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Using the balanced scorecard in assessing the impact of BI system usage on organizational performance: An empirical study of Taiwan's semiconductor industry

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Abstract

There is currently a trend towards the integration of business intelligence (BI) systems with existing information systems in order to improve decision-making capabilities in organizations. Even though much attention has been paid to the factors influencing the adoption of BI systems, in practice there is still limited research investigating the business value of BI systems in a post-adoption environment. The motivation for this study is to examine the impact of BI system usage on organizational performance. This study develops a multidimensional measurement for assessing organizational performance, based on the balanced scorecard (BSC) approach developed by Kaplan and Norton. Data for the study were collected from 139 companies in the semiconductor industry in Taiwan and the relationships proposed in the framework were tested using Partial Least Squares method. The results indicate that higher levels of BI system usage will lead to improved financial performance indirectly through enhanced internal process, learning and growth and customer performance (non-financial performance). Moreover, higher levels of BI system usage can also lead to improved internal process, customer, and learning and growth performance in organizations. The results also show that internal process and customer performance have positive significant impact on financial performance. While learning and growth does not directly lead to the improvement of financial performance, it indirectly influences financial performance through the mediating effect of internal process performance. The findings of this study provide initial evidence that the adoption of BI systems leads to increased financial performance. The results indicate that these four BSC performance measures for BI system usage are interrelated, supporting the core premise of the BSC.

Keywords

business intelligence, balanced scorecard, non-financial performance, organizational performance; financial performance, semiconductor industry, Taiwan

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Use of business information systems can indirectly have a positive influence on financial performance through the mediating effects of internal process performance, customer performance, and learning and growth.

Introduction

Today, many organizations continue to increase their investment in implementing information technology (IT) and various types of information systems (IS), such as enterprise resource planning (ERP) and

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customer relationship management (CRM) primarily because of the belief that "IT/IS has a significant positive impact on organizational performance" (Osei-Bryson and Ko, 2004). Evaluating the impact of IT/IS on organizational performance has received considerable attention by both practitioner and academic literature (Davern and Kauffman, 2000; Irani and Love, 2000; Remenyi et al., 2000). However, previous studies that examined the relationship between investment in IT/IS and organizational performance at the firm level have reported mixed results that ranged from positive (e.g. Brynjolfsson and Hitt, 1996; Kohli and Devaraj, 2003; Stratopoulos and Dehning, 2000) to non-significant, to even a negative relationship (e.g. Weill, 1992; Strassmann, 1990; Brynjolfsson, 1993). Mooney et al. (1996) proposed that these studies provided limited insight into how productivity gains could be realized by individual firms, in spite of whether or not these studies successfully demonstrate a positive return on IT investment. Performance measurement is undoubtedly an area of great importance for both academics and practitioners. However, many companies still rely primarily on traditional financial measurements to evaluate organizational performance (Kaplan and Norton, 1996b). Despite the high levels of investment in IS, organizations have not always realized commensurate financial returns. Renkema (1998) indicated that around 70% of all IS investment had resulted in inadequate financial return. Therefore, executives had difficulties in measuring the business value of IS (Tallon et al., 2000).

Prior research on IT/IS business value for organizational performance is limited to financial measures, such as the return on investment, net present value, and the return on assets (Cronk and Fitzgerald, 1999; Martinsons et al., 1999; Poston and Grabski, 2001; Hunton, Lippincott, and Reck, 2003; Nicolaou, 2004; Li et al., 2006). Although these financial measures are suitable to quantify the business values of some early IT applications, such as transaction processing systems, they are not as well-suited for newer generations of IT applications, which provide a wide range of intangible benefits for organizations. Examples of intangible benefits could be increased user effectiveness, improved decision-making processes, and a greater consensus for the selected decision (O'Keefe, 1989; Martinsons et al., 1999). Kaplan and Norton (2001) argued that financial measurements were not sufficient for companies to measure organizational performance. They developed a Balanced Scorecard (BSC) approach, which included financial measurements, but also added measurements from three non-financial perspectives, namely customer, internal process, and learning and growth, in order to provide a comprehensive indicator of organizational performance. The BSC framework developed by Kaplan and Norton (1992) suggests a sequence of four perspectives that reflects the value creation activities of firms. The sequence begins with the learning and growth perspective, followed by internal process, customer, and financial perspectives. Core outcome measures (performance measures) within each perspective are assumed to be leading indicators of core outcome measures in the next perspective. Within each of the four BSC perspectives, performance drivers (performance measures) exist that are presumed to be leading indicators of core outcome measures (Kaplan and Norton, 2004). Several researchers (Martinsons et al., 1999; Rosemann and Wiese, 1999) indicated that the BSC approach might be an appropriate technique for helping managers to evaluate the IS performance of organizations in a holistic manner.

