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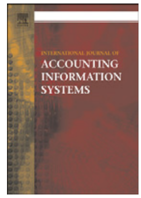

Measuring the effects of business intelligence systems: The relationship between business process and organizational performance

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ABSTRACT

Business intelligence (BI) systems provide the ability to analyse business information in order to support and improve management decision making across a broad range of business activities. They leverage the large data infrastructure investments (e.g. ERP systems) made by firms, and have the potential to realise the substantial value locked up in a firm's data resources. While substantial business investment in BI systems is continuing to accelerate, there is a complete absence of a specific and rigorous method to measure the realised business value, if any. By exploiting the lessons learned from prior attempts to measure business value of IT-intensive systems, we develop a new measure that is based on an understanding of the characteristics of BI systems in a process-oriented framework. We then employ the measure in an examination of the relationship between the business process performance and organizational performance, finding significant differences in the strength of the relationship between industry sectors. This study reinforces the need to consider the specific context of use when designing performance measurement for IT-intensive systems, and highlights the need for further research examining contextual moderators to the realisation of such performance benefits.

1. Introduction

Measuring the bottom-line contribution of information technology (IT) has long been seen as a major challenge for researchers and professionals (Kohli and Devaraj, 2003; Chan, 2000; Barua and

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Mukhopadhyay, 2000; Dehning and Richardson, 2002). Part of the challenge lies in the unique nature of different information technologies, their heterogeneous applications, and their subsequent qualitative as well as quantitative impacts. These characteristics require the use of performance measures that are specific to the technologies in question and consistent with management objectives and business plans regarding IT (Mooney et al., 1995). For instance, it may not be appropriate to use accounting measures such as firm profitability and return on investment (ROI) when measuring the business performance of a transactional IT tool such as transaction processing systems (TPS), or a typical decision support system (DSS) (Anderson and Lanen, 2002; Lucas, 1993; Liang and Tang, 1992; Weill and Olson, 1989). This is because such measures are often neither consistent with the firm's strategic intention regarding the technology, nor sufficiently close to the immediate influence of such systems.

In this study we develop a measure of business process performance and explore its relationship to an organisational performance measure, in the context of Business Intelligence (BI) systems. BI systems refer to an important class of systems for data analysis and reporting that provide managers at various levels of the organization with timely, relevant, and easy to use information, which enable them to make better decisions (Hannula and Pirttimaki, 2003). Examples of BI tools include those software and solutions which are provided by vendors such as COGNOS, Business Objects and SAS. Such BI systems typically require specialized IT infrastructure in order to function effectively, including query, analysis, and reporting tools (such as online analytical processing "OLAP", data mining tools, statistical analysis, forecasting, and dashboards), and the underlying specialized databases (such as data warehouses and data marts). BI systems are often implemented as enhancements to widely adopted ERP systems. IDC estimates that global spending on BI systems and related products is expected to reach $US6.1 billion by 2008 (Elbashir and Williams, 2007). The scale of investment in BI systems is reflective of their growing strategic importance and highlights the need for more attention in research studies.

A fundamental question is *what* benefits are achieved by organizations that use BI systems. To address this question, we model the effects of BI systems on both business process performance and organisational performance. Consistent with both accounting and information systems (IS) perspectives on performance measurement of IT investment (Dehning and Richardson, 2002; Barua et al., 1995), we expect the effect on business process performance to be reflected in organisational performance. Furthermore, we examine in this paper the interrelation of the benefits at the business process and organizational levels, and the moderating effect of context on the strength of this interrelation. Specifically, following Chiasson and Davidson (2005), we consider the effect of industry on the strength of the association between business process performance and organizational performance.

More formally the research questions addressed in this paper are:

1. *What are the performance effects of BI system use at the business process and organizational levels?*
2. *To what extent are performance effects at the business process level reflected in organizational level performance? and*
3. *Does industry affect the strength of the relation between business process performance and organizational performance?*

To address these questions effectively, in context, requires the development of new measures, as the existing literature lacks systematic attention to BI systems (Thomas, 2001; Cottrill, 1998). There are some case studies evidencing benefits generated by organizations that are successful with the use of BI systems (Hesford and Antia, 2006; Edwards, 2001, 2002, 2003), but no prior empirically validated measures. Indeed there have been several studies calling for the development of a measure for evaluating the business performance effects of BI systems (Lönnqvist and Pirttimäki, 2006; Marin and Poulter, 2004; Davison, 2001; Herring, 1999).

This study makes several contributions:

(1) *The development of a validated, reliable and easy-to-administer instrument for measuring the business process level performance impacts of BI systems*. Prior IT payoff studies, especially those which adopt the production economics approach, use aggregate measures (such as IT spending and pool of IT) to capture IT investments (Barua and Mukhopadhyay, 2000). Investigating IT investments as an aggregate neither allows researchers to engage in richer theories about IT use, nor understand the different impact of various types of IT included in that aggregate (Elbashir, 2007; Melville et al.,

2004; Orlikowski and Iacono, 2001). The methodology followed in this study enables the development of a performance measure of BI systems closely linked to the capabilities, applications, and the management objectives for deploying those technologies (Wade and Hulland, 2004; Turner and Lucas, 1985; Swanson, 1994).

(2) *A comprehensive approach to measurement linking business process level performance with organizational performance*. With the exception of a few studies (for example, Subramani, 2004; Mukhopadhyay and Kekre, 2002; Barua et al., 1995) most prior studies have measured IT payoff either at the business processes level or an organizational level, but not both. Although choice of the level of investigation is usually driven by the aim of the study, capturing both levels of BI systems performance will provide a more comprehensive conceptualisation of their performance impact (Dehning and Richardson, 2002).

(3) *An exploration of the relationship between business process level performance and organisational performance*. Following on from (2), we explore the nature of the relationship between business process level performance and organisational level performance. Understanding this relationship and the contingencies that moderate it (e.g. industry context) is essential if we are to understand how to realize at the organizational level the value potential that exists at the business process level (Melville et al., 2004; Davern and Kauffman, 2000).

The paper is organized as follows: the conceptualisation of IT and its business value, together with the process for developing the measure for business value of BI systems is discussed in the next section. The procedure followed for developing the construct measure is then presented. The method used for data collection is described, followed by the results of analysis of the statistical properties of the new measure. We explore the relationship between business process performance and organizational performance while examining the moderating effect of industry type. Finally limitations, conclusions, implications and opportunities for future research are discussed.

