IMPACT OF BUSINESS INTELLIGENCE (BI) SYSTEMS USE ON PROCESS LEVEL PERFORMANCE

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ABSTRACT

Successful adoption and effective use of information technology (IT) innovations are generally believed to positively impact organizational performance. This is particularly the case for business intelligence (BI) systems where the focus is on managerial decision making. In spite of their widespread implementation, large investments, and increasing focus on managerial decision making, empirical studies addressing this question are limited and results tend to be ambiguous. This study investigated the relationship between BI systems use, IT infrastructure capability, and firm performance at the process level and analysed the direct effects of firm size and industry type variables on these three variables.

Using a cross-sectional survey method, data was collected from 128 business intelligence (BI) users in Australia across various industry types. Even though a majority of past studies considered BI system usage as a single item variable, this study has taken a broader view of the BI system use and measured it with reference to four aspects – extent of use of various applications/business processes a BI system supports, extent of use of several technology components of a BI system, level of management/governance of BI system use and time since the adoption of a BI system.

Our results indicate that the range of BI software solutions and tools employed in Australian business organizations today is high with a majority of firms surveyed using BI software solutions for more than 5 years and mostly using them to support financial and performance reporting processes. A majority of firms report satisfaction with the capabilities of the BI system but continue to use *Excel* for reporting and analysis functions bypassing the BI system. We found that poor management of access, rigidity of the BI system in its inability to meet dynamic changing business requirements, inadequacy of user training, poor data handling procedures, and absence of data governance are some of the challenges identified in the management of BI system usage. Successful management and use of BI system and its several technology components are heavily dependent upon the IT infrastructure. This study confirmed the enabling role of IT infrastructure capability in improving firm performance as identified in the literature, and found this to be a significant predictor of process level performance.

Firm size, measured by gross revenue and employee strength, had no influence on process level performance. Though business use of BI applications is not influenced by the size of the firm, larger firms with higher gross revenue and employee strength have higher IT infrastructure capability and use a range of BI tools effectively, the study found. Industry type, based on our study, had no influence on the BI use and process level performance, except that the impact is higher in service firms than in manufacturing firms.

Based on the results, we suggest that firms must improve their BI system management that includes access, skills and procedures, and IT infrastructure capabilities in order to improve process level performance. Effective usage of the applications that support specific business processes and good management of use tend to deliver performance benefits to organizations, rather than just the deployment of technology tools. This study demonstrates the existence of complementarity between BI systems use, generic IT infrastructure and business processes, that enables the exploitation of BI system to support effective decision making and performance management and highlights the importance of 'BI use' and its governance.

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Chapter 1

Introduction

Chapter 1: INTRODUCTION

1.1 Overview

Successful adoption and effective use of initial information technology (IT) innovations are generally believed to positively impact firm's performance. This is particularly so for business intelligence (BI) systems where the focus is on managerial decision making and strategic issues. In spite of their increasing importance to managerial decision making and corporate performance and widespread implementation of these systems, the impact of BI implementations on performance are ambiguous. This research study investigated the relationship between the use of BI systems and process-level performance with information technology (IT) infrastructure capability as the moderating variable. This chapter first explains the background and motivation to this research study and presents the research questions. It then briefly outlines the research approach, important results and contributions, and gives an outline of this thesis.

1.2 Background and motivation

BI systems are increasingly adopted across a wide range of industry sectors and in all sizes of firms to support managerial decision making with the goal of improving organisational performance. According to Gartner, the worldwide investment in BI systems was $14.4 billion in 2013, a growth of 8% compared 2012 with further interest and adoption of these solutions predicted. In fact, the implementation of BI system was among the top five IT investment initiatives in business organisations for a number of years (IDC 2012).

BI systems aim to provide information that is timely, relevant and easy to use to managers at various organisational levels. The information provided by BI systems is both strategic and operational and are deployed to help improve decision making and attain enhanced operational competitive advantage (Werner and Abramson 2003). With the challenges of technical implementation overcome by business organisations, the focus is now shifting towards its business value.

Successful adoption and effective use of any IT innovation is expected to impact organisational performance. IT innovations in general offer the potential to change organisational processes, routines and management controls (Mishra and Agarwal 2010) and BI systems are no different. Some firms investing in BI systems and implementing best practices have seen increased revenues and significant cost savings (Watson et al 2006) and reduction in stock return volatility (Rubin and Rubin 2013), while others have not seen the promised benefits (Gessner & Volonino 2005). BI systems are considered risky as they require collaboration among IT and business managers, and among operational personnel (Wagner and Weitzel 2012).

Past studies in the BI systems field have predominantly focused on the critical success factors for BI implementation (Yeoh and Koronios 2010), impact on supply chain performance (Trkman et al 2010), data collection strategies for BI implementation (Ramakrishnan et al 2012), role of culture and leadership in BI implementation, role of organisational capabilities in assimilating the BI systems (Elbashir et al 2011), and the effect of culture and maturity on BI systems success (Popovic et al 2012) among others. Though several research publications describe the benefits from BI research, most of these studies were exploratory in their approach and do not adequately explain the important issues of information systems as they relate to BI systems (Jourdan et al 2007). While the extent of use of BI systems drives the value generated by the organisation in terms of its improved performance and decision making (Elbashir et al 2013), studies analysing the use of BI systems are limited. Various components of enterprise performance systems such as BI systems were often studied in isolation with strategic execution discussed at strategic level decision support at the IT department level, and process efficiency at the operational level.

Several organisational factors are expected to moderate the impact of IT innovations on business performance. Although use of an IT system by itself does not guarantee business performance, it is considered an important factor along with other factors such as IT infrastructure capability, information management practices and others (Mithas et al 2007, Barua and Mukhopadhyay 2000). Implementing, managing and working with BI system requires a sophisticated and specialised IT infrastructure including recent technologies such as data warehouses, data mining and multi-dimensional and visualisation tools (Gibson et al 2004, Mansmann and Scholl 2007). IT infrastructure capabilities enable other organisational capabilities and impact firm performance (Fink and Neumann 2007). Given its relationships with and dependence on IT components, the role of IT infrastructure capability is considered important in the context of BI systems.

1.3 Research questions

Huge global spending on BI systems and their increasing strategic importance highlights the need for more empirical research on the use of BI systems. This study aims to fill this research gap and analyses the impact of BI systems use on process level performance. Specifically this study aims to answer the following research questions.

1. What is the extent of use of business intelligence (BI) systems deployed?
2. How does the use of BI systems impact firm performance at process level?
3. How does organisational IT infrastructure capability influence the process level performance?
4. How do the industry type and firm size influence the relationship between BI system use and process level performance?

1.4 Research approach

In order to answer the research questions, use of BI system, IT infrastructure capability and process performance outcomes were first operationalised using the past studies and literature. Using a cross-sectional survey methodology and multi-respondent strategy, this study collected the perceptions of the use of BI systems from business organisations. Using four sub factors - extent of applications use, extent of tools use, perceptions of management of use and length of BI system use, the independent variable 'BI use' in an organisation was operationalised and measured. In addition, process performance outcome and IT infrastructure capability constructs were measured using established well validated questionnaire items.

Using a multiple regression model with process performance as the dependent variable, and BI use and IT infrastructure capability as independent variables, the relationship was analysed. Further using independent samples t-tests at 5% significance level, the effect of industry type, firm size measured in terms of number of employees and gross annual revenue, and respondents' position in the organisation were analysed and results presented.

1.5 Important findings and contributions

Based on empirical data collected from BI users in Australia, this study investigated the relationship between BI systems use, IT infrastructure capability, and firm performance at the process level. In recognition of the importance of day-to-day 'use' of functionality and features rather than whether or not an organisation has a BI system, BI use in this study is conceptualised and measured with reference to four dimensions – applications use, tools use, management of use and time since adoption. Thus, this study focused on the functional use of a BI system, the extent of its use, maturity of its use and management of its use.

Our results indicate the positive influence of extent of use of applications that support various business processes, management/governance of BI system use and IT infrastructure capability on process level performance. This study confirmed the enabling role of IT infrastructure capability in improving process level performance and its positive influence on BI system use.

A majority of firms surveyed have deployed more than one BI software solutions, to mostly support financial and performance reporting processes and are in use for more than 5 years. Recognising the importance of management/governance of BI use, this study identified poor management of access, rigidity of BI system, inadequacy of user training, poor data handling procedures and absence of effective data governance as challenges that limit the impact of BI system use on process level performance. Emphasising the importance of business aspects of BI system use, this study found no discernible impact of the extent of use of tools and time since BI system is adopted on process level performance. The assumption that longer a system is in place, better its use is not found to be valid in this study. Even though it may take some time to assimilate a BI system and use it effectively, beyond a certain period, time since adoption has no effect on process level performance, the study observed.

In order to improve process level performance, firms must improve their BI system management procedures and governance structures and IT infrastructure capabilities and create an environment that facilitates increased use of various applications supported by a BI system. Firm size, measured by gross revenue and employee strength and industry type, according to this study, have no influence on the BI use and process level performance. Effective use of applications that are supporting specific business processes and better management of use would lead to higher levels of process performance, the study concluded.

1.6 Outline of the thesis

The rest of the thesis is organised as follows. Chapter 2 provides a review of the relevant literature, explains the terminology and identifies the gaps in the past research. It leads to the identification of specific research questions. Chapter 3 describes and justifies the research methodology adopted. It details the design of the data collection instrument, selection of respondents, development of operational measures for each of the constructs, survey administration processes and statistical techniques and models used in the analysis of data. Chapter 4 presents the analysis of data undertaken to test the proposed hypotheses and answers the research questions. The details of the results and the findings from the study are presented in this chapter. Chapter 5 presents the conclusions and a discussion of the results of this research. It explains the contribution to the knowledge made by this study and discusses implications of the findings for research and practice. Finally, the limitations of the research and the opportunities for future research are identified and discussed.

Chapter 2

Literature Review

Chapter 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of relevant literature and identifies the research gap that is addressed in the present study. The literature review identifies research gaps, and informs the development of the research model and research questions. This chapter is divided into four sections. It begins by defining the umbrella term business intelligence (BI) system and explains several technology, information systems and other related components associated with the implementation and use of BI system. In the second section, the relationship between BI systems use and organisational performance and the role of information technology infrastructure is discussed. Taking into account previous studies in Australia and overseas, the gaps in the research and the main research questions that emerge from the literature review are presented in the third section. In the fourth section, the research model, proposed hypotheses and operationalisation of all three constructs/variables in the model – BI use, process performance and IT infrastructure capability, and control variables are explained.

2.2 Business Intelligence (BI) systems

Business Intelligence (BI) systems are not just technologies. They are a broad category of applications, technologies and processes used for gathering, storing and analysing data to help users make better decisions (Wixom and Watson 2010, Olbrich et al 2011). They form a group of processes, organisational procedures, technological and management tools and human competencies that are used in combination to analyse information and support decision-making processes.

2.2.1 Applications that support business processes

Defined differently by various authors (Arnott and Pervan 2005; Howson 2007; Trkman et al 2010), BI has no unanimous definition. Most of the past definitions of BI systems focused on technical infrastructure and did not stress the business and user aspects (Lukman et al 2011). The term 'business intelligence' was used more than 50 years ago by Luhn (1958) while explaining dissemination of information techniques. According to Golfarelli et al (2004), a BI system is an information system that processes data into information and then into knowledge to facilitate decision making. BI systems have the capability to do intelligence exploration, integration, aggregation and analysis of data originating from various information resources (Yeoh and Koronios 2010). They are strategic information systems that organisations deploy to improve decision making and performance (Werner and Abramson 2003).

Thus, BI system, at a conceptual level, refers to systems and procedures that transform raw data into useful information for managers to use to make better decisions (Wixom and Watson 2010. At the operational level BI is defined as an information system that has three elements – technological element, human competencies element and business process element (Laursen and Thorlund 2010). While at technological level, it is a tool to collect, store and deliver information, at human competencies level it refers to the ability of human beings to retrieve data and deliver it as knowledge and information and their ability to make decisions based on this new knowledge. At a process level, BI system supports specific business process(es) that make use of the information or new knowledge for increasing process level performance. Some of the activities performed by the BI systems while supporting financial/performance reporting processes include reviewing of costs and revenues, comparative analysis of financial statements and analysis of financial markets (Olzak and Ziemba 2003). Similarly, supporting marketing/sales/customer related processes involves analysis of sales, profitability, competition; supporting logistics processes involve identification of bottlenecks, delayed orders, and analysis of inventory control problems; and supporting human resource management processes deals with the analysis of wage data relating to employment types, contributions and surcharges and employee turnover and employee personal data (Olzzak and Ziemba 2003; Hsu 2004).

At a business process level, BI systems provide timely, relevant and easy to use information to managers (Hannula et al 2003) and support data analysis and decision making on the basis of internal and external data (Chung et al. 2005; Watson and Wixom 2007). Thus, using BI systems involves using the systems or its components that support various business processes/applications such as financial reporting, internal performance reporting, supply chain management, customer relationship management and logistics. In addition it involves working with various technology components such as data warehouses, data visualization tools, dashboards and analytics tools as explained in the next section.

2.2.2 Tools/technology components

BI systems are also defined as a set of tools and methodologies that are designed to exploit actionable knowledge discovered from the company's information assets (Loshin 2003). Combining traditional BI with real-time information and decision support capability, they offer an integrated set of tools to collect heterogeneous data from dispersed sources and to analyse and present complex information (Yeoh and Koronios 2010). They include decision support tools such as data warehousing, packaged data marts, online analytical processing, dashboards, analytics services and tools for data mining, query and reporting (Gibson et al 2004).

Data warehousing, a subject oriented, time-variant database is an important part of a modern BI system, different from conventional transactional processing databases useful to support business and non-business domains (Mansmann et al 2007). The objective of data warehousing is to standardise and consolidate the enterprise wide data with data definitions, business rules and data registration requirements and methods and make it commonly available. Users can query across departmental boundaries for dynamic retrieval of relevant decision support information from these complex data structures (Yeoh and Koronios 2010). They adopt a multidimensional data model tackling the challenges of online analytical processing (OLAP) via efficient execution of queries that aggregate over larger amount of transactional data (Codd et al 1993). Data warehousing is used to extract, transform and load data from transaction systems such as Enterprise Resource Planning (ERP) systems and sources outside the enterprise such as internet and industry databases. It delivers the ability to store aggregated and already analysed data in a thematic context.

The on-line Analytical Processing (OLAP) tool, another technology component of a typical BI system, lets users access, analyse and model business problems and share generalisations, regularities and rules in data resources stored in data warehouses (Olszak and Ziemba 2006). Some of the modern BI software solutions come with text mining and predictive monitoring capabilities also.

Dash boards are another set of tools available in a modern BI system and are typically used to link strategy with measurement and performance (Bruggerman 2004). Drawing from the balanced score card concepts, these dashboards link performance metrics associated with the traditional performance perspectives such as shareholders, customers, internal processes and innovation and learning to the organisational strategy (Viaene and Willems 2007). These dash boards provide interactive measurement-driven gauges that depict trends, identify outliers and drill-down capabilities (Selby 2009) and help managers track progress, compare alternatives, evaluate risks and predict outcomes. Analysis in the dashboards and/or score boards is facilitated by Online Analytical Processing (OLAP) and structured query language (SQL) tools that provide consistent, fast and interactive access to a wide variety of views to managers.

Analytics tools, another technology component in BI systems help manage corporate performance by identifying profitable customer segments, tracking loyalty and upselling strategies, forecasting future gaps in workforce, influencing behaviour of customers, markets and supply chains, and tracking fluctuations in brand image (Todd 2009). They provide the best possible intelligence about customers, suppliers, human resources, operations and finances. In addition, they are also used for monitoring sentiments, voice mining and video analysis with other sophisticated object-recognition technologies. A number of analytics technologies such as operations analytics, business model analytics, value chain and network analytics, and game theory are available in the market (Tian et al 2009**)**. All these tools play an important role and using them effectively may deliver improvement in corporate performance and decision making (Viaene and Willems 2007).

2.2.3 BI systems and organisational performance

The implementation of a BI system is widely accepted as one of the most important IT initiatives to improve organisational performance (Jourdan et al 2008), even though the complexity, broader scope and turbulent nature of the business world makes measuring and managing corporate performance a challenge (Bose 2006). Complemented with the introduction of new management approaches and relevant organisational changes, implementing and effectively using a BI system is expected to add value to organisations (Wells 2008). Increases in fact-based decision making, recognition of the competitive value of BI, the increasing need to comply with changing regulations, budgetary constraints and pressure for returns on IT investments are forcing organisations of all sizes and types to successfully adopt and effectively use BI systems (Olbrich et al 2011; Jourdan et al 2008; Vesset et al 2009).

BI systems, over the long term, can lead to optimised decision-making processes and contribute to improved performance (Vesset et al 2009). By assisting in the identification of problems and opportunities, in the alignment of operations with corporate strategy, and in the decision-making process, a BI system contributes to organisational competitiveness and sustainable development (Olbrich et al 2011). As BI systems support intelligent exploration, aggregation, integration and multidimensional analysis of data originating from a diverse set of information resources, the intelligence delivered is rich in scope and reach (Olszak and Ziemba 2007). In addition, the timely delivery of actionable management information, synchronisation of the organisational information and decision-making processes, BI systems contribute to improvements to organisational performance (Selby 2009).

Corporate performance management process involves monitoring and analysing enterprise activities from data gathered from a wide range of business activities and from different levels. BI systems deliver the ability to integrate enterprise-wide data into metrics and link them to specific performance objectives (Shao 2011). These metrics in turn help organisations to better set and monitor enterprise performance metrics (IBM 2011). Further, the pervasiveness of BI system throughout the organisation leads to greater employee accountability and consistency in performance management (Vesset et al 2009). With their ability to integrate unstructured data and external data sources via the internet (Chung et al 2005) and to trigger real-time actions (Shim et al 2002), BI systems can influence organisational performance management processes. BI systems can also facilitate identification of process disconnect issues and exceptions and measure process performance, thus contributing to improved process management and service innovation (Lukman et al 2011).

BI systems complement now pervasive Enterprise Resource Planning (ERP) systems and delivers improved decision-support capability and real-time actionable information to managers. ERP systems, already in place for more than a decade now, link core business processes such as procurement, manufacturing, logistics, accounting and human resources (Newell et al 2003; Parr and Shanks 2000) and have accumulated massive amounts of data in their databases. While, they contribute to functional integration across the enterprise and good in data capture and sharing, their focus is mostly on the automation of repetitive transactional processes and offer very limited decision-support (Chang et al 2008; Holsapple and Sena 2005) and have poor reporting capabilities (Adam and Doyle 2001). In fact, lack of flexibility in reporting and the excessive resources needed to amend existing reports and/or develop new reports are some of the reasons cited for the inability of ERP systems to support decision making (Stanek et al 2004; Weir et al 2007). Acknowledging these inadequacies, ERP software vendors such as SAP and Oracle have started offering business intelligence solutions and support decision making in various business processes context.

In general, BI systems are considered to be tools for decision support and therefore operate at middle and senior management level. But their impacts are widespread, as they allow people at several organisational levels to access, interact with and analyse data to manage the business and operate efficiently (Howson 2007). BI systems are widely viewed as an innovation that can leverage the wealth of transactional data stores in an enterprise system and support the anticipated transformation to broader management control systems (Robertson et al 2007, Gnatovich 2007).

In the past, BI systems were viewed as tools that were used exclusively to support strategic decision making (Elbashir et al 2008). By deploying these BI technologies and systems to support wider business activities (Rogge 2005), organisations are now using them for operational process improvements, supply chain management and customer service (Williams and Williams 2003; Elbashir and Williams 207). Integrating BI systems with business processes enables managers to access relevant and timely information and make better operational decisions (Williams 2004). In fact, the value of any IT innovation is achieved by its direct impact on business processes and BI systems are no different (Ray et al 2005; Subramani 2004; Barua and Mukhopadhyay 2000; Talon et al 2000). BI systems not only contribute to improved decision making and corporate performance, but also generate operational benefits across the value chain.