According to the 2015 IT spending survey results from Gartner, business intelligence (BI) continues to be the top spending priority for chief information officers (CIOs) in order to raise enterprise visibility and transparency, particularly sales and operational performance (Gartner, 2008). Furthermore, more than half of the respondents in another survey by *Information Age* (2006) stated that improving decision-making and better corporate performance management were the two main drivers of BI investment. As an increasing number of companies have adopted BI systems, there is a need to understand their impact on organizational performance. Although BI systems have been well accepted as business value creators by organizations, justification of BI value is not always clear in order to evaluate BI investment. "Measuring the business value of BI in practice is often not carried out due to the lack of measurement methods and resources" (Popovič et al., 2010). There is also a lack of research on measuring the value of BI systems. While the BSC has been applied in various contexts, empirical studies on the use of BSC for assessing performance to the specific IT application, such as BI, are lacking. Moreover, the cause-and-effect relationships among the four perspectives are fundamental to the BSC achieving its desired outcomes; little empirical work on the relationships and causality among BSC perspectives has been done.

The primary purpose of this study is to address this gap in the literature by examining how BI system usage affects four BSC performance measures and identifying significant causal relationships among BSC perspectives. By using Partial Least Squares (PLS) as the analytical tool, this work attempts to answer the following questions:

(a) How does BI system usage influence internal process, learning and growth, customer, and financial performance?
(b) How do internal process, learning and growth, and customer performance improvement influence financial performance after BI adoption?
(c) How does learning and growth performance improvement influence internal process and customer performance after BI adoption?

This research thus attempts to enhance understandings of how BI system usage influences the four perspectives of the BSC.

The remainder of the paper is organized as follows. Firstly, the relevant literature on BI systems, system usage, and performance measures is briefly discussed as motivators of this study. Next, the research framework and hypotheses of the study are developed. This is followed by the description of the research methodology and the analysis of the results. A discussion of the research findings and conclusions are presented in the final section.

Theoretical background

Business intelligence systems

Today, many organizations have already implemented ERP systems, considered to be one of the most significant and necessary business software investments for firms. ERP systems offer organizations the advantage of providing a single, integrated software system that links their core business activities such as operations, manufacturing, sales, accounting, human resources, and inventory control (Lee, 2000; Newell et al., 2003; Parr and Shanks, 2000). As more companies implement ERP systems, they have accumulated massive amounts of data in their databases. Although ERP systems are good at capturing and storing data, they offer very limited planning and decision-making support capabilities (Chen, 2001). It is widely accepted that ERP should provide better analytical and reporting functions to aid decision-makers (Chou et al., 2005). According to an Aberdeen Group survey report, business intelligence (BI) applications have the highest percentage of planned implementations by companies using ERP systems (Aberdeen Group, 2006).

As Mikroyannidis and Theodoulidis (2010) explained, the BI system was a "collection of techniques and tools, aimed at providing businesses with the necessary support for decision making" (p. 559). Moss and Atre (2003) also defined BI as being a "collection of integrated operational as well as decision support applications and databases that provided the business community with easy access to business data" (p. 4). As such, BI systems could be regarded as the next generation of decision support systems (Arnott and Pervan, 2005). Companies that adopted BI systems could empower their employees' decision-making capabilities in a faster and more reliable way. Therefore, BI systems could provide real-time information, create rich and precisely targeted analytics, monitor and manage business processes via dashboards that displayed key performance indicators, and displayed current or historical data relative to organizational or individual targets on scorecards. Since a BI system included technology for reporting, analysis, and sharing information, it could be integrated into ERP systems to maximize the return-on-investment (ROI) of ERP (Chou et al., 2005). Manglik (2006) outlined the following effects which arise from the lack of adopting BI in an organization:

- Business users spend more time acquiring and validating data than analyzing it.
- Revenue is lost due to delayed or incorrect decisions.
- Higher risk exposure is due to decisions taken based on inaccurate or delayed information.
- Opportunities are lost due to a delay in the availability of information.
- Increased maintenance costs of non-integrated and redundant data sources.
- Decreased flexibility and responsiveness to change due to inability to measure key performance indicators in a timely manner.