2. Theoretical framework

2.1. The business value of BI systems

Accounting researchers have long considered the effect on performance that is provided by investment in IT. In the early 1990s, there were many event and market valuation studies using archival data that sought to demonstrate payoff from IT investments. This work rapidly matured to consider contingencies that lead to enhanced payoff (Dehning and Richardson, 2002). Meanwhile, researchers were proposing that IT is a generic term that represents a range of different investments including physical (technical) IT, human IT, and IT applications (Melville et al., 2004; Bharadwaj, 2000; Armstrong and Sambamurthy, 1999; Hitt and Brynjolfsson, 1996). In the early 2000s, accounting researchers started to focus on specific types of IT applications, especially ERP systems, in order to create stronger and more meaningful relationships between adoption and performance effects (see Appendix A for a summary of the relevant literature). This recognizes that different IT investments are used for different purposes (e.g. supplier and customer relationship management, human resource management, and transaction processing) and therefore lead to different expected outcomes (Turner and Lucas, 1985; Weill, 1992). It is becoming increasing clear that a precise definition and measure of the business value of IT depends on what is meant by IT (Melville et al., 2004) and researchers should theorize about the specific technologies under investigation including their capabilities and context (Orlikowski and Iacono, 2001).

While performance measures must account for the specific nature of the IT resources under consideration (Wade and Hulland, 2004), a uni-dimensional perspective is unlikely to reflect the variety of management purposes for making the IT investment (Weill and Olson, 1989). IS research on the adoption of IT-intensive systems has provided many rich case studies about particular applications, the factors that affect successful implementation and consequent changes within the organization, for example changes to business processes (Arnold, 2006). This research can form the basis for multi-dimensional performance measures that are specific to a specific IT-intensive system, which will help to provide a better explanation of the relation between such an investment and its effect on organizational performance (Aral and Weill, 2004). When considering BI systems, this discussion emphasizes the need to develop a performance measure that is specific to, and captures the context of use in terms of management objectives for BI systems, as well as specific capabilities and uses of BI systems.

BI systems are rapidly being adopted to provide enhanced analytical capabilities to previously installed ERP systems, which manage and integrate a very large array of business information. BI systems are defined as *specialized tools* for data analysis, query, and reporting, (such as OLAP and dashboards) that support organizational decision-making that potentially enhances the performance of a range of business processes. BI systems are complemented by specialized IT infrastructure (including data warehouses, data marts, and Extract Transform & Load "ETL" tools) which is necessary for their deployment and effective use. The strategic performance impact of IT adoption in this domain has received relatively little research attention. To redress this deficiency we draw on rich cases studies of BI use (e.g. TDWI, 2004; Edwards, 2001, 2002, 2003; Grecich, 2000; Rasmussen, 1999), to guide the development and enhance the validity of a comprehensive measure of performance. More broadly we also recognize the importance of the context of BI systems deployment in assessing performance impacts, and thus specifically consider differences across industry sectors.

2.2. A process-oriented approach to the business value of IT

This study is founded on a synthesis of accounting research in valuing IT-intensive investments (Dehning and Richardson, 2002) and a process oriented view of IT impacts (Barua et al., 1995), now articulated as an *integrative model of IT business value* (Melville et al., 2004). Drawing upon prior research we argue that IT helps organizations to create business value through its direct impact on business processes (Ray et al., 2005, 2004; Subramani, 2004; Barua and Mukhopadhyay, 2000; Tallon et al., 2000; Armstrong and Sambamurthy, 1999; Barua et al., 1995; Davenport and Beers, 1995; Porter and Millar, 1985; Parsons, 1983). This is because IT typically provides automated support to business processes and inter-process linkages (Subramani, 2004; Mukhopadhyay and Kekre, 2002; Barua et al., 1995). As such, research on process-level benefits does not simply demonstrate that value is created; it also sheds light on how that value is provided (Barua and Mukhopadhyay, 2000; Davern and Kauffman, 2000). In order to expose a similar "locus of value" for BI systems, the process-oriented approach is followed in this study.

We adopt an industry structure perspective, using Porter's (1985) value-chain activities framework, to identify the business activities within an organization that are supported by BI systems. Porter's (1985) framework is widely used to ground measures of IT use and IT performance impact (Zhu et al., 2004; Chatterjee et al., 2002; Armstrong and Sambamurthy, 1999; Tallon et al., 2000; Mahmood and Soon, 1991; Porter and Millar, 1985). This framework partitions value chain activities into: (1) primary activities, which include inbound and outbound logistics, operations, marketing, sales, and service; and (2) support activities, which include procurement, technology development, human resources and infrastructure management. Investment in BI systems has been targeted at enhancing performance in both primary and supporting activities (Grayson, 2006; Pirttimäki et al., 2006; Head, 2004; Williams and Williams, 2003). We therefore expect that the analysis of the performance impact of BI systems on the value chain activities will enable the development of multiple process-level measures of BI systems' performance (Tallon et al., 2000). Similarly we expect that industry sector will significantly influence the relationship between business process performance and organizational performance due to inter-industry differences in value chain operations and their contribution to organizational performance.

3. Methodology for developing the construct measure

The process of developing a measure of an organization's performance attributable to BI systems is based on Churchill's (1979) methodology for designing and validating a construct. This methodology has been widely used in the literature (see, for instance, Zhuang and Lederer, 2003; Sethi and King, 1994). Churchill (1979, p.66) identifies eight stages for developing a sound measure for a construct. These stages are: (1) specify the domain of the construct, (2) generate a sample of items to operationalize the construct, (3) collect data, (4) purify measures, (5) collect new data, (6) assess reliability, (7) assess validity, and (8) develop norms. The rigorous use of Churchill's methodology helps to ensure the validity and reliability of a measure (Zhuang and Lederer, 2003). The application of each stage to the present context is presented in the following sections.

3.1. Specify the domain of the construct

BI systems are strategic information systems that organizations deploy in order to improve decision making and competitive advantage (Thomas, 2001; Nemati and Barko, 2001; Werner and Abramson, 2003). However, for organizations to achieve these advantages, BI systems need to be integrated effectively into management and operational processes. (DeVoe and Neal, 2005; Williams, 2004; Williams and Williams, 2003). Therefore, the performance impact of BI systems can be viewed on at least two levels (Lönnqvist and Pirttimäki, 2006; Cavalcanti, 2005; Bakos and Treacy, 1986): (1) improving the efficiency and effectiveness of organizational structure and business processes, i.e. the "internal strategy", and (2) outperforming other organizations in the industry, i.e. the "competitive strategy".

Using Bakos and Treacy's (1986) characterization of opportunities arising from IT, the business value of BI systems is defined and operationalized in this study at two levels:

(1) *Business process performance* includes the *operational efficiency enhancement* in various business processes that are enabled by BI systems such as cost reduction and productivity enhancement. Business process performance also includes *operational effectiveness* which relates to the benefits that arise as a result of the use of BI systems to support various value chain activities (Porter, 1996, 1985). Some of the business process benefits are expected to translate into organizational performance (Melville et al., 2004; Tallon et al., 2000). However, this is also dependent on other factors including the scope of the business process, the extent to which the business process is core to the organization, the competitive environment, competitors' actions and environmental changes (Dehning and Richardson, 2002; Melville et al., 2004; Subramani, 2004). We address concerns regarding the scope and nature of the business process by examining value impacts across the entire value chain. We consider competitive and environmental effects as proxied by a comparison of impacts across industry sectors.

