project — because circumstances can change over the life of the project.*"

Many participants also asserted that it is more beneficial if the sponsor is from the business side of the enterprise rather than from the IT sector. Similarly, a study by Watson *et al.* [30] indicates that the ideal BI sponsor should come from a business function. Such a sponsor often has a strong stake in the success of the BI initiative. Most importantly, some interviewees highlighted the point that the sponsor should be in serious need of the BI capabilities for a specific business purpose.

A BI system implementation is an adaptive information improvement initiative for decision support [3, 4]. Some Delphi interviewees further indicated that the typical application-based funding model for implementation of transactional systems does not apply to BI systems that are evolutionary in nature. That is, a BI system evolves through an iterative process of development in accordance with dynamic business requirements [19]. Therefore the BI initiative, especially for the enterprise-wide scale, requires consistent funding and resource allocation directly from senior management to overcome continual organisational issues. Contrary to conventional OLTP-based systems, these organisational challenges arise during the course of the cross-functional implementation, as it often uncovers many issues in such areas as business processing, data ownership, data quality and stewardship, and organisational structure. Many functional units tend to focus on tactical gains, ignoring the rippling effects imposed on other business units, and one participating expert observed that,

> "*The whole BI effort cut across many areas in the organisation that's making it very difficult, it hits a lot of political barriers. For instance, for a system owner, they are only interested in delivering day to day transaction, as long as all that done . . . that's what they care about.*"

Therefore the commitment and involvement of senior management is imperative, particularly in breaking down the barriers to change and the 'states of mind' within the organisation.

Clear vision and well-established business case. As a BI initiative is driven by business, so a strategic business vision is needed to direct the implementation. Many Delphi participants indicated that a long-term vision, primarily in strategic and organisational terms, is needed to establish a solid business case. The business case must be aligned to the strategic vision, thereby meeting the business objectives and needs. If the business vision is not thoroughly understood, it would eventually impact the adoption and outcome of the BI system. Speaking to this point, an interviewee emphasised that,

> "*In order for BI initiatives to be taken seriously and to be supported by corporate leadership, they need to be integrated with the overall strategy. Otherwise they will not receive the leadership support that is required to make them successful. The vision is the tool that leadership can quickly understand and identify the linkages to the corporate strategy.*"

Many participants argued that the overriding reason some BI projects fail is not due to technical challenges, because many of the technological issues have proven answers. Rather, the most common cause for failure is that the BI initiative does not align with the business vision and so fails to meet the core objectives of the business. As a result, the BI system will not satisfy the business needs and neither will it satisfy the customers. The possession of a *well established business case* is important for sustaining organisational commitment to a new BI system. Most interviewees rejected the notion that if an excellent system was established then people would want to use it. In fact, one interviewee claimed that,

> "*A BI system that is not business driven is a failed system! BI is a business-centric concept. Sending IT off to solve a problem rarely results in a positive outcome. There must be a business problem to solve.*"

Many participants stressed that a solid business case that was derived from a detailed analysis of business needs would increase the chances of winning support from top management. As stated firmly by one expert,

> "*In order for the leadership to support, they must understand; when they understand and can easily explain and provide the support needed. Of course, the business case is an extremely important tool for both leadership and the implementation team.*"

Thus, a substantial business case should identify the proposed strategic benefits, resources, risks, costs, and timeline. More significantly, it is important to understand that a BI system implementation is not a project, it is a process [4]. That is, BI systems are organic in nature. They evolve dynamically and in directions that are not necessarily finite and predictable. For instance, the warehouse data size of most BI systems doubles during the first year of operation, and the number of users also increases markedly [22].

Process dimension

Business-centric championship and balanced team composition. Most participants believed that having the right champion from the business side of the organisation is critical for implementation success. They expressed the view that a champion who has excellent business acumen is always important since he/she will be able to foresee the organisational challenges and change course accordingly. More importantly, this business-

centric champion would view the BI system primarily in strategic and organisational perspectives, as opposed to one who might over-focus on the technical issues. For example, one interviewee commented that,

> "*The team needs a champion. By a champion, I do not mean someone who knows the tools. I mean someone who understands the business and the technology and is able to translate the business requirements into a (high-level) BI architecture for the system.*"

In fact, a BI initiative often spans multiple functional units and demands extensive data and resources from these business units. In this respect, the champion is critical to ensure the careful management of the organisational challenges that arise during the course of the project. Unlike operational system projects, such challenges include getting system owners to recognise the strategic value of their data and to reflect on how their data interacts with data from other transactional systems. Therefore, the champion needs to ensure collaboration between business units and between the business and the BI project team.