A typical architecture for supporting BI within an organization consists of four stages: operational data sources, data integration, data storage, and data presentation. Operational data could be derived from ERP applications, CRM applications, MES (manufacturing execution system) applications or other legacy systems in organizations, all of which provided data resources for BI. Because data could be found in all sorts of heterogeneous systems and in all sorts of formats, the quality of the integrated data must be checked. To resolve the issue of data quality, companies used ETL (extract, transform and load) software, which included reading data from its source, cleaning it up, and formatting it uniformly, and then writing it to the target repository. Data from the data integration stage was loaded into a data warehouse, which played a major role at this data storage stage. A data warehouse stored more detailed information for strategic analysis, created data consistency, and increased organizational efficiency (Manglik, 2006). Data mart was a small-scale data warehouse designed primarily for a specific function or departmental need. BI data was presented to business users from different levels of management, and BI tools facilitate data presentation, using query and reporting, OLAP, and data mining tools. At the operational level, BI systems could provide line managers with real-time information and reports about the state of operational business processes to enable them to make time-sensitive, day-to-day decisions. BI systems at a managerial level could supply senior managers with aggregated information on a weekly, monthly or quarterly basis, which provided the manager with an overall picture of the current situation and optimized business processes by identifying what trends, anomalies and behaviors need urgent management action. At a strategic level, BI systems could supply executives with highly aggregated and integrated information, which provided an overall view of the organization and aligned multiple business processes with strategic business objectives through integrated performance management and analysis (Friedman and Hostmann, 2004). Therefore, BI software allowed dynamic enterprise data search, retrieval, analysis, and explanation to support managerial decisions (Chou et al., 2005).

System usage. Over the past decade, the system usage (synonymous with use) construct has played a critical role in IS research (Barkin and Dickson, 1977; Bokhari, 2005; Schwarz and Chin, 2007). Burton-Jones and Straub (2006) stated that system usage had been employed in scholarly studies across four domains, including IS success (DeLone and McLean, 1992; Goodhue, 1995), IS acceptance (Davis, 1989; Venkatesh et al., 2003), IS implementation (Lucas, 1978; Hartwick and Barki, 1994), and IS for decision-making (Barkin and Dickson, 1977; Yuthas and Young, 1998). Ives et al. (1983) argued that system usage could be used as a surrogate indicator of IS system success. Goodhue and Thompson (1995) defined system usage as “the behavior of employing the technology in completing tasks” (p. 218) and conceptualized it as “the extent to which the information system has been integrated into each individual’s work routine” (p. 223). In a review of technology acceptance model literature, Lee, Kozar, and Larsen (2003) found that the frequency of use, amount of time using, actual number of usages, and diversity of usage were more commonly used for measuring system usage. Similarly, Burton-Jones and Straub (2006) reported that the most common measures of system usage included the extent of use, frequency of use, duration of use, decision to use (use or not use), voluntariness of use (voluntary or mandatory), features used, and task supported.

Measuring organizational performance. Measuring organizational performance can be a problem since there is not a universally recognized measure of this concept. A number of comprehensive measurement models have been employed to measure overall organizational performance, such as the European Foundation for Quality Management (EFQM) Excellence Model, the Baldrige Criteria for Performance Excellence Model, and the Balanced Scorecard Method. Each of these performance measurement models has its own specific perspectives but, in general, there are two types of organizational performance models (Wongrassamee et al., 2003). Type one includes self-assessment techniques, e.g., the Baldrige Criteria for Performance Excellence Model, and the EFQM Excellence Model, and Type two is designed to enable managers to define a set of measures to manage and improve business processes, e.g., the Capability Maturity Matrices (CMM), the Performance Pyramid, the Effective Progress and Performance Measurement (EP^2M), and the Balanced Scorecard framework. Neely, Gregory, and Platts (1995) described performance measurement as being the process of quantifying actions, where measurement was the process of quantification, and action correlates with performance. Despite the fact that performance measurement has received considerable attention, many companies still primarily rely on financial figures as their key performance indicators (KPIs), such as ROI, profit margin or cash flow (Holmberg, 2000; Kaplan and Norton, 1996b; Tangen, 2003). However, financial information is not sufficient to measure organizational performance (Holmberg, 2000).