(2) *Organizational performance* aggregates the BI-enabled performance across the organization (Melville et al., 2004). Metrics used to capture organizational performance (such as ROI, sales growth) represent organizational objectives and competitive advantage that strengthen the organization in relation to its competitors (Melville et al., 2004; Tallon et al., 2000; Sethi and King, 1994; Mahmood and Soon, 1991; Porter and Millar, 1985). This dimension also characterizes the strategic nature and management objectives of BI systems discussed earlier.

3.2. Generating a sample of items to measure business value of BI systems

Perception-based measurements are chosen for two reasons: (1) some of the benefits from BI systems such as business processes benefits are intangible or qualitative in nature and are therefore not available as objective measures, and (2) most of the data items are confidential or strategic in nature and therefore are not publicly available from archival sources. The use of perception-based measurement provides opportunities for insights into these intangible "quality-related" business processes benefits.

Perceptual measures have been widely used in almost all the behaviourally oriented business and management disciplines. In closely related prior research, senior executives' and middle managers' perceptions are found to be a good proxy for organizational performance impact of IT (Mahmood and Soon, 1991; Sethi and King, 1994; Tallon et al., 2000; Zhuang and Lederer, 2003). Prior studies also report high convergence and/or correlation between objective performance measures and perceptual data collected from senior executives and lower level managers (Venkatraman and Ramanujam, 1987; Ray et al., 2005).[1]

Guided by Porter's framework, an initial list of measurement items was prepared through a broad review of both the academic and professional literature on the business process and organizational performance impact of IT, with special focus on BI systems. 50 cases, reported in the *Business Intelligence Journal* during the period 1999–2004, were analysed to identify candidate items (TDWI, 2004; Edwards, 2003, 2002, 2001; Grecich, 2000; Rasmussen, 1999). All of the selected cases relate to organizations that

[1] Targeting multiple respondents from each organization in this study helps to further improve the legitimacy of the perceptual data and enables the testing for biases that arise from use of a common measurement method.

won the annual *Best Practice Awards* provided by The Data Warehousing Institute (TDWI), based on their effective and innovative use of BI systems. A measurement item, relating to business process and organizational performance of BI systems, was included in the initial draft instrument if it was identified in at least two of the selected cases. This criterion provides an initial indication that such a benefit is likely to be achieved by other organizations using BI systems and not specific to just one organization. This process resulted in 26 items which relate to business processes and organizational performance that cover the full spectrum of Porter's value chain.

3.3. Collect data and purify measure (pilot test)

The face and content validity of the survey instrument was first assessed qualitatively, as is typical of the approach adopted in prior studies (Moore and Benbasat, 1991; Torkzadeh and Doll, 1999; Tanriverdi, 2006). First, two academics with expertise in accounting and business information systems were invited to assess the items related to business processes and their conceptual consistency with Porter's value chain dimensions. Then, a further ten academics with comparable expertise provided general comments on different aspects of the survey, including the wording of the measurement items, the consistency of measurement items with the underlying construct, and their ease of interpretation by respondents. The instrument was revised according to the participants' feedback. The final list of items was structured into a survey using a seven-point-likert scale ranging from (1) “strongly disagree” to (7) “strongly agree”, together with a “no basis for answering” option.

The draft instrument was then exposed to feedback from two senior managers and two focus group meetings with four senior managers and two academics. These participants were recruited based on their work experience and research on IT and business intelligence. Participants were asked to read through the instrument and comment on whether (1) the items in the instrument that relate to one construct were consistent with each other and with the underlying concept that they aimed to measure, (2) the survey questions, instructions, and scales used were easy to understand, and (3) the sequencing of questions was appropriate. Four items were removed and others reworded as a result of this feedback.

The preliminary draft containing 22 items was then sent as part of a survey instrument to fifty senior managers, including chief executive officers, business managers, managers of MIS, senior systems analysts, and IT and knowledge management consultants. The targeted respondents were selected from a database maintained by the Department of Accounting and Business Information Systems at the University of Melbourne. The senior managers were invited to answer the survey questions in the preliminary draft and to provide feedback on the content and structure of the survey. The feedback, which suggested minor changes in the wording of the survey questions, was incorporated in the final draft of the survey. The final instrument (see Table 2 below in Section 3.5.1), retains all 22 measurement items, 14 for business process performance and 8 items for organizational performance. Appendix B provides the wording for all of the final measurement items.

3.4. Data collection

To conduct a comprehensive test of the instrument, data was collected through a large sample field survey. A purposive sampling strategy was employed that allowed the capturing of the appropriate study setting by focusing only on organizations that use the focal technology (Subramani, 2004; Purvis et al., 2001). Data collection was restricted to organizations or strategic business units (SBUs) in conglomerates that: (1) had adopted BI systems provided by a single leading international BI software vendor that had agreed to participate, and (2) were actively using the technology for their business activities according to the records of the BI system vendor. This strategy controls for factors that may confound the result, such as the effect of different BI systems provided by other BI vendors, and non-genuine responses.

The sampling frame for the study was 1873 managers in 612 organizations which use BI software from the selected BI vendor. The vendor provided a contact list of their clients under a written non-disclosure agreement. Where possible, multiple respondents from each organization were selected from the vendor's contact list including ranks such as senior business and IT executives, middle managers, and IT users. For a “small organization” which had one contact person in the list, the organization was selected if the contact person was a senior manager such as chief executive officer (CEO), chief financial officer (CFO), or chief information officer (CIO). A multiple respondent strategy was preferred because it enables the collection of rich data, mitigates against bias and enhances accuracy (Sethi and King, 1994; Huber and Power, 1985).

The survey implementation strategy was guided by Dillman (2000). A survey package that included a cover letter, survey, and reply-paid envelope were mailed out. The first reminder email was sent four weeks later to all the recipients of the original mail out. A second survey package was sent four weeks after the first reminder to those who did not respond to the survey. The final reminder was sent through email two weeks later, which also included the URL link of the web-based version of the survey. The on-line survey technique has been used in prior studies as both the sole and supplementary survey methods (Chatterjee et al., 2002; Dillman, 2000). We found no difference between on-line and paper based responses in our analyses.

On average, 3 respondents in each of the targeted organizations in the sample received the survey. Respondents from organizations with multiple strategic business units (SBUs) were asked to choose whether to answer the survey on behalf of either a SBU, or on behalf of the whole organisation. This option aims to improve the accuracy of the data collected. A total of 436 responses were received from 229 organizations with 65 of the responses received on-line. 17 responses were unusable because they contained a significant amount of missing data (50% or more) on the main variables of the study. This resulted in 419 usable responses representing 212 organizations. Thus the usable response rates are 22% and 35% per individual and organization respectively. 135 respondents chose to identify and respond on behalf of their SBUs, which is used to match other respondents from the same SBU. After combining identified SBUs with the list of organizations, the final number of organizational units in the sample was 347. Two or more responses were received from 72 of the organizational units (henceforth “organisations”).