Organisations tend to rely on their IT staff to be solely responsible for most system implementation projects. However, BI projects are fundamentally different from OLTP projects [10, 25]. The project team must design a robust and maintainable architecture that can accommodate the emerging and changing requirements, this work requiring highly competent team members. Not surprisingly, all interviewees agreed that the composition and skills of a BI team have a major influence on the success of the systems implementation. They indicated that the BI team should be cross-functional and composed of both technical and business personnel, so-called "*best of both worlds*". A BI initiative is essentially a business-driven project and is critical for the making of strategic decisions. From a technical perspective, a BI project is comparable to a systems integration project and requires the active involvement of the business side of the enterprise [19]. Typically, the project team has to deal with diverse platforms, multiple interfaces, connection to legacy systems, an array of tools, and so forth. All these tasks call for people with different skills and competencies, and so a suitable mix of technical and business expertise is a key to success.

Most experts recommended that a BI team should identify and include business domain experts, especially for such activities as data standardisation, requirement engineering, data quality analysis, and testing. This enables the system design to be driven by the business and ensures that the BI needs derived from business are a driver of the logical data architecture. To enable business users to navigate and manipulate the data model, the structure and model of the data warehouse must be closely related to their perception of the business objectives and processes.

Business-driven and iterative development approach. The next factor to be considered is the business-driven and iterative development approach. According to most Delphi participants, adequate business-oriented project scoping and planning allow the BI team to concentrate on the best opportunities for improvement. Scoping helps in the selection of clear parameters and develops a common understanding among all business stakeholders as to what is in scope and what is excluded [1]. For instance, a Delphi participant gave an in-sight into his experience,

> "*The success of 90 percent of our project is determined prior to the first day. This success is based on having a very clear and well-communicated scope, having realistic expectations and timelines, and having the appropriate budget set aside.*"

Most interviewees agreed that thorough scoping and planning facilitate flexibility and adaptability to changing requirements within the time frame and resources. Moreover, adequate scoping enables the project team to focus on crucial milestones and pertinent issues while shielding them from becoming trapped in unnecessary events. As one participant remarked,

> "*The scope needs to be controlled because 'scope creep' can cause a project to not meet its targeted conclusion. That does not mean that you cannot have a change control procedure or practice in place; this is a form of control. I have seen many projects miss their delivery and cost goals because of scope creep.*"

Many experts stated that it is advisable to start with small changes and developments and then to adopt an incremental delivery, a so-called 'iterative' approach. Large-scale change efforts are always fraught with greater risks given the substantial variables to be managed simultaneously [1]. Moreover, modern businesses are changing very quickly anyway and are always seeking to identify the immediate impacts of those changes, and so an incremental delivery approach is more cautious and provides the tools for delivery of short, measurable steps. Furthermore, an incremental delivery approach allows for building a long-term solution as opposed to a short term one [1, 4]. As explained by this interviewee,

> "*Adopting incremental delivery manages risks, provides tangible results visible to the client, improves the client's ability to take ownership, eases knowledge transfer, supports effective change management, and allows for long-term solution.*"

Therefore, the scope of a BI initiative should be selected in such a way that a complete system for a specific business sector can be delivered within a reasonable time, rather than one 'massive and complete big bang' solution later on. Once the users start working with the BI system, they will fully realise the potential reporting and analysis possibilities. The preliminary BI system is then further enhanced and developed in an evolutionary and iterative approach. One interviewee elaborated that,

> "*You cannot roll out the whole BI system at once but people want to see some key areas. You need to do data marts for a couple of key areas and then maybe a small number of other key reports in an attempt to keep all stakeholders happy. Then when the first release is done and you get some feedback, you can work on other data mart areas and enhance existing subject areas over time.*"

Therefore, an incremental delivery approach allows an organisation to concentrate on crucial issues, so enabling teams to prove that the system implementation is feasible and productive for the enterprise.