2.2.4 BI system use

Acquiring a new IT innovation whether it is an enterprise system or a BI system is just the beginning of a process of exploiting its potential. IT based innovations offer the potential to significantly change organisational processes, routines and management controls and can deliver benefits for firms that can exploit them. Despite investment in, and adoption of, IT based innovations being common in enterprises of all sizes and industry sectors across the world, many firms are not successful in assimilating them and exploiting them to their potential (Liang et al 2007). The extent to which they are used and used effectively, are factors influencing the firm’s ability to derive the full benefits of any IT innovation (Grubljesic and Jaklic 2013).

Over the past decade, system use has played a critical role in information systems (IS) research (Bokhari 2005; Schwarz and Chin 2007) and has been employed in several studies on IS success (DeLone and McLean 1992), IS acceptance (Venkatesh et al 2003) and IS for decision making (Yuthas and Young 1998). The concept of system usage is defined as the “extent to which the system has been integrated into individuals’ work routine” (Goodhue and Thompson 1995, pp.223). Most of the past research on IS mainly focused on the narrower aspect of acceptance and not on how the information system (IS) is used. (Grubljesic andJaklic 2013). Although initial acceptance is considered an important step towards IS success (DeLone and McLean 1992), long term sustainability and the success of any IS is dependent upon its ability to be embedded within organisational processes, routines and strategy (Shanks et al 2012). In fact, ineffective, inappropriate and infrequent use of IS often leads to business failures (Lyytinen and Hirscheim 1987).

Unlike the focus of past research on IS use, the use of BI system should not be understood only as frequency and intensity of use (Davis et al 1989). If BI systems are deeply embedded in business organisations, it is possible to create BI-driven decision making routines and BI-enabled business processes that would take managerial decision making to new levels of understanding and foresight (Shanks et al 2012). Frequency of use and duration of use of executive information systems (EIS), for example, have reportedly contributed to the increase in speed of decision making and extent of analysis in decision making and speed in identifying problems, (Leidner and Elam 1993). In fact, system usage has a positive effect on perceived impact on decision-making quality, productivity and effectiveness (Igbaria and Tan 1997).

The use of BI systems contributes to improved measurement and management of corporate performance (Bose 2006). According to Wells (2008), BI is not just about technologies, processes and data. It is about the organisation's ability to think abstractly, comprehend intelligent information, establish goals and enable effective actions (Wells 2008). In this context, it is seen as a combination of three independent segments – the system itself, the quality of information produced by the system and finally the usage of the information in organisations (Lukman et al 2011). From a technological view, BI system have a set of data sets, stand-alone databases, data sources to provide input data such as transactional data, and technical capabilities to analyse and produce desired information. From an information point of view, the main goal of BI system is to produce and deliver accurate information to users of the system. But, presenting better information by itself does not lead to increased firm performance. It is the firm's ability to use that information or intelligence produced by the BI system that will differentiate the firm's achievements and improvements. Thus, use of BI system is critical for exploiting its full potential.

Effective use of BI system depends on the readiness of business users and efficient access to information without becoming lost in technical issues

(Waheed 2011). Some of the proven strategies such as ‘parallel run’ of the old and new systems and appropriate mechanisms to validate the data will enable BI users to use the powerful features of BI systems (Waheed 2011) and exploit their full potential.

Although much research has been carried out explaining the factors influencing the adoption of and user satisfaction with IT innovations, research related to the use of these innovations in a post-adoption environment is limited and further research is called for (Ahuja and Thatcher 2005; Barki et al 2007; Jasperson et al 2005). The real value creation potential of IT innovations such as BI systems may only be realised when firms move into the post-adoption stage and understand the factors contributing to the effective use of those systems.

Although there are several ways BI systems can be used, according to Gartner (2010), enterprises use them mainly for corporate management, optimisation of customer relations, monitoring of business activities, reporting, planning and to support decision-making at all levels of management. More popular uses of BI systems are to identify customer behaviours, create loyalty policies and investigate anomalies and frauds (Olszak and Ziemba, 2006).

BI systems enable organisations to generate business value at the process as well as at organisational levels (Elbashir and Williams 2007). The full value of any IT innovation can be exploited when these IT investments support business strategies through their support to business processes. Therefore, usage of BI tools is critical to see the real benefits. While many organisations invest in these IT innovations, they do not take additional steps to leverage them within business processes. This will make a difference to the organisation and to performance outcomes. As reported by Elbashir et al

(2008), organisations generate value from their investments in BI systems only when they effectively use these tools to support business activities and integrate them with business strategies. Understanding the use of BI systems in the value-adding processes and activities of the organisation will help justify investments in BI more so than the generic assertion that BI systems help ‘make better decisions’.

With strategic and operational implications, effective usage of BI systems has significant potential to impact organisational performance (Maghrabi et al 2011). Underscoring the importance of BI use, Gartner research (2008, 2012) warned of potential loss of market share if firms fail to realise the capabilities of BI systems. In fact, anecdotal evidence suggests the failure of several companies in the effective use of BI systems after implementation (Chenoweth et al 2006). The next section explains the IT infrastructure capability and its role in supporting BI systems and firm performance.

2.2.5 IT infrastructure capability

Implementing and managing a BI system is a complex undertaking requiring sophisticated and specialized IT infrastructure and resources over a lengthy period. IT infrastructure is important not only for the underlying specialised databases it provides but also for its powerful dashboards, analytics, visualization and reporting tools. IT infrastructure capability (ITIC) is defined as the integrated set of reliable IT infrastructure services available to support existing applications and new initiatives in firms (Weill et al 2002) and now includes basic IT components as well as shared services such as data, information and standard applications (Mithas et al 2007).

The IT infrastructure capabilities of a firm refers to its ability to provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, and confidentiality, the ability to provide universal connectivity and access with adequate reach and range, and, the ability to tailor the infrastructure to emerging business needs and directions (Fink et al 2007). IT infrastructure capabilities provide the base capabilities through which firms can build higher order capabilities which in turn have a direct relationship with firm performance.

Even though 'IT infrastructure' is a key factor in firm's performance, its conceptualization is inadequate (Kayworth et al 2001) and lacks clarity in the meaning of its domain (Born 2002) primarily due to different research approaches taken in the past (Fink and Neumann 2007). While one approach focuses on static technical resources and regards IT infrastructure as an arrangement of shared technical components, platforms, networks, telecommunications, data and core applications (Bhardwaj 2000; Rockart et al 1996; Duncan 1995; Byrd 2001), another approach supports business processes and views it as a collection of shared services (Born 2002; Kayworth et al 2001; McKay and Brockway 1989; Weill 1992).

Weill et al (2002) conceptualised IT infrastructure capability as a cluster of ten capabilities including channel management, security, risk, data management, application infrastructure, IT facilities management, IT management, IT architecture and standards, IT education and IT R & D. It is defined as the broad capability to provide extensive firm-wide IT infrastructure services that support business processes and has a technical layer and a shared service layer (McKay and Brockway 1989).

IT infrastructure capability includes both technical as well as human capability (Chanopas et al 2006). Given the limitations of human capability, changes in the technology components such as servers, personal computers and networks alone may not deliver improvements in the IT infrastructure capability (Weil et.al 2002). Further, professional expertise in technical areas, a human capability, is important to effectively identify, integrate and utilise technical skills (Byrd and Turner 2000; Ross et al 1996), to integrate new systems with old ones, to deliver data across locations and applications, to optimise IT investments and to recognise opportunities to apply new technologies as they become available (Fink et al 2007). Similarly, investment in research and development helps discover new ways of using information technologies that would create business value (Weill et al 2002). Thus, building human capabilities on enterprise specific technologies including BI systems as well as on the business use of those IT investments though important, is often neglected in enterprises (Weill et al 2002).

Rather than directly impacting firm performance, IT infrastructure capabilities enable other significant organisational capabilities that in turn impact firm performance. This enabling role was identified in past studies (Fink and Neumann 2007), however, the underlying mechanism through which this is achieved is not known (Bhardwaj 2000). Earlier studies linking IT infrastructure capabilities with performance did not address the heterogeneity of the firms (Dedrick et al 2003; Wade and Hulland 2004). Using quality management and IT business value literature, Mithas et al (2011) pointed out the contribution of information management capability to firm performance. These information management capabilities include the ability to provide data and information to users with appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access and the ability to tailor these in response to changing business needs and directions.

Mithas et al (2011) identified three organisational capabilities that facilitate the links between information management capability and firm performance.

These capabilities include performance management capability, customer management ability and process management capability. The ability to develop appropriate monitoring, evaluation, and control systems to observe business performance and guide managerial actions is termed as performance management capability (Bourne et al 2002; Eccles 1991: Kaplan and Norton 2000). The second capability, customer management is defined as the ability to develop significant customer relationships and nurture customers both as consumers and as innovation partners in new product development (Mithas et al 2005; Nambisan 2002). Process management capability is the third organisational capability and is defined as the ability to develop processes with appropriate reach and richness for guiding manufacturing, supply chain, software development, financial, and other important activities (Davenport and Beers 1995; Ramasubbu et al 2008; Sambamurthy et al 2003).

In addition, this information management capability, works as an enabler of the other two capabilities - process management and customer management capability (Davenport 2000) and reduces the process variability which in turn enhances organisational performance (Frei et al 1999). While IT infrastructure provides the base foundation, the management of information would have greater impact on organisational performance (Cotteleer and Bendoly 2006). Many scholars suggest focusing on information rather than technology itself and considered information as an asset for achieving competitive advantage (Glazer 1991). Mendelson and Pillai (1998) validated this view and emphasised the need to go beyond technology while managing the enterprise. Thus, the ability to provide timely, accurate, consistent and reliable information to managers and stakeholders would act as a variable and enable firms to redesign and tailor other organisational capabilities, which in turn would influence organisational performance.

Providing information that is timely and accurate allows a firm to attain efficiency, agility and economy in the design and management of their key business processes. As pointed out by Davenport (1993) quality and timeliness of information helps to manage the cost effectiveness of business growth processes such as product development, design, delivery and other support processes. Tailoring IT infrastructure allows firms to manage all of their organisational processes and their reconfiguration for continued effectiveness (Mithas et al 2011), and, using and designing appropriate metrics and controls (Robinson et al 2000), and using processes as strategic options in response to changes in business conditions (Kalakota and Robinson 2003). Providing universal connectivity and access with adequate reach and range allows firms to design robust and seamless processes across organisational and geographic boundaries (Mithas and Whitaker 2007). Thus, information management capability would enable superior process management capabilities. In a dynamic business environment, process management capability is a significant source of competitive advantage (Kettinger and Grover 1995).

In terms of IT, the quality of IT management practices, ability to develop appropriate information management processes to sense, gather and disseminate information, and the ability to instil desired information behaviour and values are key factors that contribute to organisational performance (Marchand 2000). For example integrating information technologies into key operational and managerial processes across the enterprise improves process visibility and delivers consistent execution of the processes. Information systems that encourage sharing of information across the enterprise and their ability to offer information integrity contribute to improved quality of decision making and organisational performance.

IT infrastructure capabilities influence both dynamic and improvisational capabilities of firms. By integrating organisational processes and activities with information technology, IT infrastructure plays an important role in creating digitised capabilities for the firm (Mithas et al 2007). It supports the functioning of BI systems' such as sensing environment, acquiring, assimilating, using and generating new knowledge by effectively synthesizing and sharing that knowledge and learning (El Sawy and Parlou 2008). It helps BI systems in making information visible and accessible (Chen and Siau 2011). BI systems help managers to make right decisions at the right time and IT infrastructure capability allows the firm to sense and respond to ongoing and emerging changes in business environments. The level of IT infrastructure capabilities influences the extent of adoption and use of BI systems, and thus potential improvements in managerial decision making and performance. For example, flexibility in IT infrastructure is expected to positively impact BI usage (Chen and Siau 2011). Although the speed of adjustments required could vary from firm to firm, the use of BI systems may potentially facilitate rapid adjustments to ongoing changes in business environments. For example, businesses such as internet service provider or online retailer are more sensitive to the speed of changes when compared to an education-based business. Thus, given the diversity of several IT components and their integration to support BI systems, and their links with business processes, IT infrastructure capability plays an important role in the use of BI systems and the way it impacts process level performance. The next section summarises research gaps and explains the research questions this study investigates.

2.3 Research gaps and questions

The study of BI systems is a relatively new area driven primarily by the IT industry which depends mostly on anecdotal reports. In spite of BI's complex structures there has been little empirical research about the impact of implementing BI systems. Studies of critical success factors for implementing BI systems by Yeoh and Koronios (2010), intelligence maturity models by Lahrmann et al (2011), impact of BI on supply chain performance by Trkman et al (2010), data collection strategies for BI implementation by Ramakrishnan et al (2011), how service-oriented architecture may help BI functions by Muller et al (2010), a case study on the role of culture and leadership in BI implementation by Seah et al (2010), integration of BI into business process improvement by Marjanovic and Roose (2011) and a study on how organisational capabilities help with BI assimilation by Elbashir et al (2011) are some of the published research studies on BI systems. Though numerous publications routinely describe the benefits of BI systems (Davenport 2006), most of the BI research undertaken was exploratory in nature and does not adequately explain the issues of information systems as they relate to BI systems (Jourdan et al 2008).

While the BI market appears to be vibrant and acceptance is widespread and growing, the success of BI implementation and its effectiveness of use vary from firm to firm. The fact that organisational and process-related factors are more influential than technological and data related factors on the success of BI system implementation (Yeoh and Koronios 2010), suggests the need for further studies. Jourdan et al (2008), in a review of literature on BI, notes the inadequacies of past research that does not explain the contexts and observes limited empirical studies linking organisational performance with the use of BI systems. With each IT innovation being unique in terms of its heterogeneous applications, its qualitative and quantitative impacts, measuring the bottom line contribution of IT innovation in general is a challenge for researchers (Kohli and Devraj 2003; Barua and Mukhopadhyay 2000). It is therefore necessary to develop appropriate performance measures and understand impacts specific to each innovation including BI systems.

Decision making is a phenomenon affected by management styles and culture and the impact of BI systems also is expected to be affected by these factors. As BI systems enable improved decision making, differences in management styles and culture may contribute to differences in perceived impacts of BI systems. For example, Asian managers rely more on 'gut-feel' decision making, while North American managers rely more on data psychoanalysis for decision making (Martinsons 2004). Even though some argue that this 'gut-feel' decision making is better for these emerging and rapidly changing business conditions in Asia (Sato and Eisenhardt 2009), concepts of linking management planning with operational activities, data-based management and quantitative analysis in managerial decision making are not common among many Asian managers (Martinsons 2004). Instead, Asian managers tend to use their informal networks and connections for collecting information, rather than depending on formal institutional databases and system (Park and Luo 2001). Lack of rich experience and skills in using information systems/technologies (Reimers et al 2004) and in working with massive data are some of the factors that have contributed to high IS/IT implementation failures in Asia (Lee et al 2003). Thus, there is growing evidence of the role of culture.

Although there has been a significant interest from researchers and practitioners in the role of BI systems in enhancing decision making capabilities (Hou and Papamichall 2010; Friedman and Hostmann 2004), studies on the impact of BI system usage on performance are rare (Hou 2012). Understanding of the relationship between BI system usage and organisational performance is important to assess the benefits of the BI system implementation. While much research explains the factors influencing the adoption of IT innovations, research related to the use of these innovations in a post-adoption environment is limited (Ahuja and

Thatcher 2005; Jasperson et al 2005). Calls for research on the use of IT innovations are made by several researchers recognising this need (Jasperson et al 2005; Barki et al 2007). The real value creation potential of IT innovations such as BI systems can only be realised when firms move into the post-adoption stage. Past research, however, has not addressed the contribution of BI usage and its interrelationship with organisational IT infrastructure capabilities, nor has it addressed the need for firms to become BI based. Richards et al (2011) argues that various components of enterprise performance systems enabled by BI systems are often studied in isolation with strategic execution discussed at strategic levels, decision support at the IT department level, and process efficiency at the operational level.

A firm's ability to use BI systems is also dependent upon the firm's prior experience in using other IT-enabled innovations. Termed as technological sophistication, this refers to the extent to which a firm uses its new IT-innovation in value-adding ways (Mishra and Agarwal 2010). For example, successful prior experience of working with other IT-enabled innovations such as enterprise resource planning (ERP) systems, will help firms to use the existing features better. This experience will enhance a firm's capabilities to exploit the opportunities created by the new IT-innovation. Thus, technological sophistication developed by successful adoption and use of IT-innovations in the past helps managers to manage the risk inherent in any new innovation effectively and successfully (Mishra and Agarwal 2010). In a BI systems context, this becomes even more significant as the BI systems require higher levels of technological sophistication in using a more complex and recent technologies such as data warehouses, data mining and multi-dimensional visualisation tools. Thus, capability to manage IT infrastructure is an influential factor that may impact BI system use and thereby performance.

Successful adoption and effective use of any IT innovation is expected to impact firm's performance. From the organisational capabilities perspective, use of BI systems along with IT infrastructure capabilities can be considered contributing factors to organisational performance. With financial performance of the firm dependent upon several factors both external and internal, the benefits of implementing an IT innovation can be generally seen in the performance of its internal business processes. Therefore, process level performance is a good leading indicator of firm level performance. As it is, BI systems are designed and implemented mainly to support better management of business processes and decision making.

In general, the extent of usage of an IT innovation is not only an indicator of the success of IT implementation, but also an indicator of how well it contributes to business performance. Although usage of an IT system by itself does not guarantee business performance, it is considered an important factor along with other enabling factors such as IT infrastructure capability (Mithas et al 2007; Marchand 2000; Barua and Mukhopadyay 2000). Consistent with a dynamic capabilities perspective (Sambamurthy et al 2003), this study aims to investigate the relationship between the use of BI systems and process level performance with IT infrastructure capability as the moderating variable. Specifically, this study aims to answer the following research questions.

1. What is the extent of use of BI systems (in organizations that have already deployed)?
2. How does the use of BI systems impact firm performance at process level?
3. How does organisational IT infrastructure capability influence the relationship between use of business intelligence systems and process level performance?

4. How do the industry type and firm size influence the relationship between BI system use and process level performance?

2.4 Research model and measurement of constructs

This study aims to investigate the relationship between BI system use, IT infrastructure capability and process level performance. Each of these variables and their measurement is explained below.

2.4.1 Research model

Based on the research questions identified above, the following research model is proposed for testing.

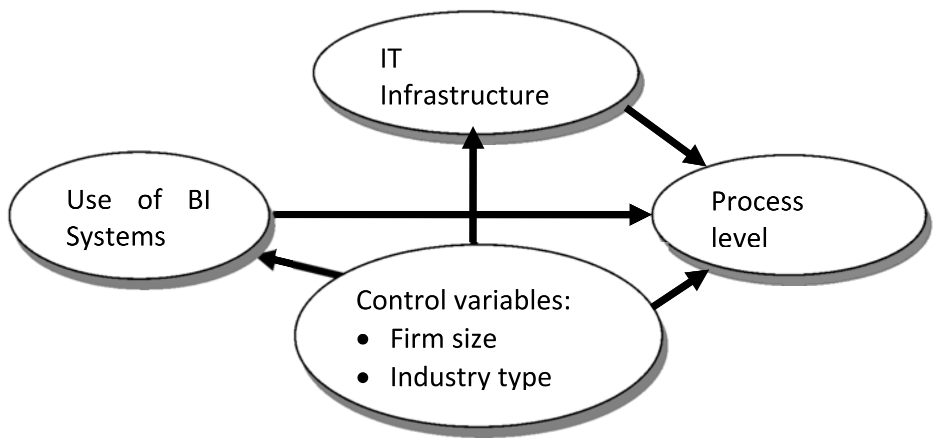

Figure 1: Research Model

From the above research model, the following two hypotheses are formulated.