To test the consistency of the responses, correlation of multiple responses from the same organization on the main constructs were computed following the method described by Armstrong and Sambamurthy (1999). All the correlations between two or more respondents from the same organization on the main constructs are significant ($p < .01$) with an average correlation of 0.324. These results provide strong evidence of the consistency between multiple responses from a single organization. As a consequence, the average scores from multiple respondents were used as the organizational response. Where there was a single response from an organization, the individual response is taken to represent the organization. Tests evidenced no significant differences between two types of organizational responses: individual responses and averaged responses. The final sample used in the analysis consists of data from 347 responding organizations.

An ANOVA test ($p < .05$) was used to test for non-response bias. Early and late responses were compared in paired samples of 150, 100, 50, and 40 responses. The results show that there are no significant differences on any of the variables of the study, including demographic and control variables. In addition, 91 respondents reported that they were not the correct informants to answer the survey. Another 70 sent their apology by email and quoted reasons for not responding to the survey such as “company policy not to answer surveys”, “very busy at the moment”. This tends to alleviate the concern that systematic factors (such as the level of an organization's success with BI systems) might be the reason for non-response.

Exploratory Factor Analysis (EFA) was used to perform Harman's one-factor test that examines whether a common method variance problem exists (Podsakoff and Organ, 1986). The measurement items of the business value of BI systems were used to perform two EFA tests. The first EFA test used all the items, including those that were used to measure organizational performance. In the second EFA test only business process performance items were used. The result of the two EFA tests shows that there are at least three “unrotated” factors that account for the variance in the measurement items. As there are multiple factors, and no general factor across the items the results suggests that there is no significant common method variance that threatens the quality of the data (Zhuang and Lederer, 2003).

Information was collected about industry category represented by organizations in the sample (Table 1). A large number of organizations in the sample are in the manufacturing industry (18.7%); this was followed by retail, wholesale, and distribution (14.4%) and then banking, finance, and insurance industries (12.4%). Hospitality, travel, and tourism received the least representation in the sample (1.7%). The study sample was predominantly large organizations with an average of 663 employees; with average gross revenue of a little over AUD$2 billion per year.

From the demographic questions, the average age of respondents was 41.1 years, with 16.5 years of work experience. 80% of the respondents were male and 20% were female. 54% of the respondents classified

Table 1
Distribution of industries represented in the sample

Industry categories	Frequency	Percentage
Service industries:		
Banking/finance/insurance	43	12.4%
Consulting/professional service	34	9.8%
Health care	35	10.1%
Hospitality/travel/tourism	6	1.7%
Media/entertainment/publishing	11	3.2%
Telecommunications	21	6.1%
Transport/Logistics	12	3.5%
Total	*162*	*46.7%*
Non-Service Industries:		
Agricultural/mining/construction	12	3.5%
Manufacturing	65	18.7%
Retail/wholesales/distribution	50	14.4%
Total	*127*	*36.6%*
Others	36	10.4%
Missing (did not specify industry)	22	6.3%

themselves as business executives/managers, while 46% were IT executives/managers, with 13% reported that they hold both business and IT jobs. 54% of respondents reported between 5–8 years of experience with BI systems, while 26% had more than eight years of experience (Elbashir and Collier, 2005). The majority of respondents clearly have considerable experience with BI systems and are well-qualified to inform this research.

3.5. Data analysis

Multiple tests were performed to assess the construct validity and reliability (Churchill, 1979; Straub, 1989). First, exploratory factor analysis (EFA) was conducted to examine the dimensions evidenced in the data and the loading of the items on the empirically specified dimensions of the performance impact of BI systems. Second, confirmatory factor analysis (CFA) was undertaken where the “structural model” and the “measurement models” were tested simultaneously using PLS. Additionally, the output from the structural model was used to test the relation between the business process performance and organizational performance of BI systems. We describe below in detail these various analyses.

3.5.1. Exploratory factor analysis

Exploratory factor analysis (EFA) was applied to examine the underlying dimensions that group the 22 items of the business value measurement instrument. In so doing, the study follows Hair et al. (1998) as a method to derive, interpret, and validate the measurement factors.

Principal component analysis was used to extract the factors with the varimax rotation method to interpret the factors. The latent root criterion was applied to determine the number of factors in the business value measure. For a factor to be retained, it should have an eigenvalue of one or more (Hair et al., 1998). The four factors shown in Table 2 are retained based on this selection criterion, which together account for 66% of the variance amongst the original 22 items.

To refine the factors further analysis was conducted (Hair et al., 1998; Verbeke and Bagozzi, 2002). Firstly, each of the items should have a loading *greater than 0.50* on the relevant factor. The rotated component analysis matrix is reported in Table 2. Item BV1 “Improved customer service” and item BV16 “Leverage the advantages of IT upgrades…” both loaded poorly (less than 0.50) on the four factors. Secondly, items BV14 “Increased efficiency of utilizing assets” and item BV15 “increased value of assets” loaded in factors which are not theoretically consistent with the nature of the other items that loaded on the relevant factor. For instance, item BV14 is an efficiency-related measure and the most consistent dimension would be factor (3) of Table 2 which contains measurement items that relate to internal

Table 2
Initial exploratory factor analysis for the 22 items

Measurement items	Factors			
	1	2	3	4
BV1*: Improved customer service.	0.16	0.35	0.36	0.38
BV2: Improved efficiency of internal processes.	0.20	0.18	**0.83**	0.03
BV3: Increase staff productivity.	0.18	0.12	**0.81**	0.14
BV4: Reduction in the cost of effective decision-making.	0.02	0.54	**0.60**	0.07
BV5: Reduced operational cost.	0.21	0.48	**0.50**	0.17
BV6: Reduced inventory levels.	**0.53**	0.27	0.06	0.34
BV7: Reduced marketing costs.	0.15	0.35	0.10	**0.77**
BV8: Reduced customer return handling costs.	0.29	0.09	0.18	**0.79**
BV9: Reduced time-to-market products/services.	0.38	0.27	0.14	**0.67**
BV10: Reduction in the cost of transactions with business partners.	**0.70**	0.01	0.33	0.27
BV11: Improved coordination with business partners/suppliers.	**0.82**	0.16	0.25	0.07
BV12: Improved responsiveness to/from suppliers.	**0.85**	0.23	0.17	0.15
BV13: Increased inventory turnover.	**0.78**	0.29	0.00	0.22
BV14*: Increased efficiency of utilizing assets.	**0.60**	0.36	0.25	0.18
BV15*: Increased value of assets.	**0.63**	0.30	0.19	0.27
BV16*: Leverage the advantages of IT upgrades, improvement.	0.35	0.12	0.48	0.26
BV17: Increased revenues.	0.23	**0.70**	0.22	0.26
BV18: Reduction of lost sales.	0.39	**0.65**	0.03	0.29
BV19: Increased geographic distribution of sales.	0.37	**0.52**	−0.02	0.41
BV20: Enhanced profit margin.	0.24	**0.81**	0.11	0.15
BV21: Increased return on investment (ROI).	0.19	**0.79**	0.26	0.16
BV22: Improved competitive advantage.	0.19	**0.76**	0.30	0.12

Items with asterisks (*) are those which were removed from the measure.
Factor loadings in bold indicate that measurement items load higher on the relevant factor than on other factors of the construct.

efficiency benefits. Item BV15 represents organizational performance and the most consistent dimension would be factor (2) which contains organizational benefits. Consequently, the four items (BV1, BV14, BV15, and BV16) were removed from the measure in order to achieve a parsimonious and theoretically sound measure (Verbeke and Bagozzi, 2002; Hair et al., 1998; DeVellis, 1991).