In practice, many companies have attempted to conduct a cost-benefit analysis to assess the business value of IS, but as Ives et al. (1983) pointed out, there were three problems in using such an approach. Firstly, intangible costs and benefits of IS were difficult to quantify. Secondly, it was impossible to measure the decision-making support benefits of IS by using the cost-benefit approach. Thirdly, it was difficult to track the return on investment in IS, when the impact of IS was across business processes and value chain activities. Thus, managers found it very difficult to identify the benefits that justified their investment on IS based solely on financial data (Murphy and Simon, 2002). Rivard and Kaiser (1990) proposed that the intangible benefits of many newer generations of IS offering high returns could not be overlooked. They noted that intangible benefits included improved decision-making, customer satisfaction and enhanced employee productivity. Hares and Royle (1994) indicated that there are four main intangible benefits of IT investment, the first of which was internal process or workflow improvement, and the second was customer satisfaction related to product quality, delivery or service. The third was the capability of foreseeing the market or product trends, and the fourth was the ability to adapt to change in products or services.

Several researchers (e.g., Sedera et al., 2001; Martinsons et al., 1999; Rosemann and Wiese, 1999) indicated that BSC might help managers to evaluate the performance of IS in organizations in a holistic manner. The concept of BSC was first introduced by Kaplan and Norton in the *Harvard Business Review* (Kaplan and Norton, 1992), and the basic idea behind the introduction of the BSC was that the traditional short-term financial measures were insufficient in managing overall performance. Kaplan and Norton (1992) suggested that a multidimensional BSC performance measurement could provide a comprehensive indicator of organizational performance. The BSC was based on the principle that a performance measurement system should provide managers with sufficient information to address four important areas of concern: financial, customer, internal business processes, and learning and growth. This ensured a larger view of organizational performance by looking beyond financial measures to customer satisfaction, internal processes, and learning and growth measures (Velcu, 2007). The four perspectives of the BSC were explained briefly as follows:

1. *Financial perspective*: The major financial objective for companies is to increase shareholder value. Companies increase shareholder value through three basic objectives – productivity improvement, revenue growth, and cost structure reduction (Kaplan and Norton, 2001). Increased return on investment and increased return on asset as a measure of productivity; increased profit margins as a measure of revenue growth (Yeniyurt, 2003); reducing operating cost and increased material/asset utilization as a measure of cost structure (Yeniyurt, 2003; Hoque and James, 2000).
2. *Customer perspective*: Many companies today have converted to a customer-focused mission. The core of any business strategy is the customer-value proposition, which describes the unique mix of product and service attributes, customer relationship and firm image offered by a company. The value proposition is critical because it helps an organization to connect its internal processes, leading to improved outcomes with its customers (Kaplan and Norton, 2001). Improving quality and functionality of products as a measure of product and service attribute (Hoque and James, 2000; Kaplan and Norton, 2004); customer response time and satisfaction as a measure of customer relationship (Hoque and James, 2000); image and reputation as measure of firm image (Kaplan and Norton, 2004). The customer perspective helps organizations to focus on the external environment and allows them to understand, discover, and emphasize their customer needs (Kaplan and Norton, 1996b).
3. *Internal process perspective*: After having a clear picture of its financial and customer perspectives, an organization needs to determine how to achieve the customer-value proposition for customers and the productivity improvements to reach its financial objectives. The internal process perspective captures three critical organizational processes – operations management process, customer management process, and innovation process. In the operations management process, managers define measures that show whether the organization has achieved operational excellence by improving supply chain management, internal process, asset utilization, and capacity management. For the customer management process, managers define measures that capture the creation of customer value. For the innovation process, managers define measures that capture the

development of new products or services (Kaplan and Norton, 2001; Kaplan and Norton, 2004).