H1: Organisation's BI usage will positively enhance organisational process level performance

H2: Organisation's IT infrastructure capability will moderate the impact of BI usage on organisational process level performance

In addition, the following other propositions that indicate the effect of control variables are also analysed in this study.

H3: Firm size and industry type will positively influence BI use, IT infrastructure capability and process level performance

- H3a: Firm size measured in terms of number of employees will positively influence BI use, IT infrastructure capability and process level performance
- H3b: Firm size measured in terms of gross revenue will positively influence BI use, IT infrastructure capability and process level performance
- H3c: Industry type will influence BI use, IT infrastructure capability and process level performance

2.4.2 BI use

BI systems use is a key independent variable in this study. The existing literature lacks systematic attention to the measurement of BI systems use (Thomas 2001; Cottrill 1998). The term 'assimilation' is defined as the extent to which the use of a technology is diffused across organizational processes and routinized (Cooper and Zmud 1990). According to Armstrong and Sambamurty (1999) IT assimilation refers to the extent to which IT has been infused into business activities and its use in value chain activities as well as in competitive strategies. In their study on the web-technologies assimilation, Chatterjee et al (2002) defined assimilation as the extent of the diffusion and effective use of the web technologies in the value chain activities. Thus previous literature on 'assimilation' included the concept of 'effective use'. Even though there was some anecdotal evidence with regard to the benefits of BI system use (Hesford and Antia, 2006), no prior empirically validated measures are available. Even though the conceptualization of IT use in the literature differs in scope and definition (Armstrong and Sambamurthy 1999;

DeLone and McLean 1992; Rai et al 2002), usage of IT/IS has a critical role in information systems research (Bokhari 2005; Schwarz and Chin 2007).

Despite the different aspects of BI use, a single item measure has been used in many studies (Armstrong and Sambamurthy 1999; DeLone and McLean 1992; Rai et al 2002). For example, assimilation is measured as the proportion of a firm's system development projects where the technology is used to support systems development work (Purvis et al 2001). Rai et al (2002), on the other hand, used a single-item variable to measure IS use in their study. Single item measures in fact are considered unambiguous for respondents (Wanous et al 1997) and a precise measurement is considered helpful to discover moderation effects (Carter and Russell 2003). Such single item measures are considered adequate when the item is explicit and clear-cut for respondents (Wanous et al 1997). In case of BI use also, it is possible to express BI use as a single item variable. Thus, a single item variable, though can reflect the extent of BI system use well, it is necessary to consider a broader view of BI use including its scope, extent of use and reach.

Other most commonly used measures include frequency of usage of the system, time of using, actual number of usages and diversity of usage, extent of use, duration of use, features used and tasks supported (Lee et al 2003; Burton-Jones and Straub 2006). System usage, is also measured by the number of various software applications and business tasks/processes for which information system is used (Igbaria and Tan 1997), by the frequency and duration of use of the system (Guimaraes and Igbaria 1997) and system dependence (Kulkarni et al 2007).

Considering the breadth and depth of the term BI use as explained earlier, it is measured with the help of four items/dimensions in this study – length of

BI system use, extent of the use of BI applications, extent of use of various BI tools and management of BI systems' use. These dimensions are explained below.

First, length of BI system use or time since adoption is used to control for the length of time organisations have deployed their BI system. Having a BI system in operation for a long time may help an organisation to develop expertise in using the system more effectively and may therefore generate better business benefits (Purvis et al 2001). In this study, respondents are asked to indicate the length of time their particular BI system is in operation in their firm. For this measure, the response is categorised into four time periods – less than 2 years, 2 to 5 years, 5 to 8 years and more than 8 years.

Extent of BI use is another dimension in this study. Given the nature of BI systems, it is not possible for managers to quantify the extent of usage accurately. Therefore, three levels of measurement – low, medium and high; are considered adequate considering the difficulty of providing an accurate and precise information that reflects the extent of use (de Vaus 2014). Given the nature and complexity of IT systems in general and BI systems in particular and consistent with prior research on the study of IT adoption and use (Hou 2012; Subramani 2004; Popovic et al 2012), these three categories are used to measure the extent of BI systems use.

The extent of use' of the BI system is measured with reference to two aspects – the business processes it supports and various technology components integral to a BI system. The scope of BI use is thus measured reflecting the range of applications a BI system support and the technology components it employs and uses in the process (Mishra and Agarwal 2010). Adopting this conceptualization, BI use is analysed and measured as it applies to various business functions/processes. Some of the BI applications considered in this study include financial reporting, supply chain management, performance management reporting, human resource management, procurement management, pricing, logistics, inventory management and others. Some of the BI tools considered include data warehouse, data visualization tools, analytics tools, reporting tools and dashboards. Further number of business users regularly accessing the BI system is also expected to reflect the extent of use. This measure is expected to give an indication of the magnitude of BI usage. Thus, the use of a BI system in a firm is measured both in terms of the applications to various business processes and the range of BI tools and technologies that are in operation, and, the extent of the intensity of their use.

Management or governance of BI use is another aspect measured in this study. In this context, management or governance of BI use involves managing access to the BI system, ensuring the quality and integrity of heterogeneous data sources, appropriate user training, reports and data maintenance and are considered important for ensuring effective use of BI systems (Howson 2006; Wixom et al 2011). In fact, different BI systems and tools have different capabilities and are designed to serve different purposes. Therefore, depending upon the purpose for which a BI system is to be deployed, organisations employ different BI applications with different access methods (Howson 2007). While some organisations deploy a BI system that provides unlimited access to its data analysis and reporting tools to all its users, others offer relatively restricted access depending upon the role and functionality (Havensetein 2006) and by matching tool capabilities with user types (Howson 2006). Some of the BI systems are designed and dedicated to specialised users that require specialized functionalities for more effective analysis (Inmon et al 2001). If users are not satisfied with the system, they might opt to seek other alternatives when available (Szajna and Scamell 1993) and in the case of BI systems these include legacy systems, excel based reports and ad-hoc reporting tools.

Further, readiness of business users and efficient access to information without getting lost in technical issues such as data reconciliations is important. Appropriate mechanisms to validate the data and 'parallel run' of new BI systems with the old report systems initially, will enable BI users to use the powerful features of BI systems (Waheed 2011) and exploit their potential. Examples of the items used to measure this construct include user access, training to users, ability of system to meet requirements, speed and efficiency of reporting, data maintenance and handling procedures, quality of data sources and use of excel.

Use of BI systems or use of any IT innovation is generally influenced by the availability of other alternative options to users. This is especially so when intelligence required for decision making may be produced either from BI systems or from other sources including manual systems and managerial judgement. It is therefore, believed that user resistance and other organisational factors such as availability of alternatives that come under the term 'management of use' may affect BI use. In order to measure the effect of this, respondents are asked to indicate whether user have access to old reports produced by the previous legacy systems including excel. All the items used to measure the management of the BI use construct are shown in the questionnaire (Appendix I). The next section discusses the process level performance construct.

2.4.3 Process level performance

IT innovations typically provide automated support to business processes and linkages between business processes (Subramani 2004). Therefore, understanding the impact of BI systems at process level, not only demonstrates value, but also explains how that value is provided (Barua and Mukhopadhyay 2000). In order to understand the activities and processes supported by the BI system and to measure IT use and IT performance impact, Porter's (1985) value chain activities framework is widely used (Zhu et al 2004, Tallon et al 2000). This framework classifies value chain activities into primary activities that include inbound logistics, operations, marketing, sales, service and outbound logistics, and support activities such as human resources, procurement, maintenance, and infrastructure management.

Performance improvement at both the primary and supporting activities in the value chain is the aim of BI systems (Grayson 2006; Wiliams and Williams 2003). Analysis of the impact of BI systems use would therefore consider the impact on multiple process level measures (Tallon et al 2000). Even though organisational performance aggregates BI-enabled performance across the organisation (Melville et al 2004), a significant relationship between business process performance and organisational performance has been noted in past research (Elbashir et al 2008). In fact, the non-service sector appears to be able to convert business process benefits more effectively into organisational performance improvements (Elbashir et al 2008). Therefore, impact of BI systems on organisational performance can be considered at internal and external levels, that is, improving the efficiency and effectiveness of business processes and outperforming competitors respectively (Lonnqvist and Pirttimaki 2006; Cavalcanti 2005). Thus, process level performance is a leading indicator of the organisational performance and measures that were developed and validated by Elbashir et al (2008) and IDC (2012) were used for the current study.

Items used for measuring the process performance relate to financial, business processes, customer and other external partners. Some of the items sourced from Elbashir et al (2008) include reduction of lost sales, increased geographic distribution of sales, increased return on investment (ROI), increased inventory turnover and improved competitive advantage, improved efficiencies of internal processes, staff productivity increase, reduction in cost of decision making, reduction in operational costs, reduction in employee cost per sales dollar, reduced cash to cash cycle time, and reduced order fulfil time. Similarly, the customer/external partners dimension of process performance has measures such as reduced time to market products/services, reduced marketing costs, reduced customer return handling costs, improved customer satisfaction ratings, improved customer retention rates, increase in new products, improved coordination with external partners and improved responsiveness to suppliers. Improved customer retention, efficiency in reporting and information sharing, identified opportunities for improvements, improved efficiency of utilising assets and improved process of responding to regulatory compliance are some of the measures sourced from IDC (2012). All the items used to measure this construct were validated and tested in previous studies.

2.4.4 IT infrastructure capability

The IT infrastructure capability in this study is defined as the ability of the IT unit to provide extensive firm-wide IT infrastructure services that support the organisation’s business processes (Fink and Neumann 2007). Items in the IT infrastructure capability constructs developed and validated by Fink and Neumann (2007) and Weil et al (2002) for measuring the IT infrastructure capability of a firm were used in this study. These constructs reflect the diversity and integration of IT components necessary to support BI systems and other business applications. All the items used to measure this construct were validated in previous studies. A summary of all the items used in this study and their sources for this construct are given in the questionnaire (Appendix I).

2.4.5 *Control variables – firm size and industry type*

Industry type (Chattarjee et al 2002; Dehning and Richardson 2002; Melville et al 2004) and firm size (Davila and Foster 2007) are two factors that can influence the use of any IT innovation. Therefore these two variables are modelled as control variables in this study to isolate the influence of BI systems use.

In the process of adoption, BI system needs to be configured to suite each individual organisation and its processes which are dependent upon the nature of industry in which this organisation works. Each BI software provider specialises and becomes popular in certain industry types with some having higher presence in certain industries than in others. For example, SAP BI systems are popular in manufacturing, chemical and mining industry types, while Hyperion is generally more popular in telecommunications, banking and other service industries. The fit between the BI system design and the business requirements may actually influence the extent and complexity of the configuration and customization required to deliver necessary intelligence support. A fully configured BI system therefore may provide differential benefits depending upon the industry type (Dehning and Richardson 2002; Melville et al 2004). Further, many studies on the technical and social boundaries of IT artefacts and IS theories are also influenced by the industry type (Chattarjee et al 2002). Therefore, industry type is used as a control variable.

In this study, 10 standard industry types classified by the Australian Bureau of Statistics are adopted and respondents are asked to self-select the industry type their firm belongs to. Examples include Building materials/construction, communication and IT services, iii) Finance/banking and insurance, manufacturing/mining and resources, retail/wholesale and distribution, transport and logistics services, utilities and others. Each firm is different and the type of industry in which the firm operates, is different in the nature and extent of adoption and assimilation of IT infrastructure components such as enterprise resource planning (ERP) systems, data warehouses, process management tools and performance management applications. Thus, IT infrastructure capabilities' including their information management capabilities (Fink and Neumann 2008) of the firms and their business units are expected to vary in sophistication in terms of their reach, range and scope (Mithas et al 2011).

BI systems are expected to help improve performance of firms of all sizes. In the IS literature, however, firm size has been used as a proxy for the sizes of organisational resource base which can enhance IT performance (Zhu et al 2004; Subramani 2004). Larger firms with larger organisational resource bases are more able to invest in different activities that support IT – for example on employee training, manpower and support services to users and others (Chatterjee et al 2002; Subramani 2004). Therefore, as proxy to firm size, number of employees and gross revenue of the firm are used in this study (Zhu et al 2004; Subramani 2004; Liang et al 2007). Instead of using the actual numbers, a range of these used in previous studies are employed in this study. For example, number of employees are classified into three groups – less than 200, 201 to 500 and more than 500 employees. Similarly, gross revenue per annum is another measure and three classifications are used i.e. less than $100 million, $101 to $500 million and more than $500 million. Thus, this study used industry type and firm size as key control variables and analysed their influence on the impact of BI use on process level performance.

2.5 Summary

Business intelligence (BI) systems involve a broad category of applications, technologies and processes used for capturing, analysing and presenting the information and intelligence to decision makers and support the decision making and performance management processes. Though adoption of BI system is common in enterprises of all sizes and types, extent and effectiveness of using those systems and their capability will influence the firm’s ability to improve performance. This chapter reviews the literature on BI systems and their impact on performance and analysed the role of IT infrastructure capability. Based on the review of literature, it identifies the gaps in research and proposes research questions and models. It then explains the theoretical model and operationalisation of the constructs. It then explains all the variables in the study – BI use, IT infrastructure capability, process level performance and control variables firm size and industry type. Next chapter explains the research methodology employed to find answers to the research questions identified in this chapter.

Chapter 3

Research Model, Methodology & Data Collection

Chapter 3: RESEARCH MODEL, METHODOLOGY & DATA COLLECTION

3.1 Introduction:

In this chapter, our research design is developed and explained. The literature review presented in the previous chapter identified research gaps, research questions and the research model. With the help of the information gained from preliminary interviews and discussions, and the literature review on research methodology, the methodology and research methods suitable for this investigation are designed. By providing a framework for the collection and analysis of data, this chapter gives a detailed description of research methods, data collection and analysis employed in this study. Firstly it justifies the choice of methodology and explains the design and administration of questionnaire and data collection. This chapter gives the details of the process of research design.

3.2 Selection of survey research methodology and justification

Selection of research methods is an important step in the research design. Although the classic selection choice is between quantitative and qualitative methods, research design can incorporate any one or both the techniques. Both qualitative and quantitative methods have their advantages and limitations, this study employed quantitative survey methodology.

Qualitative methods give importance to the context and organisational realities, provide deeper insights into the phenomenon, use multiple data sources that enhance validity and can deal with more complex 'how' and why' questions better than other approaches (Yin 2009; Klein and Myers 1999; Eisenhardt 1991). Thus qualitative studies provide researchers effective means of capturing complex phenomenon and help uncover ambiguities and conflicting results. These, qualitative methods, however, are frequently criticised in the literature because of its subjective bias, its inability to generalise findings, insufficient methodological rigour and their inferiority when compared with methods based on statistical samples of a large number of observations (Burns and Burns 2008; Yin 2009).

Quantitative methods on the other hand are argued to be strong in hypothesis testing and generalisations and are highly structured (Yin 2009; Burns and Burns 2008). Though it lacks flexibility, the questionnaire survey is the most commonly used method in business research (Bryman 2012). Survey research typically entails collection of data on a number of units with a view to collecting systematically a body of quantifiable data in respect of a number of variables, which were then examined to discern patterns of associations (Bryman and Bell 2011).

In a way, the decision to adopt either qualitative or quantitative research methodology is technical, as some methods are better suited to certain research questions than others (Yin 2009) and the access and availability of other resources in the available time determines to some extent the feasibility of particular forms of investigation. In this study, a field survey method was employed to test the hypotheses developed from the research model. In a survey method, data on a number of units at a single point in time is collected systematically with respect to a number of variables and then analysed for patterns of associations (Bryman 2012). Such cross-sectional field survey methods are considered suitable for answering 'what', 'who' and 'how much' type of research questions (Yin 2009). Moreover, it is considered an efficient way of collecting data and an appropriate technique to provide information on perceptions and beliefs (Bryman 2012). Further, the survey method is considered to be an efficient way of collecting large amounts of data at low cost in a short period of time, and is an appropriate technique to provide information on perceptions and beliefs (Burns and Burns 2008).

This study as explained in the literature review section (section 2.3) has 'what' and 'how' type of research questions and requires perceptions and beliefs of BI users to answer them. Further, the objective is to analyse the relationships between the three key constructs – BI use, IT infrastructure capability and process level performance, based on the data collected from BI users. In addition, the cost and time constraints of a masters by research thesis also limits researcher's ability to consider other methods. Thus, considering the contemporary nature of the research, nature of research questions, focus on the relationships and associations between various constructs in the model, appropriateness of the technique to collect perceptions and beliefs, and, the cost and time constraints, a cross-sectional questionnaire survey method is considered appropriate and used in this study.

Though not linear, the process of conducting survey research generally entails several steps. It includes, development of hypotheses, selection of research design, devising measures of concepts, selecting research respondents, survey administration and data analysis (Bryman and Bell 2011). Based on a thorough review of literature, research questions, research model and hypotheses are developed and explained in the literature review section (chapter 2). Considering the nature of research questions and its focus, a research design that involved a cross-sectional survey method is developed and explained in this section. Next section explains the development of measures for each of the constructs in the data collection instrument.

3.3. Development of measures in data collection instrument

Rigorous methods for constructing data collection instruments to measure social science variables have been developed by several psychologists and social scientists such as Likert (1967) and Nunnaly (1978). The process used in this study was based on generally accepted principles of survey design, and advocated by Burns and Burns (2008) and de Vaus (2013). In a survey research, the development of measures or indicators is an important step and involves development of questionnaire items to measure the constructs. In this study, there are three main constructs – BI use, IT infrastructure capability and process level performance. While process level performance is a dependent variable, all the others are independent variables. Using well-established measures developed in the previous research and using informants' from the group to be surveyed are two main approaches to developing measures (de Vaus 2013). As explained in the literature review section, questionnaire items from the works of Elbashir et al (2008), IDC (2012), Fink and Neumann (2007) and Chen et al (2011) are considered as the basis for the questionnaire design and the questionnaire is designed using the measures already developed and validated in past studies. A copy of the final questionnaire employed for data collection in this study is given in Appendix-I.

The process performance construct, a dependent variable, has 23 items, while IT infrastructure capability construct, an independent variable, has 10 items to measure in the final questionnaire. The BI use, an independent variable, is measured using four sub variables and include 'extent of the BI applications use', 'extent of the BI tools use', 'management of BI system use' and the 'length of the BI system use' in an organisation. In addition, several independent control variables and demographics variables are also included in the design. The following sections explain these variables.

3.3.1 Dependent and independent variables

BI use is a key independent variable in this study. Sections 2 and 3 in the questionnaire have questions that are designed to measure the use of BI system. In this study, BI system use is measured using four sub variables – extent of applications use, extent of tools use, management of use and length of use.

The extent of the use of BI applications and BI tools use were defined as ordinal variables and measured as low, medium and high with reference to various applications or tools and with intrinsic order (Burns and Burns 2008, de Vaus 2013). While doing so, all the applications a firm's BI system(s) could support were listed and include financial reporting, customer order management, supply chain management, treasury management, performance reporting, human resource management, procurement, operations management, sales operations and marketing, pricing, logistics, customer service, customer loyalty, maintenance/asset management and others.

Similarly, the nature and extent of use of various BI technology tools were also measured. Respondents are asked to select the BI tools deployed in their organisation and indicate the extent of their actual use in terms of low, medium or high. Types of BI tools identified in the questionnaire include data warehouse, dashboards, data mining, data visualization, analytics, reporting and others. In addition, respondents were asked to 'tick' if a particular application is relevant in their organisation. Participants would first indicate whether their BI system is supporting any of the applications and tools listed there and whether it is relevant to them or not. If it does, respondents then indicate their perception on the extent of use of each of the applications and tools in their organisations in terms of one of the three categories – low, medium or high. In addition, respondents were also asked about the nature and extent of 'excel' use in their organisation.