A second Factor Analysis was applied to the remaining 18 items, after removing the anomalous items. The result, as presented in Table 3 shows that the 18 items loaded on four factors and the total variance of the items explained by the four factors had increased to 71%. The first factor captures the benefits of BI systems at the organizational level while the remaining three factors capture different types of benefits at the business processes level. The four factors are named: (1) organizational benefits, (2) business supplier/partners relation benefits, (3) internal processes efficiency benefits, and (4) customer intelligence benefits. Table 3 presents the final four factors with their eigenvalues, Cronbach's alpha for each factor, and items included in each factor.

3.6. Interpretation of the factors

The process of interpreting the factors is influenced by the nature of the measurement items that measure the factor, and the item(s) that have the highest loadings in the factor (Hair et al., 1998). The results from the factor analyses confirm expectations that the business value from BI systems occurs at two distinct levels: the business process and the organizational. The statistical analysis reported above indicates that all scales have high reliability and validity. Furthermore, business process performance is a latent second-order factor; it reflects an underlying phenomenon that explains why the three first-order factors co-vary (Jarvis et al., 2003), each of which is measured by at least three items. The following is an interpretation of the process-level benefits of three sub-constructs established by the factor analysis:

(1) *Business supplier/partner relation benefits* include benefits that organizations gain from improved relations with business partners and suppliers, such as reduction in transaction costs, enhanced coordination with business suppliers and partners, and better inventory management.

Table 3
Factor analysis (rotated) for the performance measures

	Factor 1	Factor 2	Factor 3	Factor 4
Factor (1) organizational benefits:				
Eigenvalue = 8.33; Variance explained 46.30%; Cronbach's alpha = 0.90				
BV17: Increased revenues.	**0.71**	0.19	0.24	0.23
BV18: Reduction of lost sales.	**0.71**	0.35	0.03	0.26
BV19: Increased geographic distribution of sales.	**0.61**	0.32	−0.06	0.38
BV20: Enhanced profit margin.	**0.79**	0.19	0.20	0.17
BV21: Increased return on investment (ROI).	**0.75**	0.13	0.33	0.16
BV22: Improved competitive advantage.	**0.74**	0.18	0.37	0.09
Factor (2) business supplier/partner relation benefits:				
Eigenvalue = 1.85; Variance explained = 10.29%; Cronbach's alpha = 0.89				
BV11: Improved coordination with business partners/suppliers.	0.20	**0.85**	0.24	0.06
BV10: Reduction in the cost of transactions with business partners/suppliers.	0.00	**0.72**	0.34	0.33
BV12: Improved responsiveness to/from suppliers.	0.27	**0.85**	0.18	0.16
BV13: Increased inventory turnover.	0.36	**0.75**	−0.01	0.24
BV6: Reduced inventory levels.	0.30	**0.53**	0.08	0.36
Factor (3) internal processes efficiency benefits:				
Eigenvalue = 1.51; Variance explained = 8.41%; Cronbach's alpha = 0.82				
BV2: Improved efficiency of internal processes.	0.16	0.21	**0.81**	0.04
BV3: Increase staff productivity.	0.10	0.19	**0.80**	0.17
BV4: Reduction in the cost of effective decision-making.	0.48	0.00	**0.67**	0.09
BV5: Reduced operational cost.	0.45	0.18	**0.54**	0.20
Factor (4) customer intelligence benefits:				
Eigenvalue = 1.05; Variance explained = 5.85%; Cronbach's alpha = 0.82				
BV8: Reduced customer return handling costs.	0.30	0.15	0.09	**0.83**
BV7: Reduced marketing costs.	0.09	0.14	0.40	**0.77**
BV9: Reduced time-to-market products/services.	0.31	0.15	0.34	**0.67**

Factor loadings in bold indicate that measurement items load higher on the relevant factor than on other factors of the construct.

(2) *Internal processes efficiency benefits* refer to benefits that arise from improvement in the efficiency of internal processes such as enhanced staff productivity and the reduction of operational costs.
(3) *Customer intelligence benefits* are the most cited benefits in BI literature. Customer intelligence benefits arise from a better understanding of customers' buying habits, prediction of customers' future needs, and introducing new products and services accordingly (Cottrill, 1998; Head, 2004; Marin and Poulter, 2004; Cavalcanti, 2005; Fuller, 2006). Such benefits include reduction in the time to develop and deliver new products and services, providing customers with what they want, and reducing the cost associated with unhappy customers. Moreover, customer segmentation, which is supported by BI systems, enables organizations to reduce marketing costs by targeting customers more precisely.

Unsurprisingly, the three dimensions of business process benefits from BI systems that were evidenced in the factor analysis were consistent with the dimensions of Porter's (1985) value chain activities, specifically: inbound logistics (supplier/partner relation benefits), operations (internal processes efficiency benefits), and customers (customer intelligence benefits). Empirically, our desire for a measure that captures multiple dimensions of Porter's value chain activities appears to be supported. The three dimensions of the business process benefits measure are also collectively consistent with instruments proposed in prior IT payoff studies; although no prior study has presented as comprehensive a set of measures, specific to a particular type of IT, as we have done here. For instance, Mahmood and Soon (1991) argue that IT improves organizations' performance along the value chain of the firm in three dimensions: (1) performance benefits upstream (inter-organizational efficiency and coordination with suppliers), (2) internally (economics of production and internal organizational efficiency), and (3) downstream (marketing, sales, and the after sales service). Tallon et al. (2000) decompose a measure of performance