4. *Learning and growth perspective*: The learning and growth perspective highlights the role of aligning the organization's intangible assets to its strategy. This perspective involves three components of intangible assets that are essential for implementing any strategy – human capital, information capital, and organizational capital (Kaplan and Norton, 2001). Human capital represents employee skills and the know-how of the organization to react to the market demands and customer needs. Employee skills and know-how capabilities are a measure of human capital (Kaplan and Norton, 2004; Libby et al., 2004). Information capital, which comprises information systems and IT infrastructure, makes information and knowledge available to the organization. Knowledge management capabilities and accessibility of information can be used as a measure of information capital (Kaplan and Norton, 2004). Organizational capital is the ability of the organization to mobilize and sustain the process of change required to execute its strategy. Sharing of worker knowledge and shared vision, objectives and values are all measures of organizational capital (Kaplan and Norton, 2004). An organization with high organizational capital has a shared understanding of vision, objectives, and values, and culture of sharing knowledge (Kaplan and Norton, 2004).

A review of research works using the BSC for the evaluation of IT/IS is presented in Appendix A. In comparison to these studies, most studies have discussed the balance of the scorecard and how managers use BSC measures to evaluate organizational performance (Lee et al., 2008; Asosheh et al., 2010; Lee et al., 2013; Shen et al., 2015; Sedera et al., 2001). Several studies have investigated the applicability of the BSC in various industries, including private and public sectors. The most used methods of data collection are research questionnaire or personal interviews. Only a few studies confirmed the cause-and-effect relationships between the four perspectives of the BSC. For example, Wu and Chen (2014) developed a framework to examine the relationships between a stage-based diffusion of IT innovation and the four BSC performance perspectives in 187 Taiwanese firms. Their findings also confirmed the hierarchical cause-and-effect relationship structure among the four BSC performance perspectives, that is, finance at the top, customer at the next, internal process at the third, and learning and growth at the bottom. Lee et al. (2013) examined the causal relationships between the four BSC perspectives that explain the performance of SaaS (Software-as-a-Service). Their results indicate that learning and growth, internal business processes, and customer performance are causally related to financial performance, supporting the core premise of the BSC. Hoque (2014) pointed out that as the cause-and-effect relationships among the different measurement perspectives are fundamental to the BSC achieving its desired outcomes, little empirical work has been done on the relationships and causality among BSC perspectives. They also emphasized the need for research which investigates whether and how causal relationships among BSC perspectives could be the outcome of facilitating strategic organizational and employee learning, and could assess the impact on organizational strategic outcomes. To address a gap in the literature by examining BI systems impact through an organizational performance lens, the intention of this study is to address how BI system usage affects four BSC performance measures and identify significant causal relationships among BSC perspectives.

Research model and hypotheses

Although opinions about BI and its improvement in business value are generally accepted, evaluation of how investment in BI systems contributes to justification of business value has been a challenge faced by organizations. Measuring the business value of BI systems in practice is often not carried out due to the lack of measurement methods and resources (Popovič et al., 2010). There is also a lack of researches on measuring the value of BI systems. Many researchers have criticized that the traditional financial measurements are no longer sufficient to evaluate the business value of IT systems (Irani and Love, 2000; Sharif et al., 2010). Kaplan and Norton (1992) developed a BSC approach that included financial measurements; moreover, three non-financial measurements were added, namely customer, internal process, and learning and growth, in order to provide a comprehensive indicator of organizational performance. Several researches indicated that BSC might help managers to evaluate the performance of IS in organizations in a holistic manner (Sedera et al., 2001; Martinsons et al., 1999;