User-oriented change management. Having an adequate user-oriented change management effort was deemed critical by most

Delphi participants. They reported that better user participation in the process of change can lead to better communication of their needs, which in turn can help ensure successful introduction of the system. Many Delphi participants shared the view that formal user participation can help meet the demands and expectations of various end users. No doubt, users know what they need better than an architect or developer who lacks direct experience of the product. This is mainly because business users will directly work with the data models without an application layer that conceals the complexity of the model (as is the case in conventional OLTP systems) [22]. One Delphi participant commented that,

> "*Users should be an important partner in building and delivering the right system. Without their consistent input, we technicians cannot deliver the right system.*"

This view was supported by another participing expert who asked,

> "*How can the project team design and implement a BI system to meet the users' needs without their involvement?*"

It is evident that key users must be involved throughout the implementation cycle because they can provide valuable input that the BI team may otherwise overlook. The data dimensions, business rules, metadata, and data context that are needed by business users should be incorporated into the system and validated against the definition of deliverables [29]. Consequently, user support will constantly evolve in response to organic business requirement and supplementary BI applications [10].

Technological dimension

Business-driven, scalable and flexible technical framework. Turning now to technological issues, a key factor emphasised by many Delphi respondents was that the technical framework of a BI system must be able to accommodate scalability and flexibility requirements in line with dynamic business needs. That is, flexible and scalable infrastructure design allows for easy expansion of the system to align it with evolving information needs [21]. So with a strategic view embedded in the system design, this scalable system framework could include additional data sources, attributes, and dimensional areas for fact-based analysis, and it could incorporate external data from suppliers, contractors, regulatory bodies, and industrial benchmarks. It would then allow for the building of a long-term solution to meet the incremental needs of business, as explained by an interviewee,

> "*Scalability is always concerns to me. It seems that most BI applications and systems always seem to grow to be larger than expected or their throughput is greater than anticipated. If the design is not scalable and flexible, it is more difficult to make changes to accommodate the increase in size.*"

In fact, a BI infrastructure involves all the tasks substantive to path the technical layer for the entire BI environment. This includes the implementation of new software and hardware, the interoperability between the legacy systems and the new BI environment on a network, as well as on a database level, an administration subsystem and so on [19]. Establishing the technical infrastructure for the initial BI solution is always time consuming [29], but with the proper selection of scalable and flexible hardware and software components, the effort would be minimised for the next delivery cycle. As a consequence, the system will be able to adapt to the emerging and ever-changing business requirements.

Sustainable data quality and integrity. In regard to the important factor of sustainable data quality and integrity, the Delphi findings indicate that the quality of data, particularly in the source systems, is crucial if a BI system is to be implemented successfully. According to most interviewees, a primary purpose of a BI system is to integrate 'silos' of data for advanced analysis so as to improve the decision-making process. Often, many data-related issues within the back-end systems are not discovered until that data are populated and queried within the BI system [31]. Thus data quality at sources will affect the quality of management reports, which in turn influence the decision outcomes [9]. Corporate data can only be fully integrated and exploited for greater business value once their quality and integrity are assured. Speaking to this point, a BI expert asked, "*If the data is corrupt then what is the point?*' Another interviewee further exclaimed that, "*Without quality data the BI is not intelligence!*" These comments were echoed by another participant, who asserted,

> "*Garbage in garbage out. The user community doesn't care to understand why the information is wrong and once you have a data integrity issue you are in trouble.*"

Many Delphi participants believed that *common measures and definitions address the data quality dimensions* of representational consistency, interpretability and ease of understanding. This allows all stakeholders to know that a term has a specific meaning no matter where it is used across the source systems. It is typical for a large organisation to have many terms with slightly different meanings, because different business units tend to define terms in ways that best serve their purposes. Often, accurate data may have been captured at the source level, but the record cannot be used with other data sources due to inconsistent data identifiers [26]. This is because data values that should uniquely describe entities are varied in different business units. A typical BI system tends to be cross-functional and cross-departmental, so if only one specific business section is scoped in the initial phase, the business definitions and business rules must later be standardised in order to be understood consistently on an enterprise level [19, 26]. This characteristic could have an impact on how the business data are interpreted among different units. Once an organisation has accumulated a large number of reports it becomes more difficult to re-architect these areas. As a result, a cross-system analysis is important to help profile a uniform master data set which is in compliance with business rules. There needs to be an organisational agreement on the definitions and measurements that are part of the deliverables [26]. Hence, the development of a master data set on which to base the logical data warehouse construction for BI system will ease terminology problems. As a result, the BI team would use common definitions to develop an enterprise-wide dimensional model that is business orientated.