Table 4
PLS Measurement model loading and *t*-statistics

Item	Factor load	Standard error	*t*-Statistics
Business supplier/partner relation benefits: (Composite Reliability = 0.92, AVE = 0.69)			
BV6: Reduced inventory levels.	0.73	0.03	22.34
BV10: Reduction in the cost of transactions with business partners.	0.79	0.03	28.21
BV11: Improved coordination with business partners/suppliers.	0.87	0.02	55.86
BV12: Improved responsiveness to/from suppliers.	0.90	0.01	85.69
BV13: Increased inventory turnover.	0.85	0.02	42.63
Internal Processes efficiency Benefits: (Composite Reliability = 0.88, AVE = 0.65)			
BV2: Improved efficiency of internal processes.	0.83	0.02	36.47
BV3: Increase staff productivity.	0.81	0.03	24.44
BV4: Reduction in the cost of effective decision-making.	0.80	0.03	28.69
BV5: Reduced operational cost.	0.79	0.03	31.06
Customer Intelligence Benefits: (Composite Reliability = 0.90, AVE = 0.74)			
BV8: Reduced customer return handling costs.	0.86	0.02	37.37
BV7: Reduced marketing costs.	0.85	0.02	36.85
BV9: Reduced time-to-market products/services.	0.87	0.01	60.70
Organizational (Strategic) Performance: (Composite Reliability = 0.92, AVE = 0.67)			
BV17: Increased revenues.	0.82	0.02	36.11
BV18: Reduction of lost sales.	0.81	0.02	41.02
BV19: Increased geographic distribution of sales.	0.73	0.03	23.74
BV20: Enhanced profit margin.	0.86	0.02	44.61
BV21: Increased return on investment (ROI).	0.83	0.02	34.83
BV22: Improved competitive advantage.	0.83	0.02	38.62

impact of IT into upstream dimension (inbound logistics), internal dimension (internal operations and production), and downstream dimension (sales, marketing support, and customer service). In addition, Zhu et al. (2004) decompose the performance impact of IT measure into upstream (procurement costs and coordination with suppliers) internal dimension (including efficiency of internal processes and staff productivity), and downstream impact (including effect on sales and customer service).

The organizational dimension of the performance measure identified in this study is consistent with the classification of BI systems as strategic tools, and that organizations use BI systems with strategic objectives to achieve competitive advantage (Cottrill, 1998; Thomas, 2001; Williams and Williams, 2003).

3.7. Assessment of measurement properties

Partial Least Squares (PLS) analysis is designed to maximize the variance explained in all endogenous constructs, and therefore, is most suitable for prediction and the theory building objectives of this study. PLS also makes no distributional assumptions as compared with other structural equation modelling techniques like LISREL (Gefen et al., 2000; Chin et al., 2003, 1996; Hulland, 1999; Mathieson et al., 2001). Results of a multivariate normality test (Mardia, 1970) shows that the data collected are multivariate non-normal (t=24.55, P<0.001). Therefore, covariance-based SEM techniques such as AMOS and LISREL are not appropriate. PLS can also be used to estimate the validity and reliability scores of the measurement models:

(1) *Reliability*: The PLS analysis of reliability is reported in Table 4 and was entirely consistent with the factor analysis and Cronbach's Alpha reported in Table 3. Composite reliability for all the measures varies between 0.82 and 0.92, well above the acceptable limit of 0.70 (Nunnally, 1978).
(2) *Content validity*: The items used in the measure are supported by a thorough literature review. The measure was also subjected to rigorous refining processes including interviews, peer review, focus group meetings, and quantitative tests. These checks add to the confidence placed on the content validity that the measures reflect the reality of the measured domain.

Table 5
Correlation matrix with AVE statistics

Latent Construct/Variable	(1)	(2)	(3)	(4)
(1) Organizational	**0.82***			
(2) Internal processes	0.60	**0.81***		
(3) Supplier/Partner Relation	0.59	0.48	**0.83***	
(4) Customer Intelligence	0.61	0.44	0.60	**0.86***

* Values on the diagonal represent the square root of each construct's AVE.

(3) *Convergent validity*: The *t*-statistics of each factor loading, along with the average variance extracted (AVE) is used to examine convergent validity of each construct's measure (Chin, 1998b). As a guideline, items with loading of 0.70 or above should be retained (Hulland, 1999) and this applies to all the measurement items, as shown in Table 4. Moreover, average variance extracted (AVE) for all factors that comprise the business value measure are above 0.50, which indicates that each of the factors explain more than 0.50 of the variation in the observed variables.
(4) *Discriminant validity*: Table 5 shows the values of the square root of the AVE are all greater than the inter-construct correlations. A stricter test of using AVEs, instead of the square root of AVE, leads to the same conclusion. These results suggest that the measures exhibit satisfactory discriminant validity.

Following prior studies (Chin, 1998a,b; Gefen et al., 2000), discriminate validity was also tested by ensuring that all measurement items had higher loading on its assigned factor than on the other factors. Table 6 reports the results of this test which is consistent with the factor analysis reported in Table 3. Each of the measurement items loaded higher on the construct they are intended to measure (above 0.70) than on the other constructs (Chin, 1998a,b; Gefen et al., 2000). These results provide further support for the discriminant validity of the measure of the performance of BI systems developed in this study.

4. The relation between business process and organizational performance

Fig. 1 depicts the relation between the business process performance of BI systems and organizational performance. The derivation of the second-order factor *business process performance* was discussed in

Table 6
Measurement items loading and cross-loading

Items	Organizational	Internal processes	Business suppliers/partners	Customer intelligence
BV17	**0.82**	0.52	0.47	0.51
BV18	**0.81**	0.41	0.56	0.53
BV19	**0.73**	0.34	0.51	0.55
BV20	**0.86**	0.49	0.48	0.47
BV21	**0.83**	0.58	0.44	0.47
BV22	**0.83**	0.57	0.45	0.45
BV2	0.40	**0.83**	0.38	0.28
BV3	0.39	**0.81**	0.39	0.34
BV4	0.55	**0.80**	0.31	0.35
BV5	0.58	**0.79**	0.46	0.43
BV6	0.48	0.37	**0.73**	0.50
BV10	0.41	0.43	**0.79**	0.51
BV11	0.48	0.43	**0.87**	0.44
BV12	0.55	0.44	**0.90**	0.52
BV13	0.55	0.33	**0.85**	0.52
BV7	0.56	0.38	0.45	**0.86**
BV8	0.45	0.36	0.53	**0.85**
BV9	0.56	0.39	0.56	**0.87**

Factor loadings in bold indicate that measurement items load higher on the relevant factor than on other factors of the construct.

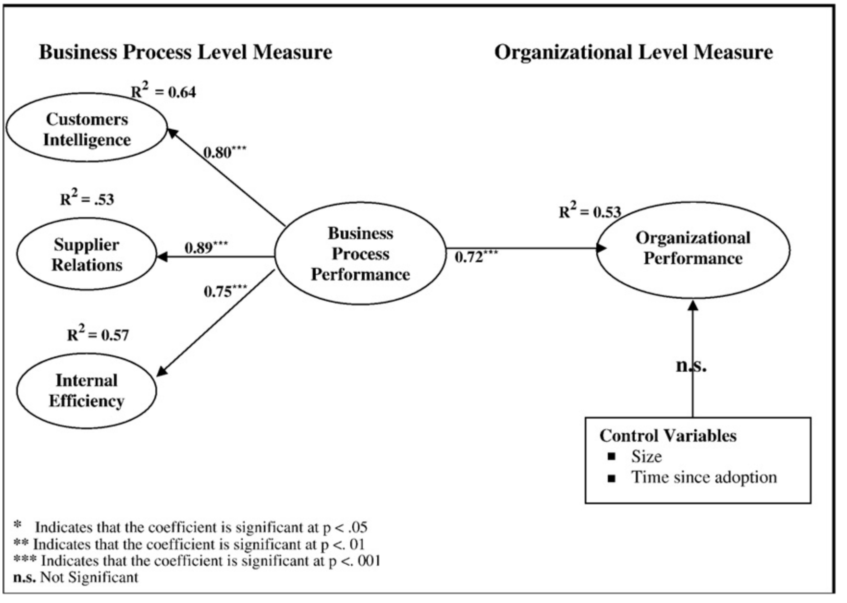

Fig. 1. The performance impact of BI systems.