'Length of BI use' (or time since adoption) is another sub-variable defined to measure the BI use. This was defined as an ordinal variable with respondents given four categories to self-select from the number of years a BI system was in operation' in their firm and include – less than 2 years, 2 to 5 years, 5 to 8 years or more than 8 years. As it relates to the particular BI software solution, this question was in section 2 of the questionnaire.

Three constructs - management of BI use, IT infrastructure capability and process performance outcomes were measured using a number of items. The construct management of BI use had 12 items; IT infrastructure management capability – another independent variable had 10 items; and process performance outcomes – a dependent variable had 23 items. Respondents were asked to rate each of these items using a 'Likert' scale from 1 to 7, where 1 = 'Disagree strongly' to 7 = 'Agree strongly'. In addition an option 'Not Relevant or NR' was also given for each item. It is possible that some of the statements/items may not be relevant to a particular organisational context. For example, an organisation may have a BI system that is specifically deployed to support their customer related processes/management. In such instances, its impact on the improved efficiency of financial reporting or treasury/cash management, other key process performance outcomes, for example, may not be relevant. In those circumstances, a respondent had the option of ticking 'Not Relevant or NR' while rating the extent of use of those applications.

Items designed to measure the 'management of BI use' were in section 3 of the questionnaire. These items sought to collect perceptions of respondents about the way BI use is managed in their organisation. These items were designed for this study to collect the perceptions of the respondents about the user access to BI system, provision of training to users, ability of system to meet user requirements, speed and efficiency of reporting from BI system, existence of good data maintenance and handling procedures, quality of data sources made available to the BI system and the use of excel as an alternative to BI system. All the measurement items are developed from the literature. For example, measures are developed from the literature – with measures for user access from Havenstein (2006), Howson (2006), Inmon et al (2001) and Waheed (2011) and measures for training, reports and data maintenance from Howson (2006) and Wixom et al (2011). A list of these statements thus developed for the construct 'management of BI use' are shown in section 3 of the questionnaire (Appendix I). In addition, for each of the statement, respondents are given the option of ticking 'not relevant' or 'NR' if they believe a particular statement is not relevant to their organisational and BI system context.

Items designed to measure the information technology infrastructure capability (10 items) were in section 4 in the questionnaire. For IT infrastructure capability construct, questions dealt with the ability of their IT department/unit to respond to changes, provide access to new data sources, provide security and risk management services, data management services, application infrastructure services, IT management services and IT education and research services. In addition it included questions that seek participants' perceptions on their IT department's ability to ensure availability of quality data for all users, to deliver reliable hardware and software systems, and to ensure their data availability mechanisms, software and hardware are current. All the measures for this construct were adapted from Fink and Newmann (2007) and Weill et al (2002).

Section 5 had questions to measure the perceptions of process level performance outcomes in the questionnaire. All the measures were adapted from Elbashir et al (2008) and IDC (2012) and were explained in the literature review section. Respondents were asked to rate their perceptions about the process level performance outcomes they believe their BI system(s) had contributed to. Participants were asked also given an option of 'Not relevant or NR' to indicate if a particular outcome was not relevant for their BI system in their organisational context and/or they have no basis for answering that question. In addition, in the final section (section 6) space was provided for the comments/feedback on the survey and/or general comments on the study.

3.3.2 Control variables

Questions about the demographic details of the respondents and organisations were there in the first section of the questionnaire. It included control variables such as firm size, industry type and respondents' role. Firm size, an important control variable was measured using two questions - number of employees in the firm or strategic business unit, and gross annual revenue of the firm. Respondents were asked to tick the relevant category of the range of number of employees and gross revenue. The variable 'number of employees' had three categories – less than 200 employees, '200 to 500 employees' and 'more than 500 employees'. Similarly gross revenue was defined in three categories – less than $100 million, $100 to $500 million and more than $500 million.

Industry type is another control variable. Data about the industry sector to which the organisation/strategic business unit belongs was collected by asking the respondent to tick relevant category from amongst several categories. Some of them include building materials, construction, finance, banking, manufacturing, mining, utilities, retail, whole sale, transport, logistics services, communication, IT services, health, education and others.

Next three questions sought information about the respondent. It included the current role of the respondent in terms of which function he/she is working (i.e. accounting, marketing/sales, information technology, manufacturing or others), the level/position of the respondent measured in three categories - senior management, middle management and operational level; and years of BI experience the respondent had. The years of BI experience is defined as an ordinal variable with three categories – less than 5 years, 5 to 8 years and more than 8 years.

Second section had questions about the Business Intelligence (BI) software solution in operation in the organisation/strategic business unit. Respondents were asked to indicate the BI software solution(s) used by their organisation. Popular BI software solutions such as Oracle-Hyperion, IBM Cognos, SAP Business Objects, SAS BI, Microsoft Micro-Strategy and Others are offered as categories. As it is possible for some organisations to have more than one software solution, respondents were asked to tick more than one category if it is relevant to their organisational context. Next section explains the validity checks and pilot testing carried out before administering the survey questionnaire (Appendix I).

3.4 Validity checks and pilot testing

Before final administration of the survey, each question and the questionnaire as a whole must be evaluated rigorously (de Vaus 2013) and the instrument validation procedures suggested by Straub (1989) are employed in this study. Most of the items used in the questionnaire for each of the key constructs were already validated in previous studies. In addition, content validity of the questionnaire thus designed was first assessed qualitatively, a method typically used in other studies (Moore and Benbasat 1991, Tanirvedi 2006). Two academics teaching and researching business intelligence systems and IT management, one practitioner who had significant experience in IT/BI implementations and another functional manager who used BI systems for 8 years were asked to assess the validity of the questionnaire items. Further, they were asked to check all the items related to al the three constructs - BI use, IT infrastructure capability and process level performance in terms of their content validity, wording of the measurement items and consistency of the items with the underlying construct. Further, they were also asked to check the ease of interpretation of the survey questions and instructions, sequencing of the questions and general aspects of the survey.

The data collection instrument thus developed had 15 items on BI system use (one for extent of applications use, one for extent of tools use and 12 for management of use and one for length of use), 10 items on IT infrastructure capability and 23 items for measuring process performance construct, in addition to various control variables and demographic details. For pilot testing this questionnaire, it was then sent to 6 senior managers that included two business managers, one chief information Officer, one financial controller and one BI Analyst and one BI implementation consultant. They were first asked to fill-in the questionnaire and give responses. In addition, they were invited to provide feedback on the content and structure of the survey, consistency of the items used to measure a particular underlying construct, and wording of the questions. The questionnaire is thus improved by not only incorporating their comments about the questions, but also their answers to the questionnaire items. Based on their feedback and comments, a final questionnaire was developed and involved revision of some questions, shortening of some others, rewording of a few and reordering of others. In addition, the questionnaire items were further evaluated for their intended meaning, flow, redundancy, scalability, timing and readability (de Vaus 2013).

The final version has 6 questions about organisation/respondent, 3 questions about the BI system implemented in their organisation, one question with a list of applications their BI system(s) could support, one question with a list of BI technology components/tools deployed and being used in their organisation/strategic business unit. In addition, 12 items to measure the management of BI system use and reasons for its non-usage, 10 items to measure the IT infrastructure capability, and 23 items to measure the process level performance outcomes, were finally incorporated in the questionnaire.

3.5 Sample selection:

As the study investigated the usage of BI systems and their impact on performance, data collection was focused on those organisations that have implemented BI system for a number of years and continue to use them. In this study a purposive sampling strategy was employed. By focusing on organisations that use technology/systems under investigation, this purposive sampling allows capturing of the appropriate study setting (de Vaus 2013). The objective of purposive sampling is to sample organisations/respondents in a strategic way, so that those sampled are relevant to the research questions being posed (Bryman & Bell 2011). Data collection was restricted to business organisations or strategic business units of multi-national corporations that had implemented a BI system.

Considering the expected response rate, and the minimum sample size required to carry out valid statistical analysis, and the limitations on cost and time, it was decided to contact various software vendors, business organisations and individual BI professionals. Business managers using the BI system for their day-to-day functioning and performance management purposes and/or BI professionals who were involved in the implementation and/or use of the BI system and/or providing support to other managers in their use were chosen as respondents for this study. In order to reach potential respondents, popular BI software solutions vendors and BI implementation consulting firms were contacted and a list of respondents was obtained. Customers of major Business Intelligence (BI) software vendors such as IBM Cognos, SAP Business Objects, Oracle Hyperion and SAS were the organisations contacted. In each of the organisation, wherever possible, multiple respondents were contacted to complete the questionnaire. In addition, the database of the School of Information Technologies, individual contacts of the researcher and other sources were used to reach as many potential respondents and organisations as possible. In addition, link to the online survey questionnaire was also made available in the LinkedIn with a request to various professional groups to participate in the study. The respondents include CIOs, BI managers, BI users/analysts, BI implementation consultants and functional managers. By selecting IT managers, BI analysts and business managers, a multiple-respondent strategy was employed in this study. This approach not only addresses the common methods bias, but also provides insights from different perspectives and enhances accuracy of data collected (Sethi and King 1994). Thus the sample was designed to be representative nationally and large enough to provide good estimates of the perceptions. The sample, however, is not random and as explained above purposive sampling is employed in order to select the respondents who are BI users and have some experience of working with a BI system.

Business intelligence is a broad term and covers a range of activities and tools. Since it is not possible to cover all types of BI systems and tools, respondents were asked to do self-select their ability to answer the questions in the study. In order to identify and measure the extent of their knowledge on the specific BI system and/or BI tool various questions about the BI system/tool/applications were included in the questionnaire. For example, respondents were asked to indicate the BI software solution they were working with (for example, SAP Business Objects, SAP BI, Oracle Hyperion, SAS etc.) and BI tools they were using (for example data warehouse, data visualization tools, data analytics tools etc.); and applications their BI systems were supporting (for example supply chain management, customer relationship management, accounting, inventory management, human resources, analytics etc.). The criteria employed for participation in this study was to have some experience in working with a BI system software solution. This experience could be either in business functions and/or in maintenance, implementation and consulting roles. Therefore, even though the respondents are not randomly chosen, given the criteria employed and the sampling method used, it is believed that the sample is representative of the population of BI users in Australia (Burns and Burns 2008).

3.6 Survey administration

A paper based survey and a web-based survey were developed and used to collect data. As a first step, the researchers applied for ethics clearance from the University Human Research Ethics Committee (HREC). As required, a copy of the questionnaire, invitation to participants, participant information statement, invitation letter to software vendors and information about the project were submitted to the HREC for approval. After obtaining the necessary approvals, hard copies of the survey questionnaires and other documents were prepared for administering the survey. In addition, the questionnaire was setup in the surveymonkey.com and the questionnaire and participant information statement were made available for potential participants.

The approach taken in the administration of questionnaires affects the quality of sample surveyed, the layout of the questionnaire and the response rate. The literature suggests that it is possible to increase the response rate by several strategies, such as enclosing a covering letter, return envelopes and/or postage-paid envelopes, and anonymity and the length of the questionnaire (de Vaus 2013, Dill man et al 2008). In order to maximise the response within budgetary constraints, the Total Design Method suggested by Dillman et al (2008) was used. In this approach, explicit attention was given to those points of the survey process at which response may break down. For example, Dillman identified some of the factors that would reduce the response rate: wrong address, low-rate postage, appearance of the questionnaire being similar to that of junk mail, lack of proper instructions for completion, and no convincing explanation why anyone should complete the survey (Dillman et al 2008).

Thus, guided by the survey administration procedures suggested by Dillman et al (2008) and de Vaus (2013), a survey package that includes a cover letter, participant information statement and a questionnaire was prepared and e-mailed to all the potential respondents and representatives of software vendors agreed to participate in the study. In addition, a self-addressed envelope was also sent along with other documents when there is a request for a hard copy of the survey package. In the cover letter, an URL link to the questionnaire on survey-monkey website was provided giving the potential respondent an opportunity to respond either by post or through online. Thus, online and physical survey methods were combined to improve data collection efficiency (DIllman et al 2008). Further, in order to reach a broader section of respondents, an invitation to the BI professionals and managers along with an URL link to the web-based version of the survey was given in the LinkedIn profile of the research team.

On the landing page in the web (survey monkey site) participant information sheet was provided to ensure reading of this information before responding to the questions in the survey. At the beginning of the questionnaire a small introduction was given explaining the objective of this survey and the way data would be used in aggregate terms and that it was anonymous and that it would take about 15 minutes. In addition, participants were told upfront about the voluntary nature of the survey and that an online version of the survey questionnaire was available along with details of its location in the web, i.e. http://www.surveymonkey.com/s/jayaseethamraju.

Following Dillman's 'tailored design method' principles, measures were taken to improve the response rate (Dillman 2000). A first reminder and another set of questionnaire package were sent after three weeks to those who did not respond to the survey. A second reminder was sent through email and posted in the LinkedIn profile after 4 weeks. Approximately 200 firms and 430 potential respondents were contacted through various means – direct email, through software vendors, LinkedIn groups and by post. A sample size of about 100 responses was considered sufficient with 10% margin of error and 95% confidence level (CRS 2014) for the analysis of the data explained in the next chapter.

3.7 Summary

In this chapter research design was explained and justified. It first justified the survey method employed in this study considering the nature of research questions and then explained the development of data collection instrument. It detailed the survey administration process including the criteria used in the selection of respondents and considerations of sample size and power. It explained the process of developing various items that measure the key constructs in the study – BI applications use, BI tools use, management of BI use, length of BI use, IT infrastructure capability and process performance outcomes. Further it explained and justified the statistical methods and procedures employed for analysing the reliability and validity of the data collection instrument, preliminary analysis of the data using frequency distributions, multiple regression analysis including the way its assumptions were addressed and the t-tests for analysing the effect of control variables on the research model. Next chapter discusses analysis of data and findings.

Chapter 4

Analysis and Results

CHAPTER 4: ANALYSIS AND RESULTS

4.1 Introduction and overview

This chapter presents the details of data collection and analysis of the survey research data. The first section explains the data coding, adequacy of sample size and demographics of the respondents and highlights the findings of the survey on various aspects concerning all the three major constructs and several control variables. It presents an analysis of the type and extent of use of various BI systems in Australia and answers the first research question. It then presents an analysis of the reliability and validity of each of the four constructs in the survey instrument and adequacy of sample size. Multiple regression analysis and the results are explained in the next section in order to answer the second and third research questions, that is, the relationship between BI use, IT infrastructure capability and process level performance. A comparative analysis of the differences between various critical subgroups or control variables such as firm size, industry type and respondents' role on the relationship between BI systems' use and process level performance and the results of statistical significance using t-tests are presented in the next section. This answers the fourth research question, that is, the effect of all the three control variables. Finally, a summary of the findings of this research study is presented.

4.2 Data coding and data entry

Responses received by post, by email and from the survey monkey site were consolidated. All the identifying information if any in the questionnaires was removed and made anonymous. Depending upon the way question is asked, the way it is coded and its purpose, the level of measurement required for various variables being used in the study was determined and set up in SPSS. Variables such as industry type, respondent's current level, respondent's current role and BI software solution used in an organisation are defined as nominal variables. Variables such as number of employees in a firm, gross annual revenue of the firm, BI experience of respondent and length of use of BI system are defined as ordinal variables with 3 or 4 categories.

Each of these categories were coded in SPSS with values of 1, 2, 3 and 4. For the each of the items in the constructs 'extent of applications use' and 'extent of tools use', respondents were asked to rate their use as 'low, medium or high'. These were also defined as ordinal variables and initially were coded with values 1, 2 and 3 respectively in the SPSS. Missing values in the data could be the result of a number of causes and therefore need to be dealt with carefully. Cases that have responded for less than 10% of the items were completely removed from analysis as they are not considered to be serious (Burns & Burns 2008, de Vaus 2013). In the analysis, missing data is handled by omitting the missing values.

4.3 Sample size and respondents:

4.3.1 Respondents

As explained in the methodology section, the survey instrument was made available in the web as well as in paper form. From a total sample of 430 potential respondents from 200 organizations, 136 responses were received. Out of this, 78 of the respondents filled-in the questionnaire online in the web and 62 have done the survey in printed form. Responses that have less than 30% of the items filled-in were removed from the analysis. As a rule of thumb, it is sufficient to remove cases that have responded for less than 10% of the items (Burns and Burns 2008). This left 73 online responses and 55 manual responses – totalling to 128 responses for this study.

4.3.2 Comments/feedback

In the last section of the questionnaire (section V) respondents were asked to give any comments and/or feedback on the survey. Out of 128 valid responses, 12 of them have given their email addresses with a request for a copy of the study findings after the study is completed. Email addresses were removed from the questionnaire in the data entry fees and separately recorded for sending a copy of the findings later on.

4.3.3 Effect of sample size

Before conducting data analysis, it is necessary to examine the effect of sample size and statistical power on the data collected. Statistical power is the probability that the test will correctly reject a false null hypothesis. A value of

0.80 or 80% (that is minimising Type I errors) is considered good in social sciences (Burns and Burns 2008). Sample size needed to detect various effects at p=0.05 (two-tailed) are dependent upon the power desired and the effect size. According to Cohen (1988) to achieve 0.80 power with 0.30 effect size, a sample size of 85 would be sufficient. Given that there were 128 valid responses received, this sample size was considered adequate for further analysis.

4.3.4 Adequacy of sample size

Further, a ratio of 5:1 is considered an acceptable ratio for the number of observations per variable in the scale (Hair et al 2011). There are three key variables in this study that are measured using a 'Likert scale'. They are process level performance, IT infrastructure capability and management of BI use. As shown in Appendix I, there are 23 items in process performance scale, 10 items in IT infrastructure capability scale, and 12 in management of BI use scale. There were 128 valid responses/cases and when compared with the number of items in each of those scales the following ratios are obtained (table 1). For each of the construct scale, the ratio is more than 5:1, an acceptable ratio (Hair et al 2011). Therefore, the sample size can be considered adequate for analysis.

Table 1: Ratio of sample size and no. of items in each construct scale

Construct (sample N=128)	No of items	Ratio (N/items)
Management of BI use	12	10.6:1
IT Infrastructure capability	10	12.8:1
Process performance	23	5.6:1

4.3.5 Non-response bias

Non-response bias is an important issue that may affect the results. Therefore, to check the validity of the responses and to find out how representative the sample was, in May 2014, the researcher sought direct and indirect opinions from some respondents and a few non-respondents. From the list of respondents, 8 people selected at random were contacted. Of those 8, three of them had not responded to the questionnaire, and indicated lack of time as being the main reason. As the sample had been made on a convenience basis and was fairly large, ensuring a good response, the effect of non-response was to some extent minimised.

The response rate in this survey is 30% and there could be some differences between non-respondents and respondents in their perceptions of BI use and process level performance. Therefore, this risk of non-response bias was assessed by comparing early respondents with late respondents. For this analysis, respondents who had responded within the first four weeks (one month) were termed as early respondents, those who have responded after 3 months were termed as late respondents. Using two-tailed t-tests for independent samples at 5% significance level, differences between those two groups (early and late respondents) were analysed for significance for each of the construct. Using Levene's test for equality of variances, appropriate t-values and significance levels were identified and presented below.

Table 2: Non Response Bias (early vs late respondents) – t-test results

Variable (Post-test)	Group – Early and late respondents	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Early respondents (within 1 month)	65	81.46	33.77	-0.637	0.525
	Late respondents (after 3 months)	45	86.00	40.66		
IT infra-structure capability	Early respondents (within 1 month)	65	40.69	14.48	-0.161	0.872
	Late respondents (after 3 months)	45	41.16	15.24		
Manage-ment of BI use	Early respondents (within 1 month)	65	42.34	14.10	-0.381	0.704
	Late respondents (after 3 months)	45	43.38	13.97		
Extent of BI Tools Use	Early respondents (within 1 month)	65	22.38	11.03	1.243	0.217
	Late respondents (after 3 months)	45	19.64	11.85		
Extent of BI Applns. Use	Early respondents (within 1 month)	65	17.45	9.66	-0.631	0.530
	Late respondents (after 3 months)	45	18.71	11.26		

**Significant at 5% level (2-tailed) and * Significant at 1% level (2-tailed)

As shown in the table above, there were no significant differences between early respondents and late respondents in their perceptions on all the five constructs in the study. The results of statistical analysis generally suggest there is no non-response bias risk in the findings and the sample was considered to be representative of the general opinion of the managers using a BI system.