In short, this Delphi study was the first step in exploring the CSFs which can influence the implementation of BI systems. The results show that there is a combination of multi-dimensional CSFs peculiar to successful BI system implementation. More importantly, the study has narrowed the research focus through the identification of a set of CSFs as presented. The next stage

comprised multiple case studies for the purpose of further validating the CSFs findings. The case studies examined whether these critical factors — and/or any other factors — influence the implementation success of BI systems.

STAGE TWO FINDINGS AND DISCUSSIONS

This section details and discusses the findings of stage 2 case studies. The BI system backgrounds of these case companies are illustrated in Table 1.

As shown in Table 2, after analysis of the triangulated results for all five organisations, three instances of notable success emerged (C1, C2 and C4), together with one moderately successful case (C3) and one failure (C5). The three successful cases of BI system implementation described their respective BI systems as stable, easy to use, fully functional, flexible and responsive within anticipated times. Furthermore, the information generated was considered accurate, timely, complete, consistent, and relevant to most participants. In addition to the encouraging trend of system use among end-users, the project leaders of these organisations confirmed that their implementation projects were completed on time and within budget. However, the moderately successful case was experiencing uncontrollable external factors in its BI system implementation. The key application of its BI system was not identical to those of conventional commercial enterprises. Due to its unique form of business and the peculiar bonus system with its major client, it was more concerned with ensuring on-time delivery of assets and meeting quality and safety standards rather than reducing costs or staffing. The BI system thus enables them to analyse and investigate underlying business activities with ease. Also, auditable reporting can be generated from the system to assist the business meet its strict regulatory requirements.

On the other hand, the firm that experienced BI failure did so because it encountered business issues at the early phase of its implementation process. The business needs and requirements for BI system had not been clearly defined, yet there existed silo information systems with multiple versions of the truth. In that firm the BI initiative was driven mainly by the information system manager alone and was viewed as a technological issue, and as a result the management had to suspend the BI initiative. This instance of failure served as a useful contrast case for comparative analysis in this research.

Next, to demonstrate how the implementation success compared against the management of the CSFs of the five case organisations, an analysis of the CSFs 1 to 7 was conducted through a cross-case analysis. Table 3 summarises the relevant

TABLE 1 — Case Company and Its BI System Background

Case	Organisation	BI System Background
C1	Rail transport and network operator	• Due to new arrangement, the company has acquired a competitor company and is now overseeing a much wider area of rail network. • The BI system success story of the acquired company has inspired the executives to expand the BI initiative to an enterprise-wide scale. • In order to facilitate 'one-stop' planning, reporting and business analysis, the company adopted BI system with great enthusiasm.
C2	Train operator (freight and passenger trains)	• The company has been using BI system for more than a decade initially for its various silo functional needs, such as safety reporting, network access, maintenance and operation. • To better facilitate overall business performance, the organisation has recently been restructured accordingly, and the silos BI system are undergoing amalgamation.
C3	Builder and maintainer of ships	• BI system was implemented as part of its ERP package. The key use of the system is for business reporting, analysis of asset lifecycle performance and supply chain management. • Due to its unique business nature, the BI tool was not meant to cut down the operating cost or for competitive advantage, but rather to meet the strict compliance requirements and bonus system.
C4	Electric and gas utilities	• BI system was implemented for advanced analysis, planning and risk management of the vast electricity network. • Due to market deregulation, legislative compliance and auditing requirement, BI system was adopted and widely supported by all stakeholders. • For the BI system, conformance and compliance is more critical than cost saving.
C5	Water, sewage, recycled water utilities	• The BI initiative was mainly driven by its manager of information system, whom is a technology enthusiast. • He has been promoting the advantages of BI system, and organised a number of interactive sessions with BI vendors. • However, the BI effort was not supported by business stakeholder, as they clearly failed to identify their BI needs and requirement.