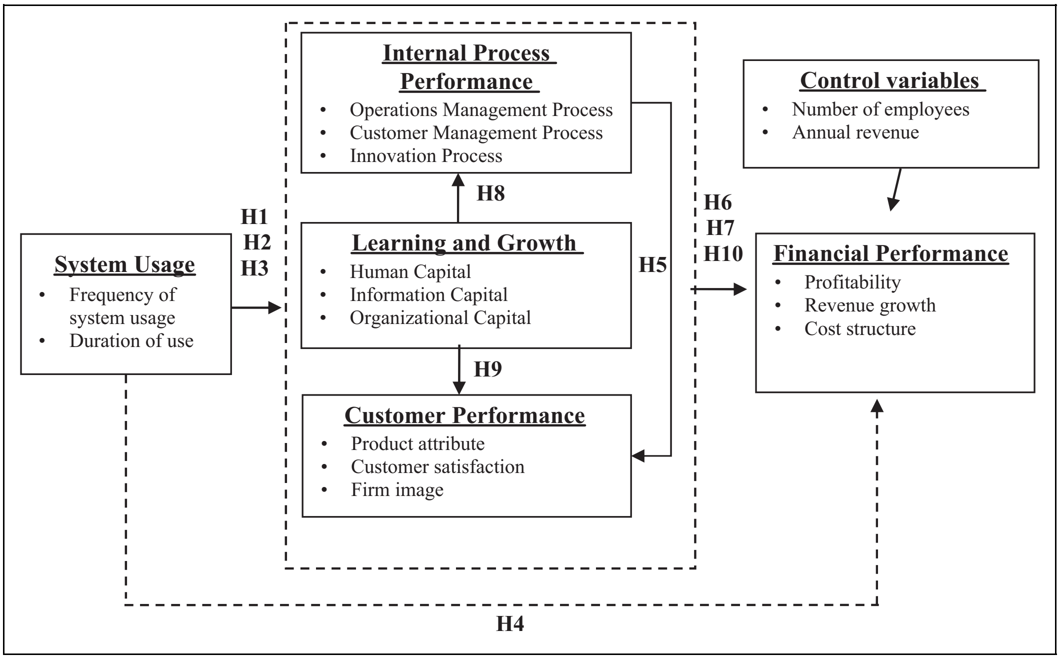

Figure 1. The research model and hypotheses.

Rosemann and Wiese, 1999). Recently, various studies have investigated the causal relationships among the four perspectives of the BSC. The causality between the four perspectives of the BSC provides a strategic map to establish a cause-and-effect logic mapping between performance measures and strategy outcomes (Wongrassamee et al., 2003). However, empirical studies that have examining the relationships and causality among BSC perspectives are still limited. To fill in the research gap, this study empirically investigates the impact of BI system usage on organizational performance based on BSC, and explores whether the cause-and-effect relationship exists among the four perspectives of the BSC. Built on the background literature discussed above, the research model underlying this study is presented in Figure 1. The research model proposes that BI system usage will have a positive impact on financial performance both directly and indirectly through internal process performance, customer performance, and learning and growth. Through the literature support, this study develops and tests hypotheses representing (a) the relationships between BI system usage and internal process, customer performance, and learning and growth, (b) the cause-and-effect relationships between financial performance and internal process, customer performance, and learning and growth, and (c) the relationship between BI system usage and financial performance. The specific hypotheses are discussed below.

Elbashir et al. (2008) found that BI systems could influence internal process efficiency, understanding of customers, and business supplier partnerships. BI could be directly integrated into an operational business process of an organization to provide users with actionable real-time information when executing their tasks (Watson et al., 2006). Therefore, BI could provide accurate up-to-date information to allow managers to monitor the outputs of a process, analyze performance gaps and take corrective action immediately. Analytic information provided by BI systems thus allowed managers to take actions to modify plans, or to optimize business processes (Richards et al., 2014). While improving decision-making capabilities was regarded as the major purpose of BI implementation for companies, there were also other benefits associated with BI system usage, including improved customer relations through in-depth sales data mining, improved customer satisfaction, reduced time to generate reports quickly, efficiency and quality increases in information processing, improving internal communication and collaboration in organizations (Wixom and Watson, 2010; Chou et al., 2005). Therefore, high organizational performance could be obtained if companies invested in their employees, information technology, and environment to support continuous performance improvement and value-creation strategies. Organizational learning and growth provided a foundation for companies to build strong decision-making capabilities, business agility, and operational excellence, which ultimately led to financial performance for their companies (Lee and Widener, 2011). Those benefits can only be realized if BI systems implemented are actually used. Thus, the following hypotheses are set forth:

H1: BI system usage is positively related to internal process performance.

H2: BI system usage is positively related to learning and growth.

H3: BI system usage is positively related to customer performance.