4.4 Demographics:

4.4.1 Firm size

Firm size is measured using two ordinal variables – number of employees in the organization and/or strategic business unit the respondent represents, and the gross annual revenue of the firm. As shown in table 3, about 49% of the respondents are from large firms with more than 500 employees and the remaining are medium sized firms.

Table 3: Number of employees – firm size

Organizational size – Number of employees	Number	Percent
Less than 200 employees	47	37%
201 to 500 employees	18	14%
More than 500 employees	63	49%
Total	128	100%

In terms of gross annual revenue, as shown in the table 4, about 45% of the firms are large firms with more than $500 million annual revenue and about 36% of the firms reported less than $100 million revenue are medium-sized enterprises. This indicates the wide-spread use of BI systems in all types of firms and the data collected represents the true nature of Australian business environment.

Table 4: Gross annual revenue – firm size

Organizational size – Gross annual revenue	Number	Percent
Less than $100 million	47	36%
$101 to $ 500 million	24	19%
More than $500 million	57	45%
Total	128	100%

4.4.2 Industry type

Using Australian Bureau of Statistics categories, data about the industry type was collected and a summary of the responding organizations details are presented below.

Table 5a: Industry types statistics – 9 categories

Industry Sector/type	Number	Percent
Building materials & construction	6	5%
Communication & IT services	30	23.5
Education	4	3%
Finance, banking & Insurance	21	16.5%
Health & community services	4	3%
Manufacturing, Mining & resources	27	21.5%
Retail, wholesale & distribution	15	12%
Transport & Logistics services	8	6.5%
Utilities, Govt corporations	11	9%
Total	128	100%

As shown in table 5a, respondents are from a cross-section of various industry types, with a significant proportion (i.e. around 75%) are from four key sectors in Australia, viz. communication & IT services, finance and banking, manufacturing and resources, and retail/wholesale & distribution sectors. Considering the low frequencies of certain industry types, these categories are combined into two industry types – Manufacturing (including mining, building materials, retail/distribution & logistics) and Services (includes IT services, communications, finance/banking, health, utilities, government & education) for further analysis and presented in table 5b.

Table 5b: Industry type – two categories

Industry Sector/type (two categories)	Number	Percent
Manufacturing (Mining, Construction, Retail, Logistics & Agriculture)	56	67%
Services (Utilities, Govt, Health, Education, Media consulting & Media)	72	33%
Total	128	100%

4.4.3 *Respondents – role, position & experience*

A summary of the respondents' background in terms of the nature of their role, their position within the organizational hierarchy and years of experience in BI systems is presented in the following tables (6, 7 and 8 respectively).

Table 6: Nature of role of respondents

Current Role in the organization/SBU	Number	Percent
Business functions (Accounting, Manufacturing, Sales & other functions)	49	38%
Information Technology	79	62%
Total	128	100%

Table 7: Level/position of respondents in hierarchy

Level/position of respondents	Number	Percent
Senior mgt (Director/CIO/CFO/COO etc.)	33	26%
Middle management	71	55%
Operational level	24	19%
Total	128	100%

Table 8: Respondents' BI experience

Experience in BI – Number of years	Number	Percent
Less than 5 years	41	32%
5 to 8 years	44	34.5%
More than 8 years	43	33.5%
Total	128	100%

As shown in table 6, about 62% of the respondents work in the Information Technology related roles about 38% work in business functions. BI system is typically used for decision making and performance management purposes and is accessed by business managers. But, BI analysts typically provide such support to functional managers and senior management because of their skills in using the BI software. In the study, these BI analysts have categorised themselves under 'Information technology' and in fact, mentioned this in the comments section. Thus, the respondents whether they are from business functions or from information technology are working with the BI system for decision making and performance management purposes. Further as shown in table 7, about 81% of the respondents reported working in senior and/or middle management levels (shown in table 7) and just 19% working in operational roles relating to BI systems. Therefore, the respondents' views can be considered valid and representative in this study. As shown in table 8, the average experience of respondent in BI use is around 6.5 years, with around 68% reporting an experience of more than 5 years. Therefore, considering the hierarchical level, current roles and years of experience in using BI system, and the issues investigated in this study, it is fair to assume that the perceptions reported by the respondents are valid and representative of the population.

4.4.4 BI software:

As shown in the table 9 below, a range of BI software solutions are used in business organizations today, with 80% of the firms using a software solution from major software vendors - SAP, IBM, Microsoft and SAS. SAP is the most popular solution with about 70% of the firms are using a SAP BI system.

Table 9: BI Software used by organizations

No.	BI system software used	Number	Percent
1	Oracle – Hyperion	19	15%
2	IBM Cognos	27	21%
3	SAP Business objects/SAP BI	91	71%
4	SAS – BI	18	14%
5	Microsoft Micro-Strategy	14	11%
6	Other BI Software vendors	24	19%
	Total occurrences (>1 software in a firm/SBU)	193	100%
	Avg. number of BI solutions used/firm (193/128)	1.51	

Table 10: Number of BI software solutions in a firm

Firms using BI software solutions	Number	Percent
Just ONE BI software	70	55%
TWO BI software solutions	51	40%
More than TWO BI software solutions	7	5%
Total	128	100%

It appears firms are using more than one BI software solution. As shown in table 10, about 40% of the firms are using two BI software solutions. Business firms appear to be using each BI software solution for a specific application and/or purpose and are prepared to deploy and maintain more than one solution in their organizations.

4.5 Preliminary analysis

The approach to data analysis in research must be problem-oriented rather than tool-driven (Burns and Burns 2008). Therefore, an exploratory data analysis was necessary to determine the appropriate choice of method and statistical tool. Using SPSS software, data was carefully examined for mistakes, data entry errors and corrected. This was carried out in order to make sure they were as intended to be and to check all the codes were valid, and that recoding and the creation of new variables was done in the intended way. In addition, the distribution of values for various variables can be examined with the help of descriptive statistics and tests for normality and homogeneity of variance can be carried out. This analysis was necessary to evaluate the appropriateness of the statistical techniques for hypothesis testing.

Data for all the variables was analysed with the help of histograms and frequency distributions to see the variability of data and the central tendency. The descriptive statistics chosen for univariate analysis depend upon the level of measurement (de Vaus 2013). For example, mode is an appropriate measure of central tendency for nominal variables such as industry type and current role, while mean was suggested as being useful for ordinal variables. Similarly, the standard variation and range were suggested as appropriate measures of dispersion for ordinal variables and interval variables. Accordingly, data was explored and the mean, mode, standard deviation, Skewness and Kurtosis were computed and histograms drawn for each of the variables in the data using SPSS software. Further, percentage of respondents that have reported low, medium and high use of particular application or tool and percentage of respondents that have reported more than 4 in each of the statements/items in the construct 'management of use' and other constructs were calculated. These details are presented in subsequent sections.

The next step in the exploratory analysis was the test for normality of the data and the homogeneity of the variance, as this was necessary to determine the appropriateness of certain statistical techniques in analysis. Since normal distribution is important for statistical inference, the assumption that the data comes from a normal distribution must be tested. It is, however impossible to find data that are exactly normally distributed (Norusis 1993), therefore data that can be approximated to the normal distribution was considered adequate for further analysis. To evaluate the assumption that all groups come from populations of equal variances, several tests are available, most of them heavily dependent on the assumption of normality. However, the Levene test of homogeneity of variance, which is less dependent upon the assumption of normality than most others, was used in this study.

4.6 Reliability analysis and statistics for the measures

4.6.1 Reliability, uni-dimensionality and validity of measures

All the three constructs in this study are measured using several items – management of BI Use with 12, IT infrastructure capability with 10 and process performance with 23 items. In order to determine whether these items belong to the scale and measure the intended constructs or not, it was necessary to analyse reliability and uni-dimensionality. Items that belong together in a scale are expected to belong together conceptually and have a modest correlations with each other item in the scale (de Vaus 2013). Cronbach alpha was used to measure the internal reliability of scales used for measuring these constructs. In addition, for each of the constructs, item-to-scale coefficients were also calculated in order to analyse the uni-dimensionality of the construct. If the item–to-total correlations are less than 0.3 or negative, that item was removed and Cronbach alpha was recalculated (de Vaus 2013, Burns and Burns 2011). A scale can be considered reliable if the 'Cronbach alpha' value is more than 0.7 (de Vaus 2013, Bryman & Bell 2011). Therefore, 'Cronbach alpha' and 'alpha if an item is dropped' were calculated for each of the constructs. Final instrument with reduced variables for each of the constructs were used for further analysis. Using these final items in each of the construct, summative scores were computed for further multivariate analysis.

While carrying out reliability analysis, some of the negatively worded statements are reverse coded and included in the analysis. These reverse phrased items are useful to stop response bias as respondents actually have to read the question and think about their opinion before ticking a particular box. The scale as shown in table below (table 11), produced an alpha of 0.775, 0.936 and 0.949 for ‘management of BI use,’ ‘IT infrastructure capability’ and ‘process performance’ constructs respectively. These alpha values are highly acceptable (Burns and Burns 2008) and demonstrates reliability of the scale. The ratio in the last column represents the number of observations per variable in the scale. As a rule of thumb, 5:1 is the acceptable ratio (Hair et al 2010, Burns & Burns 2008). As shown, all the constructs have higher ratio than 5:1 and therefore demonstrate sampling adequacy.

Table 11: Reliability analysis results (Scale – Alpha)

Construct	Mean	Variance	Stand. deviation	No of items	Cronbach alpha	Ratio
Management of BI use	40.65	192.50	13.87	12	0.775	10.6:1
IT Infrastructure capability	40.74	279.29	16.71	10	0.936	12.8:1
Process performance	79.02	1398.99	37.40	23	0.949	5.5:1

Further examination of the item-total correlations of the variables in each of the construct also revealed that the values exceed 0.50 for most of the variables and all the inter-item correlations exceed 0.30 and confirm the reliability of the scale and internal validity of the constructs (Burns and Burns 2008). Tables 12, 13 and 14 present the item statistics and item-total statistics for all the three constructs from the reliability analysis.

Table 12: Management of BI systems use – reliability analysis statistics

	Item/variable description: Perceptions on the management of BI use	Mean	Std deviation	Corrected item-total correlation	Cronbach alpha if deleted
1	Unlimited access to all users	3.06	1.82	0.375	0.775
2	Offer limited access (reverse coded)	3.86	2.29	0.329	0.777
3	Dedicated to specific power users (reverse coded)	3.17	2.22	0.363	0.763
4	Matches tool capabilities with user types	3.65	2.18	0.334	0.765
5	Does not met user expectations well (reverse coded)	3.63	2.65	0.365	0.765
6	Allows to build own self-serve reports	4.12	2.04	0.347	0.764
7	Allowed to continue to use excel (reverse coded)	3.09	1.92	0.416	0.757
8	Takes long time to run reports (reverse coded)	4.59	2.09	0.553	0.742
9	Does not facilitate changes to business requirements changes (reverse coded)	3.23	2.19	0.544	0.742
10	Training is inadequate (reverse coded)	3.96	2.10	0.589	0.738
11	Data sources reliable & integrated well	4.56	2.24	0.443	0.754
12	Good handling & maintenance procedures	4.36	2.09	0.604	0.737

Table 13: Process performance – reliability analysis statistics

No	Item/variable description: BI system contributed to the following performance outcomes	Mean	Std. devi-ation	Correct. item-total corre-lation	Cronbach alpha if item deleted
1	Reduced customer return handling costs	1.93	2.41	0.68	0.93
2	Reduced marketing costs	2.73	5.09	0.34	0.950
3	Reduced time to market products/services	1.93	2.33	0.66	0.935
4	Improved delivery of products/services to customers	3.71	2.19	0.60	0.936
5	Creation of new products/services and/or improved tailoring of offers	2.71	2.55	0.63	0.936
6	Improved customer retention and/or new customer acquisition	3.55	2.26	0.56	0.937
7	Improved product/service/process innovation	3.32	2.25	0.73	0.934
8	Improved coordination with & responsiveness to suppliers	3.45	2.34	0.71	0.935
9	Reduced cost transactions with suppliers	2.12	2.43	0.70	0.935
10	Increased inventory turnover or reduced inventory levels	2.91	2.42	0.64	0.936
11	Improved efficiency of internal processes	4.36	1.76	0.66	0.936
12	Increased staff productivity	4.53	2.51	0.59	0.935
13	Improved the process of decision making	4.71	1.96	0.73	0.935
14	Reduced process costs	3.20	2.26	0.77	0.935
15	Increased business process agility	3.55	2.19	0.68	0.935
16	Improved manufacturing or operations processes	2.80	2.75	0.66	0.935
17	Improved identification of opportunities for process improvements	3.54	2.30	0.69	0.935

18	Improved competencies of managers	3.66	2.41	0.67	0.935
19	Improved efficiency in internal performance reporting	4.74	2.02	0.69	0.935
20	Improved efficiency in information sharing	4.72	1.79	0.67	0.936
21	Improved efficiency of financial reporting and analysis	4.48	2.33	0.60	0.936
22	Improved process of responding to regulatory compliance requirements	3.15	2.50	0.63	.936
23	Increased efficiency of utilising assets	3.21	2.47	0.66	.935

Table 14: IT Infrastructure capability – reliability analysis statistics

No	Item/variable description: How your IT unit	Mean	Std. deviation	Corrected item-total corre-lation	Cronbach alpha if item deleted
1	Respond to change requests from functional lines of business	3.82	2.01	643	.935
2	Provide quick access to new data sources and/or integrated existing and new data sources	3.65	2.02	.634	.935
3	Provides wide range of security & risk management services	4.49	2.13	.631	.936
4	Provides a wide range of data management services	4.11	2.20	.884	.923
5	Provides a wide range of application infrastructure services	4.25	2.17	.751	.930
6	Provides wide range of IT management services	4.19	2.10	.810	.927
7	Provides a wide range of IT education and research services	3.50	2.00	.815	.927
8	Provides / ensures the availability of high quality timely data and information of all our key users	4.09	2.09	.842	.925

9	Provides/ensures that hardware systems and software are reliable and user friendly so that access is facilitated and encouraged	4.52	2.07	.669	.934
10	Provides/ensures that data availability mechanisms, software and hardware are current with changing business needs and directions	4.13	2.14	.773	.929

4.6.2 Summative scores

According to Hair et al (2010), summated scales have the ability to portray complex concepts in a single measure while reducing measurement errors. Summative scores of the reliable and valid scales are considered suitable for multivariate analysis (Hair et al 2010). Therefore, after refining the scales for each of the three constructs as explained above, summative scores were calculated. In each of the construct some statements/items were positively worded while a few were negatively worded. This was done to make the respondents really read and understand the items before they respond. In the analysis, these negatively worded statements were reverse coded and scored. These reverse phrased items were useful to stop response bias as respondents actually have to read the question and think about their opinion (Bryman 2012). For example, in the construct 'management of BI use', statements such as '*BI system does not meet user requirements, it takes long time to run reports using BI system, training is inadequate, BI system offer limited access to users, BI system dedicated to specific power users and BI system does not easily facilitate changes'*, are negatively worded. These statements were therefore reverse coded in order to calculate summative scores and average scores for the 'management of BI use' construct. In order to obtain a total summative score that is interpretable, recoding of all the items in a construct in a consistent direction is necessary.

Thus, summative scores for management of BI use construct and other constructs such as ‘IT infrastructure capability’ and ‘process performance outcomes,’ were computed. These are valuable in any multivariate analysis. Its reliability score as measured by Cronbach’s alpha should exceed 0.70 for the summated scale to be used for further analysis. As shown in table 10, Cronbach alpha for all the three constructs is more than 0.70 (i.e. 0.735 for Management of BI use, 0.936 for IT infrastructure capability and 0.949 for process performance construct) and therefore an average summated scale can be computed and used in the proposed multiple regression analysis. It is therefore fair to assume that the scale employed in this study to measure the constructs – management of BI use, IT infrastructure capability and process performance are good and have internal reliability and construct validity and average summated scores for each of the constructs can be used for further analysis.

4.7 BI systems use

4.7.1 Variables and measurement

BI use is a key independent construct in this study. This is measured using four important variables – length of BI system use, the extent of use of various BI applications, extent of use of various BI tools and management of BI systems’ use in organizations. The variables ‘extent of BI applications use’ and ‘extent of BI tools use’ had several items referring to a particular application or tool. For each of the item, respondents were asked to rate the extent of its use in a scale of low, medium and high. For the purpose of computing the summative scores for the

‘BI applications use’ and ‘BI tools use’ constructs, weightages of 1, 4 and 8 were assigned for low, medium and high ratings respectively. This was necessary in order to accentuate the intensity of use of BI system when it was categorised as ‘high’. Given that the BI use is a key independent variable in the study, it was necessary to capture the full intensity of BI system use with these weightages.

For the variable ‘extent of BI applications use’, there were 16 applications mentioned in the questionnaire. When some of these applications were rated ‘not relevant’ by a majority of the respondents, they were conceptually combined into six categories for further analysis. Those six categories were – Financial accounting/reporting, Internal performance reporting, customer related processes, logistics processes, procurement and others (that include HR, operations, treasury, maintenance and sustainability). Using these six categories and the weightages of 1, 4 and 8 for low, medium and high’ usage, a ‘total applications use score’ and ‘average applications use score’ were computed. For the variable ‘extent of BI tools use’, however, all the 6 variables were used for computing the summative score. Using the weightages of 1, 4 and 8 for low, medium and high usage, total ‘tools use score’ and ‘average tool use score’ were calculated. Results of the data for each of the BI use variable along with their statistics and summative scale scores are presented in the following sections.

4.7.2 Length of BI system use

A summary of the length of BI system in use is presented in table 15. As shown below, about 64% of the firms have BI system in use for more than 5 years and 86% are using it for more than 2 years. On average firms are using a BI system for about 6 years and therefore it is fair to assume that they have a good understanding and experience of using their BI system and would have seen the impact on firm performance.

Table 15: Length of BI system in use (time since adoption)

Length of BI system in use	Number	Percent
Less than 5 years (avg.2.5 years)	46	36%
5 to 8 years (avg 6.5 years)	49	38%
More than 8 years (avg 10 years)	33	26%
Total	128	100%
Average length of BI system use (0.36*2.5+ 0.38*6.5 + 0.26*9 =5.97 years)	5.97 years	

4.7.3 *Applications and extent of their use*

The following table (table 16) gives a range of applications BI systems are supporting. As shown in table 16, finance/accounting is the most popular application. About 83% and 75% of the firms' BI systems are supporting external financial reporting and internal performance reporting functions respectively. In addition, customer related processes that include order management, pricing, and customer service management; and logistics related processes that include logistics, warehouse, distribution and supply chain management; and procurement and spend management are other applications well supported by their BI systems. Only 11% of the respondents reported using other applications such as treasury/cash management, human resources management, maintenance and sustainability reporting and the extent of usage of those applications is also very low as shown above. Therefore, these applications are removed from further analysis and only the first five application types are considered for computing the overall score for the extent of applications use. The extent of the BI applications use is measured as low, medium and high and given a weightage of 1, 4 and 8 respectively, in order to compute the overall use score. For example, the use score for the extent of use of financial applications is calculated as 4.96 (i.e. 0.08 * 1 + 0.28*4 + 0.47*8 = 4.96). The average scores for other applications are calculated as 4.53, 3.74, 2.28, 1.91 and 0.14 and shown in the table above (table 16).