TABLE 2 — Implementation Success for the Five Cases

	Success measures / Case code	C1	C2	C3	C4	C5
Infrastructure performance						
1	System quality	✓	✓	✓	✓	N/A
2	Information quality	✓	✓	✓	✓	X
3	System use	✓	✓	*P*	✓	N/A
Process performance						
4	Budget	✓	*P*	✓	✓	X
5	Time schedule	✓	✓	✓	✓	X
	Overall	S	S	*P*	S	*U*

Note: ✓=Good; P =Acceptable; X=Poor; S=Successful; P =Partially successful; U =Unsuccessful

TABLE 3 — Evaluation of Critical Success Factors in Multiple Organisations

CSF	C1	C2	C3	C4	C5
1. Committed management support and sponsorship	✓	✓	*P*	✓	X
2. Clear vision and well-established business case	✓	✓	*P*	✓	X
3. Business-centric championship and balanced team composition	✓	✓	*P*	✓	X
4. Business-driven and iterative development approach	✓	✓	*P*	✓	X
5. User-oriented change management	✓	✓	X	✓	X
6. Business-driven, scalable and flexible technical framework	✓	*P*	✓	✓	*N*
7. Sustainable data quality and integrity	✓	*P*	✓	✓	*N*
****Overall business orientation approach***	✓	✓	*P*	✓	X

*Note: * denotes emerging finding from case studies*

CSFs performance in matrices recommended by Miles and Huberman [18], and these were used as an initial step in analysing patterns in the data. For each case, management of each CSF is rated through a summary rating of ✓ (for a CSF that was fully-addressed), *P* (for a CSF that was partially addressed), or X (for a CSF that was ignored).

Essentially, the evidence from these studies clearly substantiated the construct and applicability of the multi-dimensional framework. More importantly, the studies further reveal the significance of addressing those CSFs through the business orientation approach. That is, without a specific business purpose, the BI initiatives rarely produce a substantial impact on business. As a result, the implementation of a BI system has a much greater likelihood for success when business needs are identified at the outset and used as the driver behind the implementation effort. Thus, the entire system implementation must be business-driven and organisation-focussed. It should also have interactive business-side involvement, and be adapted to meet evolving business requirements throughout the lifecycle. Invariably, a 'build it and they will come' approach which overlooks business-focused strategies in system implementation proves to be unsatisfactory and very expensive. In other words, this particular meta-factor (i.e. a business orientation approach) dictates the commandment of the proposed CSFs.

Notably, the three successful cases (C1, C2 and C4) seemed to emphasise the business-oriented approach when addressing the CSFs, while the partially successful case (C3) appeared to comprise a mixture of business and customer-centric approaches. The instance of failure (C5) was not totally business-driven but instead was technology oriented. The three successful cases shifted their focus from the technological view and instead adopted an approach that put their respective business needs first. On the basis of these case studies, it is apparent that the manner in which an organisation addresses those CSFs, whether through a business-oriented, technology-oriented, or customer-oriented approach, will have a substantial impact on the implementation outcome. Having a clearly-defined set of CSFs is important, but it is even more critical to address the CSFs from the right approach. In the case of BI systems implementation, the triangulated data of case studies clearly demonstrates that by placing business needs ahead of other issues an enterprise has a higher likelihood of achieving a useful BI system.

What is more, in order to meet the need for systems which provide management with dynamic analytics and business reporting, the findings of these case studies indicate that business stakeholders should involve interactively throughout the implementation process. In other words, it necessitates the participation of business stakeholders in the development of a reporting that usually demands practical business experience. Moreover, due to evolving business needs and ever-changing information requirements, it was found that the respective BI teams had to provide continual high-level maintenance and support not only on tools application, but also at broader data modelling and system scalability issues. The designing of data models and system architecture frameworks needs consistent input from those most familiar with the business needs of the enterprise.

In summary, the three successful cases clearly demonstrated that addressing the CSFs from a business perspective was the cornerstone on which they successfully based the implementation of their BI systems. Conversely, the unsuccessful case failed because it focused primarily on the technology and neglected the core requirements of its business. In order to better address the CSFs it is essential for an organisation to emphasise the business orientation approach, and in so doing it will gain an advantage over competitors. Indeed, this view was supported by Gartner Research [6] who stated that, "best in class organisations focus on business objectives and use a business-driven approach to define and scope their people, process, application, technology and/or services strategy."

CONCLUDING REMARKS AND CONTRIBUTIONS

Understanding CSFs is a key for successful implementation of a BI system. This study examined the CSFs impacting BI systems implementation. A set of multi-dimensional CSFs was identified during the course of three rounds of a Delphi study with 15 BI system experts. The findings from the Delphi study were then examined empirically in case studies of five large organisations. The evidence from these studies clearly confirmed the construct and applicability of the CSFs framework.