A limited number of studies have successfully linked IT investment and financial performance, such as an improvement of the firm's return on investment, sales growth and profitability (Brynjolfsson and Hitt, 1996; Kohli and Devaraj, 2003; Stratopoulos and Dehning, 2000). Although some of these studies have found an association between IT investment and financial performance, the linkage is indirect and complex (Lee, 2001), mainly due to the difficulty in controlling variables that impact financial performance (Chan et al., 1997). Many researchers emphasized that investing in IT was not a necessary and sufficient condition for improving a firm's performance, since IT investment may be wasted (Davern and Kauffman, 2000; Mooney et al., 1996; Tallon et al., 2000; Soh and Markus, 1995). Soh and Markus (1995) identified the relationship between IT investment and business value, focusing on how, when and why IT created business value. They proposed that IT investments should be converted into IT assets, such as IT infrastructure and applications and said that IT assets would, also have to be used appropriately to create value for the organization. Appropriate use was expected to create intermediary effects, such as improved business processes, increased customer satisfaction and enhanced decision-making capabilities, which, in turn, can be expected to affect organizational performance (Ravichandran and Lertwongsatien, 2005).

From the resource-based view (RBV) of the firm, the RBV has been applied to explain how firms can create competitive value from IT resources and capabilities to affect firm performance (Ravichandran and Lertwongsatien, 2005). Based on Barney (1991), IT resources and capabilities can be classified into three categories: physical resources, human resources, and organizational resources. Physical resources include all the tangible resources owned and used by a company, such as IT infrastructure and business applications. Human resources refers to technical and managerial expertise. Technical expertise includes application development, integration of multiple systems, and maintenance of existing systems. Managerial expertise includes the ability to identify appropriate projects, marshal adequate resources, and lead and motivate development teams to complete tasks according to specification and within time and budgetary constraints. Organizational resources include non-IT physical capital resources, non-IT human capital resources, and organizational capital resources, including organizational structure, policies and rules, workplace practices, culture, etc. (Melville et al., 2004). Following BSC perspective, a company's learning and growth measures involve three components of intangible assets: human capital, information capital, and organizational capital (Kaplan and Norton, 2001). Learning and growth measures could be considered as IT resources and capabilities. Therefore, the following hypothesis is set forth:

H4: BI system usage is indirectly and positively related to financial performance through the mediating effect of internal process performance, customer performance, and learning and growth.

The goals of internal business processes in the BSC model are to innovate and improve the process of identifying and satisfying customer demand, as well as to provide excellent customer management service afterward. Customers can then recognize that the service company provides the best customer value, and thus customer satisfaction increases. The customer's performance facilitates market share and customer profitability in the target market, achieving the organization's financial goals (Lee et al., 2013). Thus, it is expected that:

H5: Internal process performance positively affects customer performance after BI is adopted.

H6: Internal process performance positively affects financial performance after BI is adopted.

The customer's performance facilitates market share and customer profitability in the target market, allowing financial goals to be achieved. Customer performance has been proven to be a decisive factor in financial performance (Lee et al., 2013). Previous studies have suggested that customer and financial performance BSC measures are causally interrelated. Ittner and Larcker (1998) found that customer satisfaction had a significant effect on future financial performance, whereas the results of Behn and Riley (1999) indicated that customer satisfaction had an effect on future financial performance in the airline industry. Their finding suggests that increased satisfaction contributes to higher profits. Yee et al. (2010) also found a significant positive relationship between customer satisfaction and the financial performance in high-contact service industries. Mittal and Kamakura (2001) pointed out that customer satisfaction leads to customer loyalty, which in turn contributes to the profitability of a firm. Martinsons et al. (1999) proposed an IS balanced scorecard based approach to measure organizational performance. They suggested that financial performance can be increased by improved customer performance. Thus, it is expected that:

H7: Customer performance positively affects financial performance after BI is adopted.

Gonzalez-Padron et al. (2010) used BSCs to assess how organizational learning affects actions relating to global marketing strategy and subsequent financial performance. Thus, organizational change based on learning is a crucial factor for improved organizational internal process and customer service. Top management's ability to understand and learn in uncertain and competitive environments is important for business processes and customer service. Top management interprets information on behalf of organizations, and the creative learning of top management likely affects the creative learning of organizations. Thus, organizations should acquire knowledge of business environments and perform learning processes faster than competitors to maintain good business and customer relations. The learning and growth of companies is a fundamental force driving customer service performance and customer relationship management. Organizational learning occurs when individuals and subunits acquire knowledge after understanding the possibility of organizational change. Organizational learning improves the potential capability for effective actions of organizations and individuals through improved business processes and customer service (Lee et al., 2013). Chareonsuk and Chansa-ngavej (2010) identified that the learning and growth perspective influences the internal business perspective, leading to improved financial performance. Moreover, several studies found the interrelationships of learning and growth to business performance through internal process and customer performance (Bontis et al., 2000; Carmeli and Tishler, 2004; Wang and Chang, 2005). Thus, it is expected that:

H8: Learning and growth positively affect internal process performance after BI is adopted.