Table 16: Extent of use of various BI Applications

	Applications supported by BI system and the extent of its use	No of firms using	Low (1)	Med-ium (4)	High (8)	Score
1	Financial accounting/reporting	112 (83%)	8%	28%	47%	4.96
2	Internal Performance reporting	96 (75%)	9%	21%	45%	4.53
3	Customer related (customer order, Pricing, customer service)	90 (70%)	14%	22%	34%	3.74
4	Logistics/warehouse/distributio n/ supply chain management	68 (53%)	16%	21%	16%	2.28
5	Procurement & spend management	61 (48%)	15%	22%	11%	1.91
6	Others – HR, Operations, treasury, maintenance & sustainability	14 (11%)	10%	1%	0%	0.14
	Total Use score - Applications					17.56

As shown above, the overall use score is 17.56. Data reveals that the average usage of BI systems that support financials, costing, performance and customer related processes are the most popular and the extent of its use is ‘medium’ (i.e. more than 4). For applications such as logistics and procurement/spend management, it is ‘low’. Current deployments of BI systems are not used to support some of the specialised applications such as treasury, human resources, operations and sustainability, the study found. On average a firm has its BI systems supporting three of the six groups of applications listed in table 16.

4.7.4 Tools and extent of their use:

Another variable to measure the extent of use of BI systems is various tools deployed within BI systems implementation. They include data warehousing, data mining, reporting and visualization tools and dashboards. A summary of the range of tools used by the firms and the extent of their use measured as low, medium and high are shown below (table 17).

Table 17: Extent of use of various BI Tools

	BI Tools deployed and extent of its use	No of firms	Used by	Low (1)	Med-ium (4)	High (8)	Avg use score
1	Data warehouse	92	73%	7%	26%	40%	4.31
2	Dash boards	106	82%	24%	33%	25%	3.58
3	Data Mining	65	51%	13%	15%	23%	2.57
4	Data Visualization tools	56	44%	17%	15%	12%	1.73
5	Analytics tools	78	63%	11%	22%	30%	3.39
6	Reporting tools	119	93%	6%	26%	61%	5.98
7	Excel Tool	95	74%	4%	28%	42%	NR
8	Other BI tool	16	12%	1%	10%	1%	NR
	Total score (excluding excel & others)						21.56

The extent of use is computed by applying a weightage of 1, 4 and 8 for the low, medium and high ratings respectively. Accordingly, an average use scores of 4.31, 3.58, 2.57, 1.73, 5.39 and 5.98 were computed and shown in able 17. For example, the average score for the extent of use of data warehousing tools was 4.31 (i.e. 0.07*1 + 0.26*4 + 0.40*8 = 4.31). Based on the ratings given by the respondents, the extent of use of BI tools, excluding excel tool and others, is computed as 21.56 and used for further analysis. As shown in the above table (table 17), a large proportion of firms (93%) studied are using reporting tools and the extent of their use is also ‘high’ with an average score of 5.98. In addition, dash boards, analytics and data warehousing tools are the second most popular tools used by Australian organizations and their usage rated as ‘medium’. Data mining and data visualization tools are very rare and the extent of their use is observed to be ‘low’ (an average score around 2). In addition, excel is also a very popular tool with about 74% of the respondents reporting its use in their organizations. On average a firm used 4 tools, the study observed.

4.7.5 Management of BI use

Management policies on the access, data management, integration, usage of excel and training are expected to contribute to improved usage of the BI system and thereby could potentially contribute to process performance. As mentioned in the literature, perceptions on the management of BI system use and the context in which it is used is an important factor in understanding the impact of BI use on performance. Percentage of respondents who have rated each statement more than 4 in a scale of 1 (disagree strongly) to 7 (agree strongly) are also reported in this statement.

Table 18: Management of BI systems use

No.	Perceptions on the management of BI use and the context	% agree (>4)
1	Unlimited access of BI system to all users	29%
2	Limited access to users because of insufficient user licences	34%
3	BI system dedicated to specific power users that require specialized functionalities	58%
4	BI system effectively matches its tool capabilities with its user types	41%
5	BI system does not meet user expectations (disconnect between users and IT)	23%
6	BI system allows users to build their own self-serve reports and share them with others	54%
7	Users are allowed to continue to use Excel and others to produce reports bypassing BI system	72%
8	It takes very long time to run reports using the BI system deployed (with ad-hoc queries)	27%
9	BI system does not easily facilitate changes with dynamic business requirements	55%

10	Training on the use of BI system is INADEQUATE	40%
11	Data sources used in BI system are reliable, consistent and well integrated with BI application infrastructure	63%
12	We have good handling and maintenance procedures for the data that goes into BI system(s)	58%

While doing so, some of the statements are reverse coded in order to obtain a consistency in the rating for summation purposes. Therefore, data collected with reference to several statements on the management of BI systems' use are analysed and a summative score is calculated. A summary of the statements including the statements that are reverse coded are shown in table 18.

The above analysis reveals the challenges involved in the use of BI system. On the reporting side, respondents expressed satisfaction with the BI systems as they allow users to build their own self-serve reports and share them and it won't take too much time to produce reports from the system. While respondents are satisfied that their BI system allows them to build their own reports, in practice, they seem to be using excel to build reports. A significant percentage of respondents (72%) observed that their firm allows users to bypass the BI system and use excel to produce reports. Either because of the inadequacy of their BI system or lack of skills or lack of management 'resolve' to enforce process discipline, many firms are allowing users to bypass the system. Even though it is convenient and expedient, the full potential of BI system would not be exploited if users continue to bypass the system. If continued, this may pose a risk to data integrity and affect the quality of support provided to decision making and performance management.

Even though access to a BI system is not considered a major issue in the literature, study reveals the challenges in access. Access is limited by insufficient number of user licenses and/or by giving access to few power users. As observed in this study, about 34% of the firms reported insufficient number of user licenses, and in 48% of the firms, BI system is dedicated exclusively to a few power users. Only 29% reported unlimited access to all types of users while about 40% of respondents observed a good match between the BI system capabilities and user types.

BI implementation, though, is reported problematic in literature, a majority of respondents (77%) reported no disconnect between users and IT department and that the BI system deployed generally meets user expectations. The rigidity of the system, however, is noted with 55% of the respondents reporting that it is not easy to change the BI system consistent with changing business requirements. Even though adequate training of users to use BI system is an important factor affecting its use, 40% of the respondents complained about the inadequacy of training in their organizations. Stressing the importance of data quality and integration of data sources with BI infrastructure in many firms, 63% of the respondents reported good data quality and integration. Even though good data handling and maintenance procedures are important to continue to use the BI systems effectively, 42% of the firms reported lack of those procedures in their firms.

4.8 Multiple regression analysis

In order to answer the second and third research questions, i.e. impact of BI use and IT infrastructure capability on process performance, multiple regression analysis was conducted. In this analysis, process performance is the dependent variable while business intelligence systems use measured by four factors is the key independent variable. BI systems use in this study is measured by the extent of use of various BI applications, extent of use of various BI technology tools, management of BI systems use and the length of BI system in use in an organization. In addition, Information Technology (IT) infrastructure capability of the firm was also included as an independent variable in this model and multiple regression analysis was carried out. When variables have different response anchors, mean scores can be used in multivariate analyses such as multiple regression (Hair et al 2010). In this study, as explained earlier, the variables process level performance, management of BI use, IT infrastructure capability were measured with a 1 to 5 scale, while the extent of applications use and extent of tools use were measured with a scale of low, medium and high. Another variable, the length of BI use was an ordinal variable and converted into a dichotomous variable for analysis.

4.8.1 *Multivariate analysis – multiple regression*

Before doing multivariate analysis, assumptions such as normality and collinearity were tested and presence of outliers or influential cases was examined using appropriate statistical techniques (Hair et al 2010). Using SPSS, a standard multiple regression analysis was conducted in order to test the relationship between one dependent variable (process performance outcomes) and several independent variables (BI applications use, BI tools use, management of BI use, length of BI use and IT infrastructure capability) using mean scores calculated earlier. In multiple regressions, multicollinearity, very high correlations between independent variables should be avoided (Burns & Burns 2008). If the correlation between two variables is more than 0.90, it implies that the two are measuring the same variance and therefore only one of the two is required in the regression model (Burns & Burns 2008). This is measured by the 'Variance Inflation Factor (VIF) shown in regression statistics in SPSS which should be less than 10. 00.

An analysis of the standardized residuals showed no pattern of increasing or decreasing residuals thereby indicating homoscedasticity in the multivariate (the set of independent variables) case. Another assumption of linearity was assessed through an analysis of residuals (testing the overall variate) and partial regression plots for each independent variable in the analysis. The plots did not exhibit any nonlinear pattern to the residuals and ensured that the overall equation is linear. Thus assumptions of multicollinearity, normality of residuals and homoscedasticity and non-existence of outliers required for multiple regression were verified and results were interpreted.

Adjusted R-square value, standard error of estimate and significance of the model were computed using SPSS and analysed and the relationships between the dependent variable and independent variables were examined. Further, for the model and results to be valid, number of cases must be at least 15 times more than the number of independent variables (Burns & Burns 2008). As the number of independent variables in this study were 5, a minimum of 75 cases were considered sufficient to make the model valid and for meaningful interpretation of the results.

An independent variable, 'length of BI system in use in an organization', however is an ordinal variable and has three categories (less than 5 years, 5 to 8 years and more than 5 years) as shown in table 15. Using a rule of thumb for creating dichotomous variables from categorical independent variables with more than two categories, (3-1 = 2) suggested in the literature (Hair et al 2011), these two dichotomous variables are created. Considering the first category as a reference category, two dichotomous variables are created with values 0=below 2 years, 1= '2 to 5 years' and 2= 'More than 5 years').

4.8.2 *Preliminary analysis*

Various descriptive statistics of the variables are examined as a first step in the analysis and shown in the table 19.

Table 19: Descriptive statistics for variables in multiple regression analysis

Avg scores	Mean	Std. deviation	Skewness	Kurtosis
Extent of Applications use	3.478	1.979	0.515	-0.702
Extent of tools use	3.593	1.896	0.236	0.214
Management of Use	3.546	1.161	-0.521	-0.144
IT Infrastructure capability	4.068	1.477	-0.170	-0.842
Process performance	3.500	1.596	-0.055	0.640
Length of BI Use	1.796	0.942	-0.328	-0.787

The values for skewness and kurtosis are very small, as shown in the table above, indicating that the variables most likely do not include any influential cases or outliers. An analysis of the histograms and normality revealed that all the variables do not violate the normality assumption, though some of them are slightly skewed.

Another assumption in the regression analysis is linearity. There are two measures of multicollinearity in regression analysis. First measure is 'tolerance', defined as "*the amount of variability of the selected independent variables not explained by other independent variables*," (Hair et al 2010, pp.201). By inspecting the correlation matrix of the independent variables, this 'tolerance' measures the presence of high correlations between independent variables. This is analysed by calculating the Pearson correlation coefficients and their significance. Bivariate correlations of 0.90 and above between any two independent variables implies that those two are measuring the same variance, over-inflating the R value (Burns & Burns 2008, Hair et al (2010) and therefore only one of the two is needed in the model. As shown in the table below (table 20), the bivariate correlations range from 0.189 to 0.496 and are not higher than the correlations between the independent and dependent variables. Therefore, multicollinearity is of no concern in this model. A summary of the correlations are presented below (table 20).

Table 20: Correlations matrix for assessing multicollinearity

	Extent of applns Use	Extent of tools use	Management of BI use	IT infra. Capability	Length of BI use	Process performance
Extent of applications use	1	0.363	0.431	0.376	0.297	0.732
Extent of tools use		1	0.189	0.187	0.243	0.371
Management of BI use			1	0.496	0.335	0.635
IT infrastructure capability				1	.412	0.696
Length of BI system use					1	0.365
Process performance					.365	1

- All of them significant at 0.01 level (2-tailed)

The results indicate moderate positive correlations between all the independent variables and their values (which are well below 0.50) are not the cause of any concern. Based on the above analysis, all the continuous independent variables are retained as they are significantly correlated with the dependent variable and has low correlations among themselves. Outliers and influential cases can negatively affect the fit of the model. Therefore, residuals and Variance Inflation Factor (VIF) and Tolerance statistics are analysed to check for multicollinearity in the next section.

4.8.3 Regression model statistics

Using SPSS, a standard multiple regression analysis is carried out with one dependent variable and five independent variables as explained above. In multiple regression, sample size is the most important element under the control of researcher and its effects are seen in the statistical power of the significance testing and the generalisability of the result (Hair et al 2010). In multiple regression, power refers to "*the probability of detecting as statistically significant a specific level of R^2 or a regression coefficient at a specified significance level for a specific sample size*," (Hair et al 2010, pp.174). So, the minimum R^2 that can be found statistically significant at 0.01 significance level, with a power of 0.80 for five independent variables and a sample size of 100 is **16** (Hair et al 2010, pp.174). As a rule of thumb, maintaining a power at 0.80 in multiple regression requires a minimum sample of 50 and preferably 100 observations (Hair et al 2010). With a sample size of 128 and R^2 value of 0.79 achieved (shown in table 21) in this study, the model wold have higher statistical power of significance testing than 0.80.

Sample size, in addition to its role in determining the statistical power, affects the generalisability of the results by the ratio of observations to independent variables. As suggested in the literature, the minimum ratio between the number of observations and independent variables required for the results to be managerially significant is 5:1, even though the desired level is 15 to 20 observations for each independent variable (Hair et al 2010). In this study, there are five independent variables and 128 observations. With an actual ratio of 25.6:1 (128 observations and 5 independent variables), it easily meets the guideline for the desired level (20:1) and allows the results to be generalisable. Thus, the regression analysis carried out in this study was deemed sufficient not only to identify relationships that are statistically significant but also to bring out relationships that had managerial significance.

As shown in table 21, the model fits well with R-square value of 0.793. The adjusted squared multiple correlation was significantly different from zero (F= 93.529 and p>0.001) as shown in ANOVA table (table 22). With 79.3% of the variation in the dependent variable was explained by the set of five independent variables, all the five independent variables are uniquely and significantly contributing to the explanation of the process performance.

Table 21: Regression model summary

R	R-square	Adjusted R square	Std. Error of estimate
0.891	0.793	0.785	0.7407

Table 22: Regression model - ANOVA

Model	Sum of squares	Df	Mean square	F	Sig.
Regression	256.564	5	51.313	93.529	0.000
Residual	66.933	122	0.549		
Total	323.497	127			

Highly collinear variables can distort the results substantially and does not allow generalisability. Therefore, it is necessary to measure the degree and impact of multicollinearity. This impact is assessed by calculating the variance inflation factors (VIF) in the multiple regression model, as shown in the table 23. This VIF measures the impact of collinearity and is an inverse of the tolerance value discussed earlier. Higher degrees of multicollinearity are reflected in lower tolerance values and higher VIF values (Hair et al 2008). VIF value of more than 10.0 is considered of concern (Burns and & Burns 2008, Hair et al 2010). All the VIF values in this analysis range from 1.039 to 1.462 as shown in table 23 and therefore there is no problem with the collinearity. Thus the model fits well with good statistical values and therefore explains the relationships well. As the analysis suggests, 79% of the variance in the process performance construct is explained by the five independent variables in the model.

Table 23: Regression model – Coefficients

	Unstandardized coefficients		Standar-dized coefficient (Beta)	t-value	Sig.	Collinearity stat. VIF
	β	Std. error				
Constant	-0.658	0.264		-2.492	0.014	
Extent of applications use	0.357	0.040	0.443	9.017	0.000	1.425
Extent of tools use	0.090	0.038	0.106	2.370	0.019	1.189
Management of BI use	0.310	0.068	0.226	4.533	0.000	1.462
IT infra. Capability	0.438	0.053	0.405	8.329	0.000	1.397
Length of BI system use	-0.161	0.071	-0.095	-2.259	0.026	1.039

Further it is observed that all the five independent variables have positive relationship with process performance. It appears multicollinearity is not a concern in this model because the VIF scores are much less than 3 (Hair et al 2010). The factors 'IT infrastructure capability, 'extent of applications use' and 'management of BI use' have strongest impact on the process performance, and each time these independent variables change by one unit, the process performance changes by 0.438, 0.357 and 0.310 units respectively (see table 23). Similarly, the study found that the independent variables 'length of BI system use' and 'extent of tools use' together have very negligible effect (-0.051) on process performance. Therefore, it can be concluded that the independent variables - IT infrastructure capability, extent of BI applications use and management of BI use, have the greatest relative impact on process performance in that order. Therefore, in order to improve process performance, it is necessary to improve the use of BI applications, management of BI systems use and IT infrastructure capability of the firm.

The constant in the model is the predicted value of the dependent variable when all of the independent variables have a value of zero. In the context of this analysis, the predicted process performance score for firms with a BI system in use for less than 2 years is -0.658 with zero BI applications use, zero BI tools use, zero management of BI use and zero IT infrastructure capability, and for the firms with 2 to 5 years of BI applications use, it is 0.342 (i.e. 1-0.658). This suggests low impact as on process performance in the first 2 years of BI system use and possible increase thereafter. The negative value and the low impact on process performance is expected in the first 2 years of the BI system in place. It generally takes some time for the managers assimilate the new BI system and for the system to be properly and fully embedded in the organizational decision making processes. In the initial stages, at times, the performance may in fact be negatively affected as managers are trying to learn the system, use it effectively and the impact on process performance is therefore negligible and negative. After 2 years, there is good increase in the process performance as explained above.

The slope of 'IT infrastructure capability' is 0.438. This means that for every one unit increase in the IT infrastructure capability, predicted process performance score increase by 0.438 units after controlling for other independent variables. The slope for the length of BI use is -0.161. This means that, on average, predicted process performance scores for firms with more than 2 years of BI use are 0.161 points lower than for firms with less than 2 years of BI use, after controlling for other independent variable such as extent of BI applications use, management of BI use and IT infrastructure capability.

4.9 Effect of control variables

There are three control variables in this study - firm size, industry type and role of respondents in the organization. In order to analyse the impact of these variables on the process performance and other important independent variables such as BI applications use, BI tools use and IT infrastructure capability, each of the control variable was classified and recoded into two groups. Using two-tailed t-tests for independent samples at 5% significance level, differences between those two groups were analysed for significance for each of the construct and employed. Using Levene's test for equality of variances, appropriate t-values and significance levels were identified and presented. Because of its robustness, versatility and its general acceptance in the literature, parametric tests such as t-tests are increasingly used with ordinal data (Hair et al, 2010, de Vaus 2013). The effects of all the three control variables on process performance, extent of BI use, management of BI use and IT infrastructure capability are compared between these two groups. A summary of t-test results for each of the control variable is presented in the following sub-sections.

4.9.1 Firm size – revenue and number of employees

An independent samples t-test was conducted to evaluate the hypotheses that there are significant differences with reference to the firm size, in terms of various constructs. Firm size is measured using two variables - gross annual revenue and number of employees and each variable is grouped into two categories. $500 million for gross revenue and 500 employees for employee strength were used as cut off points to divide the firms into two categories and independent samples t-tests were conducted. Results of the t-tests are shown below (tables 24 and 25).