Section 3.6, and is consistent with Porter's value chain activities. Following prior research, two control variables, *time since adoption* and *firm size*, are included in the model.

(1) *Firm size* is used in prior IS literature to proxy for the size of the organization resource base that can enhance IT performance (Zhu et al., 2004; Subramani, 2004). Large firms are more able to invest speculatively in different activities that support IT such as employee training (Chatterjee et al., 2002; Subramani, 2004). Two variables, number of employees and gross revenue of the firm, are used to measure firm size.
(2) *Time since adoption of the BI System* was used to control for the length of time organizations had deployed the BI system. A longer period may enable organizations to develop expertise to use the system more effectively to generate business benefits (Purvis et al., 2001).

Neither firm size or time since adoption proved to be significant.

Initially, the PLS technique was applied to test the significance of parameter estimates of the structural model paths presented in Fig. 1. The bootstrapping approach is applied as the resampling technique to estimate the significance (*t*-value) of the paths using 500 samples which were drawn from the complete sample.

The result indicates a positive and significant relation between business process performance and its three reflective factors.[2] The result also shows a positive and significant relation between business process performance and organization performance. The R^2 indicates that 53% of the variation in the organizational performance is explained by the business process benefits of BI systems. These findings provide support to

[2] Business process performance is specified as reflective model. The choice of a reflective measurement model (as opposed to a formative model) follows the criteria of Jarvis et al. 2003. Specifically, our measurement items exhibit high correlation, and the direction of causality flows from the latent construct (business process performance) to the measurement items, which suggests a reflective model is appropriate. We view the various dimensions of business process performance captured by the measurement items as manifestations or reflections of the underlying business process performance effects of the BI system. Thus the causality is from business process performance to the measurement items and a reflective model is appropriate.

Table 7
The moderating effect of industry type on organizational performance

	Coefficients	*T*-value	Level of significance
Constant	1.191	4.010	0.000
Business Process Performance	0.671	11.926	0.000
Non Service Industry dummy	−0.423	−2.222	0.027
Industry dummy*Business Process Performance	0.383	1.967	0.050

the two-stage measurement model developed in this study. The results are also in line with prior IT payoff studies which suggest that business processes performance of IT enhances organizational performance (Subramani, 2004; Barua and Mukhopadhyay, 2000; Barua et al., 1995).

4.1. Context of use — testing the effect of industry type

While BI software has broad applicability, as demonstrated by its significance to the three dimensions of value chain activities, it needs to be configured to suit the requirements of each individual organization. It remains possible that the fully configured BI system provides differential benefits to different types of organization or industries (Dehning and Richardson, 2002; Melville et al., 2004). Indeed, Chiasson and Davidson (2005, p. 592) argue that "Accounting for industry will help researchers determine the technical and social boundaries of IT artifacts and IS theories." Furthermore, industry can effectively proxy for the competitive and business context in which a firm operates. While there is little theory to guide a choice of industry typology, Chatterjee et al. (2002) examined a dichotomy between service and manufacturing (non-service) firms as a control in their investigation of organizational assimilation of web technologies. With only 14 non-service firms, the control was non-significant, but with our larger sample size, this typology of organisations is worthy of further examination. To this end, we compared the relationship between business process level performance and organisational performance between the two broad industry groupings: service and non-service. In our data, service firms include financial services, consulting and professional services, while non-service firms include retail and wholesale, and manufacturing (see Table 1 for details). A factor analysis of the sample partitioned into service and non-service firms reveals that all three dimensions of business process performance are significant constructs in both partitions.

To explore the differential effect of industry types on the relationship between business process and organisational performance, we postulate that industry type moderates the relationship between business process performance and organisational performance. This cannot be tested by adapting the structural equation model because PLS does not deal well with categorical variables. Instead we test a regression of organisational performance on the business process performance measure incorporating a dummy variable coding for whether a firm was a service firm (0) or a non-service firm (1). The results of the regression are shown in Table 7.

The results confirm a significant relationship between business process performance and organisational performance for both service and non-service sectors. However, there is a significant difference between service and non-service industries, with the latter showing a significantly stronger relationship between business process level performance and organisational level performance. The non-service sector would appear to be able to convert business process benefits more effectively into organisational performance improvements. This should come as no real surprise since one dimension of the process level benefits is with respect to relations with suppliers, a dimension ultimately far more critical to the organisational performance of non-service businesses than service businesses. Relations with suppliers are a far less critical part of the value chain of a service business (although still a statistically significant part of business process level performance in the service sector).

More generally, this finding provides empirical support for industry to be considered as an important element of IS research (Dehning and Richardson, 2002; Melville et al., 2004; Chiasson and Davidson, 2005). It also highlights the potential for misunderstanding the impact of IT investments when considering only organisational level performance measures. Further research exploring exactly how business process level performance translates into organisational performance, with due consideration of industry, is clearly needed.

5. Limitations

As with any study, there are several caveats to the broader application of our work. First, the population of the organizations sampled is comprised of customers of one BI software vendor. This significantly enhances the internal validity of our study and its measure (Purvis et al., 2001). By the same token, external validity may be compromised when considering other vendors that provide software with different specializations or capabilities. Secondly, benefits from BI systems are likely to evolve over time with the advancement of BI technologies and with their diffusion and innovative use by organizations. Thirdly, benefits from BI systems are likely to become more specialised as vendors offer a variety of software components or modules for specific purposes. This study therefore provides a snapshot of the impact of BI systems at a point-in-time only. Future research in organizations which use BI software provided by other BI vendors or software which has significantly advanced over time should re-validate this measure prior to its use.

This study relies on subjective "perception-based" measures at both the process and organizational level which can cause common method bias. The use of mangers' perceptions was considered appropriate because most of the data required to measure business processes performance are intangible or qualitative in nature and would be difficult, if not impossible, to collect objectively. Such information that is in-principle objective, especially at the organisational level is of strategic importance and highly confidential and therefore not openly shared. Statistical tests were conducted in an effort to discount serious threats to the quality of the data from either common method variance or poorly specified perceptual measures.

The research frameworks used as the basis of this study (Dehning and Richardson, 2002; Melville et al., 2004) identify contextual factors that may moderate the relationship between process performance and organisational performance. While we have considered a comprehensive model of business processes, controlled for firm size, and investigated the effect of industry type, other contextual variables such as specific competitive environments, competitors' actions and environmental change, amongst others, may also have effects that are not measured. Further research is needed to explore the factors that may moderate the business process to organizational performance relationship such as organizational culture, employee resistance and IT infrastructure (Davern and Kauffman, 2000).