An analysis of the findings further indicates that non-technical factors, including organisational and process-related factors, are more influential and important than technological and data-related factors. Furthermore, the present study also gives evidence that the contextual issues of the CSFs are quite different from the implementation of other systems. Therefore, these CSFs cannot be applied to BI systems without giving careful consideration to the relevant contextual issues.

It appears that there is a macro-level pattern for interpreting the CSFs related to such infrastructure-based projects. Both the organisational and process dimensions are probably generic and vary somewhat among BI systems and other infrastructural systems implementation. But it is apparent that there is a new understanding of factors associated with the technological dimension due to the technical challenges that vary with the nature of the infrastructure system. Nonetheless, this research suggests that organisations are in a better position to successfully address those CSFs through the business-orientation approach. That is, without a clear business-driven objective, the BI initiatives rarely produce substantial impact on business. As a result, the implementation of a BI system has a much greater likelihood of success when specific business needs are identified at the outset, and when those needs are used to direct the nature and scope of the implementation effort. Therefore, this business orientation meta-CSF should be regarded as the most critical factor in determining the implementation success of BI systems.

This research has made a theoretical contribution to our understanding of the CSFs that impact on BI systems implementation. The literature review reveals relatively little previous work on this subject. This study helps to fill the gap by building the theory of the ways in which CSFs impact BI systems implementation. This study represents the first rigorously-conducted enquiry which will develop our understanding of the factors that affecting the implementation of BI systems. The findings and outcomes extend current theory and allow firms to identify and focus their scarce resources in those CSFs areas. Besides that, academic researchers are often criticised for failing to address issues of concern to practitioners. The collection and analysis of empirical data in this study responds to those criticisms and supplements the current limited understanding of the factors that affect the successful implementation of BI systems. The result of this work highlights those factors that need to be addressed, and it also points out those that are not so critical. Hence, it focuses attention on those important areas that might otherwise be neglected or taken for granted but are significant for the implementation success.

Not only does this research contribute to the academic literature on this topic but it benefits organisations in several ways as well. First, large and complex organisations that are planning to implement enterprise level BI systems will be better able to identify those factors that will enhance the likelihood of success. The findings will help them to determine those factors on which they should give particular attention to ensure that they receive continuous management scrutiny. For senior management, this research finding can certainly assist them by optimising their scarce resources on those key areas that will improve the implementation process. Also, management can concentrate on monitoring, controlling and supporting only those critical areas. The findings with regard to the CSFs represent best practices for firms that have successfully implemented BI systems. The evidence that was revealed provides reference for BI stakeholders that can increase the chances of implementation success.

REFERENCES

[1] Ang, J. & Teo, T. S. H. "Management Issues in Data Warehousing: Insights from the Housing and Development Board," *Journal of Decision Support Systems*, 29(1), 2000, 11-20.

[2] Ariyachandra, T. & Watson, H. "Which Data Warehouse Architecture Is Most Successful?" *Business Intelligence Journal,* 11(1), 2006.

[3] Arnott, D. "Decision Support Systems Evolution: Framework, Case Study and Research Agenda," *European Journal of Information Systems*, 13(4), 2004, 247-259.

[4] Arnott, D. & Pervan, G. "A Critical Analysis of Decision Support Systems Research," *Journal of Information Technology*, 20(2), 2005, 67-87.

[5] Bose, R. "Advanced Analytics: Opportunities and Challenges," *Industrial Management & Data Systems*, 109(2), 2009, 155-172.

[6] Burton, B., Geishecker, L., & Hostmann, B. "Organizational Structure: Business Intelligence and Information Management," *Gartner Research*, 2006.

[7] Delone, W., & McLean, E. "Information Systems Success: The Quest for the Dependent Variable," *Journal of Information System Research*, 3(1), 1992, 60-95.

[8] Delone, W., & McLean, E. "The DeLone and McLean Model of Information Systems Success: A Ten-Year Update," *Journal of Management Information Systems*, 19(4), 2003, 9-30.

[9] Friedman, T. "Gartner Says More Than 50 Percent of Data Warehouse Projects Will Have Limited Acceptance or Will Be Failures Through 2007," 2005. Retrieved 21 Feb 2009, from http://www.gartner.com/it/page.jsp?id=492112

[10] Fuchs, G. "The Vital BI Maintenance Process", in Business Intelligence Implementation: Issues and Perspectives," In B. Sujatha (Ed), ICFAI University Press, Hyderabad, 2006, 116-123.