Table 24: Independent samples t-test results – Firm size (Revenue)

Variable (Post-test)	Group – Annual gross revenue of the firm	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Less than $500 million	71	74.99	30.01	1.848	0.068
	More than >= $500 million	57	87.39	42.39		
IT infra-structure capability	Less than $500 million	71	38.39	14.49	1.976**	0.050
	More than >= $500 million	57	43.53	14.73		
Management of BI use	Less than $500 million	71	42.01	14.34	0.495	0.621
	More than >= $500 million	57	43.25	13.51		
Extent of BI Tools Use	Less than $500 million	71	18.37	9.93	3.723*	0.000
	More than >= $500 million	57	25.54	11.88		
Extent of BI Applns. Use	Less than $500 million	71	16.85	8.11	0.668	0.506
	More than >= $500 million	57	18.07	11.79		

**Significant at 5% level (2-tailed) and * Significant at 1% level (2-tailed)

Table 25: Independent samples t-test results – Firm size (No of employees)

Variable (Post-test)	Group – Annual gross revenue of the firm	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Less than 500 employees	65	74.99	30.01	1.848	0.068
	More than >= 500 employees	63	87.39	42.39		
	Less than 500 employees	65	38.39	14.49	1.976**	0.050

IT infra-structure capability	More than >= 500 employees	63	43.53	14.73		
Management of BI use	Less than 500 employees	65	42.01	14.34	0.495	0.621
	More than >= 500 employees	63	43.25	13.51		
Extent of BI Tools Use	Less than 500 employees	65	18.37	9.93	3.723*	0.000
	More than >= 500 employees	63	25.54	11.88		
Extent of BI Applns. Use	Less than 500 employees	65	16.85	8.11	0.668	0.506
	More than >= 500 employees	63	18.07	11.79		

**Significant at 5% level (2-tailed) * Significant at 1% level (2-tailed)

Results indicate the influence of firm size on IT infrastructure capability and extent of BI tools use. For the constructs, process performance and extent of BI applications use, equal variances are not assumed as the Levene's test for equality of variances revealed (F is significant). For all other constructs, equal variances are assumed and results presented. The mean scores of firms with less than $500 million turnover (N=71, M=38.39, sd=14.49; M=18.37, sd=9.93) was statistically significantly different (t=1.976, df= 126; t=3.723, df=126) from that of the firms with more than $500 million turnover. Similarly, the mean scores of firms with less than 500 employees (N=65, M-38.39, sd=14.49; N=65 M=18.37, sd=9.93) was statistically significantly different (t=1.976, t=df=126; t=3.723, df=126) from that of the firms with more than 500 employees.

The above analysis suggests that larger firms with higher gross revenue and higher employee strength have higher IT infrastructure capability and as expected use a range of BI tools well. This outcome is expected, as firms with larger revenues are expected to invest resources on IT infrastructure and BI tools and therefore will have better capability and higher use of their BI technology tools. Firm size measured by these two variables, however, has no influence on the other three constructs – process performance, extent of BI applications use and management of BI use. Unlike the previous two constructs that were dependent on the extent of investments on infrastructure and technology tools, these three constructs are more reliant on the business side of the use of BI systems rather than on mere technologies. Therefore, it is fair to conclude that process performance and the extent of the business use of BI systems are not influenced by the firm size.

4.9.2 Industry type

Industry type is considered to be one of the factors that would differentiate the impact of BI use on process performance. To test this hypothesis all the responses are categorised into two industry types – manufacturing and services, and differences are analysed using an independent samples t-tests. Results are presented below (table 26).

Table 26: Independent samples t-test results – Industry type

Variable (Post-test)	Industry type	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Services	72	88.14	36.87	2.734	0.007*
	Manufg. firms	56	70.70	34.375		
IT infra-structure capability	Services firms	72	41.83	12.448	0.963	0.338
	Manufg. firms	56	39.20	17.313		
Management of BI use	Services firms	72	44.54	13.901	1.838	0.068
	Manufg. firms	56	40.02	13.692		
Extent of BI Tools Use	Services firms	72	20.63	13.806	-1.138	0.257
	Manufg. firms	56	22.77	7.086		

Extent of BI Applications Use	Services firms	72	17.76	10.419	0.482	0.630
	Manufg. firms	79	16.91	9.255		

* Significant at 1% level (2-tailed)

As shown in the above analysis, there are significant differences between the services firms and manufacturing firms in terms of their perceived process performance. According to study, it appears the impact of BI use on perceived process performance is higher in services firms than in manufacturing firms. Industry type, in terms of whether it is in services sector or manufacturing sector, had an influence on the relationship between BI system use and perceived process performance.

4.9.3 Respondents' role

It is possible that the role of respondents – whether they are in information technology field or in a business function may influence their perception of the BI systems use and performance. Therefore, an independent samples t-test was conducted to evaluate the hypotheses that there are significant differences with reference to the respondents' role. As shown in table 26, the perceived process performance and the perceived use of BI tools are statistically significantly different between these groups. Respondents working in IT function have perceived better process performance and lower use of BI tools when compared with those working in business functions.

Table 27: Independent samples t-test results – Respondents' role

Variable (Post-test)	Respondent's role in organization	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Business function	49	69.86	35.998	-2.646	0.009*
	Information technology	79	87.11	35.792		
IT infra-structure capability	Business function	49	37.82	16.450	-1.741	0.084
	Information technology	79	42.46	13.429		
Management of BI use	Business function	49	40.12	12.112	-1.569	0.119
	Information technology	79	44.08	14.833		
Extent of BI Tools Use	Business function	49	23.96	9.330	2.021	0.045**
	Information technology	79	20.08	12.303		
Extent of BI Applications Use	Business function	49	17.45	9.948	0.052	0.958
	Information technology	79	17.35	9.929		

**Significant at 5% level (2-tailed); and * Significant at 1% level (2-tailed)

It is possible that business managers are not fully aware of the potential of BI tools such as dashboards, data visualization tools and analytics tools and therefore may have reported higher use. Respondents working in IT function, however, reported lower use of these tools given their understanding of the tools and their capabilities.

4.9.4 *Respondents' position*

Respondents participated in this study are categorised into three levels - senior management level, middle management level and operating level. In order to test the differences between these two groups, independent samples t-test at 5% significance level were conducted. Results are shown below (table 28).

As shown in the table, the perception of management of BI use and the IT infrastructure capability are found to be significantly different between these two groups, with senior managers perceiving them to be higher. Senior management acknowledge the importance of maintaining and improving the IT infrastructure capability and management of BI system use for deriving improved performance outcomes through their BI systems.

Table 28: Independent samples t-test results – Respondents' position

Variable (Post-test)	Respondent's role in organization	N	Mean	S.D.	t value	Sig. (2-tailed)
Process performance	Senior managers	33	3.679	0.861	1.023	0.308
	Others	95	3.438	1.781		
IT infra-structure capability	Senior managers	33	3.702	1.445	2.202	0.029*
	Others	95	3.556	2.034		
Management of BI use	Senior managers	33	3.957	0.777	2.975	0.004*
	Others	95	3.404	1.239		
Extent of BI Tools Use	Senior managers	33	3.702	1.445	0.446	0.657
	Others	95	3.556	2.034		
Extent of BI Applications Use	Senior managers	33	3.357	1.925	0.405	0.686
	Others	95	3.520	2.006		

**Significant at 5% level (2-tailed); and * Significant at 1% level (2-tailed)

4.10 Summary of findings and discussion

The study analysed the impact of business intelligence (BI) system use on process level performance in business organizations. Results indicate the positive influence of extent of use of applications, management/governance of BI use and IT infrastructure capability on process level performance. A brief discussion of the key findings is presented below.

Study found positive relationship between BI use and process level performance. In particular, increase in the extent of use of BI applications supporting various business processes, improved management of user access, data quality, training, integration with other data sources and data maintenance would contribute to improvements in process level performance.

The study confirmed the enabling role played by IT infrastructure capability in improving the BI use and process level performance. BI systems are technology-intensive and effective use of BI systems require sound IT infrastructure capabilities. In order to improve the impact of BI use on process level performance, firms must create and maintain sound IT infrastructure capabilities which include both technical and human capabilities.

This study took a broader view of the term BI use and measured the extent and scope of BI use with reference to four perspectives – extent of the use of various applications or processes a BI system is implemented to support, extent of the use of various technology components and tools embedded in a typical BI software solution, management and governance of the day-to-day use and maturity of its use measured in terms of length of time since its adoption. Instead of defining it as a single variable with a scale, this study employed a multi-dimensional view of BI use and measured it.

On average organisations participated in the study have been using a BI system for more than 6 years. Further, respondents have reported about 6.5 years of experience in using a BI system with most of them from senior and middle management levels. This reflects the validity of the perceptions and findings reported in this study and maturity of BI system use in Australia. Even though random sampling is not employed in the selection of respondents and organizations in this study, the findings can be considered representative of the general population of BI users in Australia.

The study observed widespread implementation and use of BI systems in Australia. A large number of firms are using on average 1.5 BI systems and major BI software vendors such as SAP, Oracle and SAS have established their presence with many firms using more than one software solution. Despite some challenges such as inter-operability and integration with back-end systems and other enterprise systems, as identified in the practitioners' reports, firms are willing to bear the costs of deploying and maintaining more than one BI software solution. Each solution it appears is selected to specifically support decision making in a particular business process context. Financial and performance reporting is the most popular application among Australian firms. This suggests their continuing emphasis on internal and external reporting processes and attempts to overcome inherent reporting weaknesses of the ERP systems. Even though BI software solutions available in the market have capabilities to support certain unique processes such as treasury/cash management, sustainability reporting, human resource management and operations, their low adoption reflects the narrow focus of Australian firms and potential loss of opportunity to discover new insights in these other processes. Further, low use of more recent tools for data mining, analytics and data visualisation confirms conservative attitude of Australian firms in adopting more sophisticated and modern tools embedded in BI solutions.

As noted in the analysis, management and governance of BI use is a critical aspect to improve use as well as process level performance. Management of BI use that includes management of access, data quality and skills are observed to be challenges. Even though access to BI system is a problem in some firms, a significant percentage of firms allow users to bypass the system and use tools such as excel for reporting and analysis. Non-availability of skills, inadequate resources to train and use the system and absence of appropriate procedures to manage the data quality are challenges observed in this study. Though this may be expedient for managers who may not have adequate skills and resources to use the BI system effectively, continued use of Excel may pose a risk to data integrity, the study observed. In order to derive full value of BI systems, managements must enforce 'process discipline' by not allowing users to bypass the system with excel and other ad-hoc tools. Information produced and maintained in excel is likely to be disintegrated, less timely, not up-to-date and less secure. With version control, macros and informal ways of developing reports may pose challenges to the management if excel is allowed to dominate the decision making environment.

According to the study, firm size has mixed effect on various variables. Though larger firms (measured as gross revenue and employee numbers) would have higher IT infrastructure capability and use a range of BI tools well, it has no effect on the extent of BI applications use, management of BI systems use and process level performance. As these are more reliant on the business side of the enterprise rather than technology side, it appears process performance and the extent of business use of BI applications is not influenced by the firm size. Industry type, classified into services and manufacturing, however had an influence on process performance. When compared with firms in non-services sector (manufacturing, mining, agriculture, logistics etc.), services firms (insurance, IT, communications, banking etc.), have higher impact on BI use and process performance. Next chapter presents the conclusions of this study and discusses the implications for research and study limitations.

Chapter 5

Conclusions

Chapter 5: CONCLUSIONS

5.1 Overview

The aim of this research study is to investigate the impact of the usage of business intelligence (BI) systems and information technology infrastructure capability on process level performance in business organisations. Based on empirical data collected from respondents using a BI systems in Australia, this study showed that the extent of the use of BI systems that support various business processes, IT infrastructure capability of the firm and the management/governance of BI use have significant impact on the process level performance. Extent of use of BI technology components and length of use of BI system (time since adoption) and firm size however had no significant impact on performance.

This chapter first presents a brief review and discussion of the research findings in section 5.2. It is followed by a discussion of the contribution this research (in section 5.3). In section 5.4, implications of these study findings to the research community and practice are discussed. In conclusion, limitations of this research study and suggestions for future research are presented.

5.2 Discussion of the findings

Investing in BI systems is common in enterprises of all sizes and types. Effective uses of applications and business processes supported by BI systems, management/governance of system usage and IT infrastructure capability have positively influenced process level performance, the study found. Though financial performance of a firm is dependent upon several factors, the impact of BI system use can be seen first at the performance of its internal business processes, as leading indicator. In order to discover its full potential, it is necessary to improve management of BI system usage and the extent of usage by getting as many users as possible to work with the system and deliver right amount of detail to the right people at the right time. Demonstrating a good understanding and experience of working with BI systems in Australian context, a significant proportion of the firms surveyed reported using BI system for more than 5 years.

Considering the importance of day-to-day 'use' rather than an 'implementation or deployment' of the BI system, the term BI use is conceptualised in this study. Taking into consideration the broader interpretation of the term 'BI systems' in business today and its several components deployed to support decision making and performance management processes in firms, BI use in this study is measured with reference to four dimensions – extent of the use of various BI applications (processes), extent of the use of various tools (technology components), length of the use and the management/governance of use. Effective usage of BI system is not just the mere adoption of the system. Therefore, rather than focusing on whether or not an organisation has a BI system, this study focused on the functional use of the BI system, the extent of its use, maturity of its use and management of its use that enables enhanced business process level performance. This broader perspective of the usage of a BI system that is deployed to serve different purposes and processes across different industries is taken in this study.

According to study, the range of BI software solutions and tools employed in Australian business organisations today is high. It appears, all the leading BI software solutions providers such as SAP, IBM Cognos and Oracle Hyperion and SAS are already in use in a 90% of the firms surveyed. Each of these software solutions, depending upon the application or business process they are designed to support, has certain strengths that vary from one vendor to another. Recognizing their relative strengths and matching them with their own internal requirements and strengths, business organisations have deployed more than one BI software solution.

BI systems that are deployed to support financial reporting and performance reporting processes are the most popular and heavily used applications while treasury/cash management, human resource management, maintenance, sustainability reporting are the least popular applications, the study observed. Financial reporting and performance reporting processes are common in all types of firms whether they are in manufacturing or utilities or services such as banking and insurance, and therefore are widely deployed and used. Even though firms are using BI systems to support inbound logistics and outbound logistic processes, extent of their use is observed to be low and as expected limited to manufacturing and logistics firms.

Reporting tools are also very popular and a large proportion of firms are heavily using reporting tools embedded in their BI systems. Considering the poor reporting capabilities of the ERP systems now pervasive in most of the firms in Australia, reporting tools available in BI systems are therefore popular and widely used.

Reporting functionality in the context of any packaged IT solution is a challenge considering the varying requirements of the firms and managerial preferences. While the study observed satisfaction with the reporting capabilities of the BI system, a significant proportion of users continue to use excel to produce reports and bypass their BI system. Though this is convenient and expedient, the risk it poses to data integrity and the consequent impact on the quality of support to decision making and performance management are significant and cannot be ignored. Even though the data sources used are common, allowing users to access older reporting systems and tools may remove any incentive to learn something new. Importantly, the motivation and opportunity to find the unknown, to dig deep and uncover a new perspective on the organisation from these new intelligence systems may be lost if the firms continue to allow users to bypass their BI systems.

Management and governance of BI use has emerged as an important issue in this study. Poor management of access, rigidity of the BI system in its inability to meet dynamic changing business requirements, inadequacy of user training, poor data handling procedures and absence of data governance are some of the challenges identified in this study.

Access to a number of users is an important issue. Managing the access in order to get as many users as possible to work with the BI system is important to the delivery of right information to the right person in right detail. Further, the study observed improved usage of BI system where there are good data handling and access procedures. Maintaining an integrated metadata repository with appropriate authorizations to maintain them, and single source of data across the enterprise are important to deliver quality decision support to managers. A majority of the firms (60%) have reported satisfaction with their current data handling and maintenance procedures. The challenge is to balance the management of security rights to control and update data with the maintaining currency of data and data dictionaries. Maintaining and ensuring the quality of data is the key to create insights from BI systems. Confirming this, firms with high levels of data-related infrastructure oriented towards data collection, cleansing, access authorizations and maintenance have reported higher use of their BI systems as well higher levels of process level performance than others.

Training and skill development is a critical factor contributing to improved BI usage, the study observed. Even though usability of these systems is good, there is a significant complexity on the data side. For example, hundreds of features in some of the key components such as report design, ad hoc query, OLAP analysis tools and visualisation tools and hundreds of columns of data in a simple data warehouse would add lot of complexity on the data side to users. Most of the executives and managers who use BI system typically are non-technical business users. These managers, who are often key strategic decision makers, need a faster easier way to get the information they need and cannot handle the complexity introduced in a BI system from data side. Therefore adequate training and ongoing support is essential if these tools are to be understood and used effectively and derive performance benefits.

IT infrastructure capability has emerged as a critical factor influencing the impact of BI use on process performance in this study. Successful implementation, management and use of BI system and its several technology components are heavily dependent upon the IT infrastructure in terms of databases, networks, security, communication as well as technical and management skills of IT personnel. This study confirmed the enabling role of IT infrastructure capability in improving firm performance as identified in the literature, and observed this to be a significant predictor of process level performance.

While the extent of applications has a significant influence, the extent of tools use and length of BI systems use have very negligible effect on process performance, the study found. To improve the impact of BI systems on process level performance, firms must improve their BI system management procedures and processes, IT capabilities and increase the use of various applications supported by a BI system.

Firm size, measured by gross revenue and employee strength, have no influence on the process level performance. It appears size of the firm measured in terms of employee strength and gross annual revenue, has no impact on the extent of usage of BI system - whether it is applications or tools or management of use or time since adoption. These three constructs, unlike the other two - extent of BI tools use and IT infrastructure capability, are not dependent on technology investment and are more reliant on the business side of the use of BI systems. Therefore, as expected, IT infrastructure capability and use of BI technology components is higher for larger firms, the study noted. Though business use of BI applications is not influenced by the size of the firm, larger firms with higher gross revenue and employee strength have higher IT infrastructure capability and use a range of BI tools effectively, the study found.

Industry type, according to study, has no influence on the BI use and process level performance, except that the impact is higher in service firms than in manufacturing firms. Service firms such as banks, insurance companies, IT and communication services are typically more knowledge-intensive and are likely to invest more resources for effective deployment, use and maintenance of BI systems when compared with manufacturing firms.

5.3 Research contributions

This research aimed to study the impact of BI system's use on process level firm performance. Even though a majority of past studies considered BI system as a single item variable and assumed that its use is contingent upon the deployment of a BI system and/or time since its adoption, this study has taken its multi-faceted broader perspective in its measurement. Recognising the differences in the focus of each BI system in different organisations, and the broad interpretation of the term 'BI system' in firms, BI system use in this study is measured with reference to four aspects - the extent of use of various applications a BI system supports, extent of use of several technology components that are part of a BI system, level of good management/governance of BI system use and time since the adoption of a BI system. This study probably for the first time operationalises the construct 'BI system usage' and contributes to the knowledge on business intelligence systems by recognizing its multi-dimensional nature and by bringing broader interpretation of the practitioners into research model.

This research highlights importance of management/governance of BI system usage and contributes to the literature on business value of IT investments. Consistent with prior research on the usage of IT innovations, better management of usage and higher levels of applications resulted higher levels of process performance in this study and thereby leading to better returns on

IT investments. Implementing an IT innovation itself is not a sufficient condition to achieve performance improvement. Effective usage of the applications that are supporting specific business processes through good management deliver the performance benefits to organisations, rather than just the deployment of technology tools, the study concludes.

The assumption that longer a system is in place, better its usage is not found to be valid according to this study. Use of various technology components/tools embedded in a typical BI system and time since a BI system is adopted have no positive influence on process level performance. Even though it generally takes some time to assimilate a BI system and use it effectively, beyond a certain period, time since adoption would have no further impact on performance, the study observed.

BI systems though are implemented to support key business objectives, they are technology-intensive and require sophisticated IT infrastructure to run various advanced technology components such as reporting tools, data warehouses, data visualization, dashboards, data mining and analytics embedded within BI solutions. Therefore, its use is dependent upon the IT infrastructure capability of the firm. Confirming the past research on the enabling role of IT infrastructure, this study highlighted the influence of IT infrastructure capability on the BI system use as well as on the firm performance at process level. Importantly, this study demonstrates the need for building and maintaining IT infrastructure capability, in order to be able to generate business value from their BI investment.

The results demonstrate the existence of relationship between BI systems use, generic IT infrastructure and business processes, that enables the exploitation of BI system to support effective decision making and performance management. The findings are consistent with some of the aspects of the complementarity theory examined in the literature (Milgrom and Roberts 1995, Barua et al 1995). IT innovations, IT infrastructure and the related business processes, if aligned well with appropriate management of use will work in synergy and enhance organisational capabilities to generate performance improvements.