6. Conclusion and managerial implications

In their early days, BI systems were viewed as tools that were used exclusively to support strategic decision-making. However, organizations have recently begun to further exploit the capabilities of BI systems through deploying these technologies to support wider business activities (Rogge, 2005). Organizations now use BI systems for tactical and operational process improvements, supply chain, production and customer service (Williams and Williams, 2003; Elbashir and Williams, 2007). These new developments have allowed line managers to access relevant and timely information (such as daily customer and product updates) and make better and instantaneous decisions. The dimensions of the business process benefits reported in this study demonstrate the current move in the deployment of BI systems at the operational level. The results suggest that organizations are now able to create a broad range of operational benefits along their value chain activities.

With the ever-increasing investment in BI systems, it is essential to provide a valid and reliable measure to capture the business value that arises from their deployment. The development of the measurement is timely, being prior to the commencement of a substantial amount of research about BI systems. The development of the instrument is based on sound theories, established method, and extensive collection of appropriate data. We argue that the rigorous process followed provides a high degree of confidence in the validity of the measure (Moore and Benbasat, 1991). Consistent with the recommendation in prior literature, the measure has multiple evaluative perspectives that consider both the diversity of stakeholders in BI systems as well as the candidate business processes served by BI systems (Banker et al., 1993).

The performance of BI systems cannot be fully understood by analysis only at an organizational level or only at a business process level (Barua et al., 1995). The measures of benefits at these two levels are shown to be related by this research. The organizational-level measure is an *evaluative* tool which informs managers whether the firm has realized the organizational performance benefits. While the process-level performance measure is a *diagnostic* tool, which will inform management on why/why not organizational performance is improved; i.e. which of the value chain activities is not performing effectively and therefore impacting on the expected organizational benefits. Furthermore, it is important to consider the nature of the relationship between performance at the two levels. We provide preliminary evidence that the relationship is moderated by the context of use (as proxied by broad industry sector). Further research into this complex relationship between business process level performance and organizational performance is thus necessary if we are to better understand how to realize the value of BI systems, and indeed IT investments generally.

Appendix A. Prior studies about the performance impact of IT in the accounting information systems literature

Author and Year	Subject of the study	Focal IT	Performance Measure	Level of Analysis
Dehning and Stratopoulos (2002)	Archival analysis showing increased efficiency is a distinctive benefit from IT investment.	IT (General)	ROA, NPM, TAX.	Firm level
Poston and Grabski (2001)	Archival study of ERP adoption.	ERP Systems	SG&A/Sales, COGS/Sales, NoEmp/Sales, Residual income.	Firm level
Hunton et al. (2002)	Experiment looking at financial analysts assessment of ERP announcements in small or large, healthy or unhealthy firms.	ERP Systems	Analysts' Earnings forecasts.	Firm level
Hunton et al. (2003)	Archival longitudinal study of paired fairms that adopt/non-adopt ERP systems considering firm size health.	ERP Systems	ROA, ROS, ATO, and ROI.	Firm level
Nicolaou (2004)	Archival study of ERP adoption over a two-year time frame. Considers vendor choice, implementation goal, modules implemented as moderators.	ERP Systems	Financial ratios which measure efficiency (first-order effect) and overall enterprise profitability including: ROI, ROA, OIA, ROS, OIS, CGSS, SGAS, and ES.	Firm level
Nicolaou and Bhattacharya (2006)	Archival longitudinal study that examines announcements about changes to ERP implementations.	ERP Systems	Financial ratios including ROI, ROA, OIA, ROS, OIS, CGSS, SGAS, and ES.	Operational (efficiency) and Enterprise (profitability) levels.
Rikhardsson and Kræmmergaard (2006)	Case-based examination of the impact of ERP implementation and use in Denmark.	ERP Systems	Changes in IT function, Increased IT literacy, coordination and integration of accounting and business processes, changes in financial performance (cost & income).	Firm level, but also examines the impact at the process level.
Wier et al. (2007)	Archival study of the complementarity between adoption of ERP systems and non-financial performance incentives.	ERP Systems	ROA and stock return.	Firm level
Ismail and King (2005)	Survey of alignment between AIS capacity and requirements for SMEs in Malaysia.	AIS	Manager's perception on firm performance relative to competitors on: profitability, availability of financial resources, sales growth, and image and client loyalty.	Firm level
Boulianne (2007)	Survey of Canadian business units, their typology of AIS use plus Miles and Snow strategy type.	AIS (General)	ROA, Net profit margin, and Revenue growth.	Business unit
Banker et al. (2002)	Case studies and empirical analysis of productivity improvements in 5 offices of a public accounting firm that invest in IT.	Audit software and knowledge sharing application.	Productivity (measured by monthly revenue).	Firm level

Appendix B. The survey instrument of the business value of business intelligence systems

Since it first implemented Business Intelligence Systems, the following business benefits have been achieved by my organization:

	No Basis for Answering	Strongly Disagree			Neutral		Strongly Agree	
(a) Improved customer service	0	1	2	3	4	5	6	7
(b) Improved the efficiency of internal processes	0	1	2	3	4	5	6	7
(c) Increased staff productivity	0	1	2	3	4	5	6	7
(d) Reduction in the cost of effective decision-making	0	1	2	3	4	5	6	7
(e) Reduced operational costs	0	1	2	3	4	5	6	7
(f) Reduced inventory levels	0	1	2	3	4	5	6	7
(g) Reduced marketing costs	0	1	2	3	4	5	6	7
(h) Reduced customer return handling costs	0	1	2	3	4	5	6	7
(i) Reduced time to market products/services	0	1	2	3	4	5	6	7
(j) Reduction in the cost of transactions with business partners/suppliers	0	1	2	3	4	5	6	7
(k) Improved coordination with business suppliers/partners	0	1	2	3	4	5	6	7
(l) Increased responsiveness to/from suppliers	0	1	2	3	4	5	6	7
(m) Increased inventory turnover	0	1	2	3	4	5	6	7
(n) Increased efficiency of utilizing assets	0	1	2	3	4	5	6	7
(o) Increased value of assets	0	1	2	3	4	5	6	7
(p) Leveraged the advantages of IT upgrades, improvements, and/or new developments in back-end IT systems	0	1	2	3	4	5	6	7
(q) Increased revenues/services provided	0	1	2	3	4	5	6	7
(r) Reduction of lost sales/lost services provided	0	1	2	3	4	5	6	7
(s) Increased geographic distribution of sale/services provided	0	1	2	3	4	5	6	7
(t) Enhanced profit margin/surplus	0	1	2	3	4	5	6	7
(u) Increased return on investment (ROI)	0	1	2	3	4	5	6	7
(v) Improved competitive advantage.	0	1	2	3	4	5	6	7

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