[11] Gartner Research, "Gartner EXP Worldwide Survey of 1,500 CIOs Shows 85 Percent of CIOs Expect 'Significant Change' Over Next Three Years," 2008. Retrieved 21 Feb 2009, from http://www.gartner.com/it/page.jsp?id=587309

[12] Gartner Research, "Gartner EXP Worldwide Survey of More than 1,500 CIOs Shows IT Spending to Be Flat in 2009", 2009. Retrieved 21 Feb 2009, from http://www.gartner.com/it/page.jsp?id=855612

[13] Hwang, M. & Xu, H. "A Structural Model of Data Warehousing Success," *Journal of Computer Information Systems*, Fall 2008, 48-56

[14] Inmon, W.H. *Building the Data Warehouse 4 Edn*, John Wiley & Sons, Indianapolis, 2005.

[15] Jagielska, I., Darke, P., & Zagari, G. "Business Intelligence Systems for Decision Support: Concepts, Processes and Practice," Proceedings of the 7th International Conference of the International Society for Decision Support Systems, 2003.

[16] Little, R.G. *Identification of Factors Affecting the Implementation of Data Warehousing*, Thesis, Auburn University, 1998.

[17] Linstone, H. A., & Turoff, M. *The Delphi Method: Techniques and Applications*. Addison-Wesley, Reading, MA, 2002.

[18] Miles, M. & Huberman, A.M. *Qualitative Data Analysis: An Expanded Sourcebook*, Sage, Thousand Oaks, CA. 1994.

[19] Moss, L. & Atre, S. *Business Intelligence Roadmap: The Complete Lifecycle for Decision-Support Applications*. Addison-Wesley, Boston, MA. 2003.

[20] Negash, S. "Business Intelligence," *Communications of the Association for Information Systems*, 13, 2004, 177-195.

[21] Olszak, C & Ziemba, E. "Approach to Building and Implementing Business Intelligence Systems," *Interdisciplinary Journal of Information, Knowledge, and Management*, 2, 2007, 135-148.

[22] Reinschmidt, J. & Francoise, A. *Business Intelligence Certification Guide*, IBM International Technical Support Organization, San Jose, CA, 2000.

[23] Shin, B. "An Exploratory Investigation of System Success Factors in Data Warehousing," *Communications of the Association for Information Systems,* 6(4), 2003, 141-170.

[24] Stuart I., McCutcheon D. & Handfield R. "Effective Case Research in Operations Management: A Process Perspective," *Journal of Operations Management*, 20(5), 2002, 419-433.

[25] Turban, E., Sharda, R., Aronson, J. & King, D. *Business Intelligence*, Prentice Hall, New Jersey, 2007.

[26] Wadehra, A. "The ABCs of Master Data Management: Architecture, Business Case, and Customer," *Business Intelligence Journal*, 12(1), 2007.

[27] Wang, H. & Wang S. "A Knowledge Management Approach to Data Mining Process for Business Intelligence," *Industrial Management & Data Systems*, 108(5), 2008, 622-634.

[28] Watson, H., Abraham, D., Chen, D. "Data Warehousing ROI: Justifying and Assessing a Data Warehouse," *Business Intelligence Journal*, 2004, 6-17.

[29] Watson, H., & Haley, B. "Managerial considerations," *Communications of the ACM*, 41(9), 1998, 32-37.

[30] Watson, H., Annino, D. A., Wixom, B. H. "Current Practices in Data Warehousing," *Journal of Information Systems Management*, 18(1), 2001, 1-9.

[31] Watson, H., Fuller, C., & Ariyachandra, T. "Data Warehouse Governance: Best Practices at Blue Cross and Blue Shield of North Carolina," *Journal of Decision Support Systems*, 38(3), 2004, 435-450.

[32] Wixom, B., & Watson, H. "An Empirical Investigation of the Factors Affecting Data-Warehousing Success," *MIS Quarterly*, 25(1), 2001, 17-41.

[33] Yin, R. *Case Study Research: Design and Methods 3 Edn,* Sage, Thousand Oaks, CA, 2003.

[34] Ziglio, E., & Adler, M. *Gazing into the Oracle: The Delphi Method and its Application to Social Policy and Public Health*, Jessica Kingsley Publishers, London, 1996.