This study made an attempt to delve into the underlying phenomena surrounding BI systems deployment and use and understand the factors that would create business value in terms of improved decision making and enhanced process performance. The present study extends the IT business value literature to the business intelligence domain and provides empirical evidence to the significant relationship between BI system use and process level firm performance. The results help explain why some organisations are able to use and leverage their investments in BI systems better than others. Instead of assuming that an IT implementation by itself delivers performance improvements, this study emphasizes the importance of 'BI use' and its governance in order to improve its effectiveness. The results suggest that future IT innovation and business value studies should include 'system use' as a key variable in the research model.

5.4 Implications for research and practice

In spite of greater attention from researchers and practitioners on the role of BI systems as a source of enhancing decision making capabilities (Hou and Papamichail 2010; Elbashir 2007), empirical studies investigating the relationship between BI system use, performance, IT infrastructure capability and other organisational capabilities are limited. As volume of investments on BI systems and the power of analytical tools that are embedded in BI systems are growing at a high speed, findings from this research can be useful for practice and research.

The process performance benefits of using a BI system reported in this study demonstrate the value of deploying BI systems at operational level and support specific business processes. The findings would encourage managers to increase investments in BI systems with the aim of improving specific process level performance outcomes, rather than to exclusively support strategic decision making. Thus focus on the operational level, would help line managers to access relevant and timely information about day-to-day operational events and make better and instantaneous decisions. Rather than focusing on the deployment of various BI technology tools and then exploring their usage to support various processes, firms must first focus on deploying the specific applications that support their key business processes and on governance of usage and then determine the technology tools required at the backend.

This study used an established method, carried out an extensive collection of appropriate data and followed a rigorous process providing a high degree of confidence in the validity of the measures and results. These process performance outcomes are leading indicators that could be used as diagnostic tools, and inform the management about corresponding improvements in the organisational performance or lack of it.

For researchers, this study provides strong evidence that BI use is a multi-faceted construct that consists of four dimensions – applications, technology components, management and time since adoption. This study presents a research model and empirically tests a significant positive relationship between BI system use and process level performance and validates the relationships that have been already proposed by IS success models.

Good data or tools or their use by managers alone will not guarantee better decision making and performance unless the managers and BI analysts are equipped to pose good questions or interpret the outputs of data analysis with their deep domain knowledge and judgment that often comes with experience. Whether increasingly advanced BI capabilities embedded in modern BI systems may create opportunities for radical change or may lead to an incremental improvement to existing systems is dependent upon the usage and management of usage. Sheer availability of data and BI systems does not guarantee improved decision making and organisational performance. It is important to remember that previous generations of decision support systems and technologies have frequently failed to deliver their full potential in practice and many businesses are struggling to make sense of the intelligence/data discovered by their BI systems.

5.5 Limitations and future research

As with any study, there are several limitations of this study. First the population of the firms and respondents sampled in this study comprised of customers of several leading BI software vendors. Given the differences in the relative strengths of these software solutions, its performance benefits are likely to become more specialized as software vendors offer a variety of software modules or extensions for specific purposes. This study provides a snap-shot of the impact of generic BI use on process level performance at a point-in-time only and does not consider unique features of the BI systems and their unique configurations. This study presented a cross-sectional research that measured BI system users' perceptions at one point in time across a range of applications and tools. These perceptions may change over time as they gain more experience of using BI system (Matheison et al 2001). A longitudinal approach would help understand the specific factors that contribute to improvements in process performance specific to a particular application.

This study is reliant on subjective 'perception-based' measures for all the three constructs - the extent of BI use, IT infrastructure capability and process level performance outcomes. These subjective measures can cause common method bias. Even though the data collection was aimed at collecting data from several respondents in an organisation, and the responses were all anonymous, it is possible that the respondents have overrated or underrated their views and the common method bias may not be fully eliminated. The use of manager's perceptions, however, considered appropriate as the data required to measure BI use, process performance outcomes and IT infrastructure capability are qualitative in nature and would be difficult to collect objectively. For example, objective information about the process level performance and BI use are of strategic importance and confidential and therefore are not openly shared by business organisations. Rigorous statistical tests, as explained in the analysis chapter were conducted to counter the data quality threats arising from common method variance and poorly specified perceptual measures.

This study controlled for firm size and investigated its effect on BI use, IT infrastructure capability and process performance. Other contextual factors such as industry type, environmental changes and specific competitive environments in a given industry type; and internal organisational factors such as culture, management control mechanisms, employee resistance and decision making styles may also have effects and are not measured in this study. Further research is required to explore the moderating effects of these contextual factors and other organisational capabilities such as information management capability and process management capability.

This empirical study was conducted in Australia. Taking into consideration the cultural differences, differences in the technology-readiness of the firms, the findings might not be directly applicable to other countries. Further empirical studies testing this model across various countries would give further insights into the influence of other factors. This study focuses on perceptual measures of BI Users on the usage of BI system and process performance rather than on objective measures of organisational level performance. Most of the data required to measure process level performance are leading indicators and intangible or qualitative while firm level performance measures are objective and lagging indicators. Further studies on the relationship between BI use, process level performance (leading indicators) and firm-level performance (lagging indicators) would offer deeper insights into the business value of IT investments in general and BI systems in particular.

This study collected information only from BI system adopters and users and combined various applications and tools. It did not differentiate between the nature of applications and/or tools designed to support a particular business process in a given organisational context and their core processes. Studies that focus on a particular core business processes, for example customer order management or financial reporting and how a BI system is selected, configured and managed to support the core process, how intelligence is derived and used for managerial decision making and control will offer new insights for practitioners and researchers on the BI system adoption and usage.

Some of the BI systems come with some recently emerged advanced tools and used to support key processes such as financial reporting or performance management. The experience of managing and using them, and expertise required to manage is significantly different. For example, the configuration and management of a BI system use to support financial reporting could be significantly different when compared with a system configured to support customer order management or sustainability reporting. Therefore, further studies investigating the effectiveness of use, and its impact on performance in specific application contexts are necessary.

An organisation typically uses several BI systems and technology tools and the information and knowledge-intensity of each firm is different. Through BI systems, firms collect information from within and outside the organisations, employ different tools and technologies for consolidation, presentation and sharing and create insights for decision making. It is not clear how inter-operability of these systems/components (or lack of it), level of integration of data and processes and knowledge-intensity of the processes hinder or facilitate a firm's ability to use BI systems. Further studies are necessary.

IT infrastructure capability is an important enabling factor, according to this study. This capability can be built in-house or sourced from outside the enterprise. Today, In today's business world, many of the IT infrastructure components are outsourced and delivered from the cloud and/or from on-premises, either by the firms themselves or from other IT service providers. Further studies are necessary to understand the issues relating to organisation and management of these services when BI systems are outsourced or delivered from the cloud by third parties and their impact on performance benefits.

Successful deployment and use of any IT innovation in general and BI system in particular requires a synergistic effort between IT and business personnel in an organisation and deep domain knowledge and judgment of BI users/functional managers. Investigating the influence of these factors is beyond the scope of this study. Studies on the knowledge sharing, collaboration and alignment between IT and business managers at both strategic and operational level will offer further insights in the successful use of BI systems and help managers to better manage their technical as well as human resources.

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Appendices

School of Information Technologies

Appendix I

A Study of the impact of Business Intelligence (BI) Systems Use on Process level firm performance in Australia

The objective of this survey is to understand your perceptions on the impact of **BI systems use** and **IT infrastructure capability on process level organizational performance**. All answers in this questionnaire will be used in aggregate terms and for academic research purposes. No individual opinions or comments will be identified or used for publication. This questionnaire will take about 10 minutes. Your participation in this survey is VOLUNTARY and is highly valuable to us. Please answer the questions by putting a 'X' in the appropriate box and/or by giving your views in the space provided. An online version of this survey is available at (http://kmrg,cs.usyd.edu.au/BIuse) for your convenience.

Section I – DEMOGRAPHICS – Your organization/strategic business unit and you

1. Serial Number:
2. Number of Employees 1☐ Less than 100 2 ☐ 101 to 200 3 ☐ 201 to 500 4☐ More than 500

3. Gross revenue of your firm/strategic business unit per annum
   1☐ Less than $100 million 2 ☐ $101 to $499 million 3 ☐ $500 million or more

4. The industry sector to which your organization/strategic business unit belongs to:
   1☐ Agriculture, forestry, fishing
   2☐ Building materials/Construction
   3☐ Communication & IT services
   4☐ Consulting/Business/professional services
   5☐ Education
   6☐ Finance, Banking, Insurance & Investment
   7☐ Health, community services
   8☐ Manufacturing
   9☐ Media/Entertainment/Publishing
   10☐ Mining & resources
   11☐ Retail/whole sale/distribution
   12☐ Transport & logistics services
   13☐ Utilities (Electricity, Gas, Water & others)
   14☐ Government department/corporation
   15☐ Others (please specify)

5. Your current role in the organization/strategic business unit
   1☐ Manufacturing/Logistics/operations/procurement/supply chain 2☐ Information Technology
   3☐ Sales and Marketing 4☐ Finance/Accounts 5☐ Others (please specify)

6. Your current position in the organization/strategic business unit
   1☐ Director/Executive level 2☐ CIO/CFO/CTO 3☐ Middle manager level
   4☐ Operational level 5☐ Others (please specify)

7. Your BI experience
   1☐ Less than 2 years 2☐ 2 to 5 years 3☐ 5 to 8 years 4☐ More than 8 years

Section II – Business Intelligence System(s) in your organization/business unit:

8-13. Which software vendor's Business Intelligence applications (consider any or all of the applications in a typical ES suite) are implemented in your organization/business unit (please select multiple options if relevant) **(0 for No, 1 =YES for each)**
   8☐ Oracle - Hyperion 9☐ IBM Cognos 10☐ SAP - Business objects
   11☐ SAS 12☐ Microsoft - Micro-strategy 13☐ Others (please specify)

14. How long did you have this BI system(s) working in your organization/business unit?
   1☐ Less than 2 years 2☐ 2 to 5 years 3☐ 5 to 8 years 4☐ More than 8 yrs.

15. Please give an approximate number of business users that REGULARLY access the BI system(s) in your organization/business unit

16-31. BI systems are implemented to support specific applications/functions/processes. So, in the first column, please indicate whether your BI system supports the application listed (by ticking all the relevant applications/business processes/functions for which BI systems were implemented). For each of the application your BI system supports, please indicate the extent of its current use (in terms of low or medium or high) in your organization/business unit when compared to its full potential/functionality.

Not Relevant(0)	Description of the function/application your BI system supports	**Extent of current use**		
		Low(1)	**Medium(4)**	**High(8)**
☐	16. Supply chain management	☐	☐	☐
☐	17. Customer order management	☐	☐	☐
☐	18. Financial/accounting and/or financial reporting	☐	☐	☐
☐	19. Treasury and/or cash management	☐	☐	☐
☐	20. Performance management/internal reporting	☐	☐	☐
☐	21. Human resource/Work force management	☐	☐	☐
☐	22. Procurement and spend management	☐	☐	☐
☐	23. Operations/production management	☐	☐	☐
☐	24. Sales operations and marketing	☐	☐	☐
☐	25. Pricing	☐	☐	☐
☐	26. Logistics (distribution/warehouse) and inventory	☐	☐	☐
☐	27. Customer Service and after market service	☐	☐	☐
☐	28. Customer loyalty – retention and acquisition	☐	☐	☐
☐	29. Maintenance/asset management	☐	☐	☐
☐	30. Sustainability reporting/environmental acctg.	☐	☐	☐
☐	31. Others (please specify:	☐	☐	☐

32. Please indicate the nature of BI tools/components deployed in your organization/strategic business unit and the extent of its actual current use (in terms of low, medium or high) when compared with its full potential/functionality.

Not relevant (0)	Type of BI tools/components deployed in your organization/business unit	Extent of current use		
		Low (1)	**Medium (4)**	**High (8)**
☐	32. Data warehouse	☐	☐	☐
☐	33. Dash boards	☐	☐	☐
☐	34. Data mining	☐	☐	☐
☐	35. Data visualization tools	☐	☐	☐
☐	36. Analytics tools	☐	☐	☐
☐	37. Reporting tools	☐	☐	☐
☐	38. Excel tools	☐	☐	☐
☐	39. Others (please specify)	☐	☐	☐

Section III – Management of Business Intelligence System(s) use in your organization:

This section seeks your perceptions about the management of BI system use and the reasons in your organization/business unit in a scale of 1 to 7. If a statement is not relevant (N.R.) to your organization or there is no basis for answering, please tick the first column – NR.

1=DISAGREE Strongly **7=AGREE strongly**

No.	**In my organization/business unit**	**N.R**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
40	BI system(s) deployed provides **unlimited access** to all users	☐	☐	☐	☐	☐	☐	☐	☐
41	BI system(s) deployed offer **limited access to users** because of the **insufficient number of user licences**	☐	☐	☐	☐	☐	☐	☐	☐
42	BI system(s) deployed is **dedicated to specific power users** that require specialised functionalities	☐	☐	☐	☐	☐	☐	☐	☐
43	BI system(s) deployed effectively **matches its tool capabilities with user types**	☐	☐	☐	☐	☐	☐	☐	☐
44	BI system(s) deployed **does not meet user expectations** (disconnect between users and IT)	☐	☐	☐	☐	☐	☐	☐	☐
45	BI system(s) deployed **allows users to build their own self-serve reports** and share them with others	☐	☐	☐	☐	☐	☐	☐	☐
46	Users are allowed to **continue to use EXCEL and/or other tools for producing reports** bypassing BI system	☐	☐	☐	☐	☐	☐	☐	☐
47	It takes very **long time to run reports** using the BI system deployed (with ad-hoc queries)	☐	☐	☐	☐	☐	☐	☐	☐
48	BI system deployed **does not easily facilitate changes** with dynamic business requirements	☐	☐	☐	☐	☐	☐	☐	☐
49	**Training on the use of BI system is INADEQUATE**	☐	☐	☐	☐	☐	☐	☐	☐
50	Data sources used in BI system are reliable, consistent and/or well integrated with BI application infrastructure (such as data mart or data warehouse)	☐	☐	☐	☐	☐	☐	☐	☐
51	We have **good handling & maintenance procedures for the data** that goes into BI system(s).	☐	☐	☐	☐	☐	☐	☐	☐

Section IV – Perceptions on the Information Technology Infrastructure Capability:

This section will seek your perceptions about the IT infrastructure capability of your organization/business unit in a scale of 1 to 7. If any statement it is not relevant (N.R.) to your organization and/or there is no basis for answering, please tick the first column, i.e. N.R.

1=DISAGREE Strongly **7=AGREE strongly**

No.	**In my organization/business unit,**	N.R (0)	1	2	3	4	5	6	7
52	Our IT unit/dept. can quickly **respond to change requests** from functional lines of business	☐	☐	☐	☐	☐	☐	☐	☐
53	Our IT unit/dept can provide quick **access to new data sources** and/or integrate existing and new data sources	☐	☐	☐	☐	☐	☐	☐	☐
54	Our IT unit/dept. provides a wide range of **security and risk management** services (security policies, disaster planning, firewalls)	☐	☐	☐	☐	☐	☐	☐	☐
55	Our IT unit/dept. provides a wide range of **data management services** (key data independent of applications, centralised data warehouse, storage area networks, knowledge management)	☐	☐	☐	☐	☐	☐	☐	☐

	In my organization/business unit	N.R	1	2	3	4	5	6	7
			1=DISAGREE Strongly					7=AGREE strongly	
56	Our IT unit/dept. provides a wide range of **application infrastructure services** (centralised management of applications, middleware, mobile/wireless applications, ASP, workflow, payment transaction processing)	☐	☐	☐	☐	☐	☐	☐	☐
57	Our IT unit/dept. provides a wide range of **IT management services** (IS planning, investment and monitoring, IS project management, negotiations with suppliers and outsourcers, service level agreements)	☐	☐	☐	☐	☐	☐	☐	☐
58	Our IT unit/dept. provides a wide range of **IT education and research services** (training in the use of and generating value from IT, test new technologies, evaluate proposals for new IS applications)	☐	☐	☐	☐	☐	☐	☐	☐
59	Our IT unit/dept. ensures the **availability of high quality, timely data and information for all our key users** – employees, suppliers/partners and customers	☐	☐	☐	☐	☐	☐	☐	☐
60	Our IT unit/dept. ensures that **our hardware systems and software are reliable and user friendly** so that access is facilitated and encouraged	☐	☐	☐	☐	☐	☐	☐	☐
61	Our IT unit/dept. ensures that our **data availability mechanisms, software, and hardware are current** with changing business needs and directions	☐	☐	☐	☐	☐	☐	☐	☐

Section IV – Perceptions on the Business Process level performance outcomes:

This section will seek your perceptions about process level performance outcomes you believe BI systems have contributed to, in a scale of 1 to 7. If a particular outcome is NOT RELEVANT (N.R.) for your BI system and your organization or there is no basis for answering, please tick "N.R." first column.

No.	**BI system(s) in my organization have contributed to the following process level performance outcomes**	N.R (0)	1	2	3	4	5	6	7
			1=**DISAGREE** strongly					**7=AGREE strongly**	
62	Reduced customer return handling costs	☐	☐	☐	☐	☐	☐	☐	☐
63	Reduced marketing costs	☐	☐	☐	☐	☐	☐	☐	☐
64	Reduced time-to-market products/services	☐	☐	☐	☐	☐	☐	☐	☐
65	Improved delivery of products/services to customers	☐	☐	☐	☐	☐	☐	☐	☐
66	Created new products/services and/or improved tailoring of offers to customers	☐	☐	☐	☐	☐	☐	☐	☐
67	Improved customer retention and/or new customer acquisition	☐	☐	☐	☐	☐	☐	☐	☐
68	Improved product/service/process innovation	☐	☐	☐	☐	☐	☐	☐	☐
69	Improved coordination with & responsiveness to suppliers/partners	☐	☐	☐	☐	☐	☐	☐	☐
70	Reduced cost of transactions with suppliers/partners	☐	☐	☐	☐	☐	☐	☐	☐
71	Increased inventory turnover or reduced inventory levels	☐	☐	☐	☐	☐	☐	☐	☐

No.	BI system(s) in my organization have contributed to the following process level performance outcomes	N.R (0)	1 (1=DISAGREE strongly)	2	3	4	5	6	7 (7=AGREE strongly)
72	Improved efficiency of internal processes	☐	☐	☐	☐	☐	☐	☐	☐
73	Increased staff productivity	☐	☐	☐	☐	☐	☐	☐	☐
74	Improved the process of decision making	☐	☐	☐	☐	☐	☐	☐	☐
75	Reduced process costs	☐	☐	☐	☐	☐	☐	☐	☐
76	Contributed to the increased business process agility	☐	☐	☐	☐	☐	☐	☐	☐
77	Improved manufacturing/operations processes	☐	☐	☐	☐	☐	☐	☐	☐
78	Improved identification of opportunities for process improvements	☐	☐	☐	☐	☐	☐	☐	☐
79	Improved competencies of managers	☐	☐	☐	☐	☐	☐	☐	☐
80	Improved efficiency in internal performance reporting	☐	☐	☐	☐	☐	☐	☐	☐
81	Improved efficiency in information sharing	☐	☐	☐	☐	☐	☐	☐	☐
82	Improved efficiency of financial reporting & analysis	☐	☐	☐	☐	☐	☐	☐	☐
83	Improved process of responding to regulatory compliance requirements	☐	☐	☐	☐	☐	☐	☐	☐
84	Increased efficiency of utilising assets	☐	☐	☐	☐	☐	☐	☐	☐

Section V: Please give any other comments/feedback on the survey in the space provided below including whether there are any items in this questionnaire that are ‘irrelevant’, ‘confusing’ and/or ambiguous’.

Thank you very much for your help

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