H9: Learning and growth positively affect customer performance after BI is adopted.

H10: Learning and growth indirectly influences financial performance through the mediating effect of internal process and customer performance after BI is adopted.

Method

Instrument development

The items used to operationalize the constructs were adapted from relevant previous studies. All scale items were rephrased to relate specifically to the context of BI systems and were measured using a 7-point Likert-type scale (from 1="strongly disagree" to 7="strongly agree"). To ensure the content validity of scales, a pre-test was conducted with five industrial experts and 10 experienced BI users in Taiwan. They were asked to evaluate the clarity of wording and the appropriateness of the items in each scale. Based on the feedback received, the wording of some questions and instructions was modified.

The measures of system usage used widely in the literature include frequency of use, duration of use, and extent of use by the individual (Leidner and Elam, 1993; Davis, 1989; Venkatesh and Davis, 2000; Hartwick and Barki, 1994; Igbaria et al., 1995; Mathieson et al., 2001). In this study, BI system usage was measured by (1) frequency of use, which was measured on a 7-point scale ranging from "1" (less than once a week) to "7" (more than 4 times a day); and (2) the duration of use by the individual, which asked individuals to indicate how much time was spent on the system per week using a seven-point scale ranging from "1" (less than 10 minutes) to "7" (more than 2 hours).

Financial performance is conceptualized as a formative second-order construct. Seven items belong to three sub-constructs: profitability, revenue growth, and cost structure. To measure the three aspects of financial performance, the measurement scale adopted for the study is based on Hoque and James (2000) and Yeniyurt (2003).

Customer performance is also conceptualized as a formative second-order construct. Seven items belong to three sub-constructs: product attribute, customer satisfaction, and firm image. Seven items were derived from previous research (Hoque and James, 2000; Kaplan and Norton, 2004; Chand et al., 2005).

Internal process performance is measured by assessing three dimensions: operations management process, customer management process, and innovation process. Three items that measure operations management process were adapted from Solano et al. (2003), and Hoque and James (2000). Customer management process is measured with three items that were developed based on Kaplan and Norton (2004). Five items for innovation process were adapted from Hoque and James (2000) and Kaplan and Norton (2004).

Learning and growth is measured by assessing three dimensions: human capital, information capital, and organizational capital. Seven items were derived from Kaplan and Norton's (2004) work to measure the learning and growth perspective.

The firm's size was used as the control variable in this study, since this was used in prior IS literature to proxy for the size of the organization resource base which could influence organizational performance (Tippins and Sohi, 2003; Hunton et al., 2003; Ravichandran and Lertwongsatien, 2005). Larger firms with more capital resources were more able to invest in different activities that support IT, such as employee training (Subramani, 2004). The firm's size was measured by its number of employees and the total annual revenue of the firm (Elbashir et al., 2008).

To ensure data reliability, the pilot study was conducted with 30 executives from four Taiwanese semiconductor companies. Each participant was asked to complete the questionnaire, evaluate the instrument and comment on its clarity and understandability (Moore and Benbasat, 1991). Cronbach's alpha coefficient was used to measure the internal consistency of the multi-item scales used in the study. The value of Cronbach's alpha for each construct was greater than 0.7, indicating satisfactory reliability level above the recommended value of 0.6 (Nunnally, 1978). Based on the feedback received, the wording of some questions and instructions was modified. The feedback from the pilot study was incorporated into the final version of the questionnaire. The final scale items used to measure each construct and their reference sources are listed in Appendix B.

Subjects and data collection

The semiconductor industry in Taiwan was selected as the focus of the study because it has been an important industry that has contributed to the economic development of Taiwan over the past few years (Lin et al., 2006). Declining prices and shortening product life cycles have forced semiconductor supply chains to be flexible and more customer-focused (Ovacik and Weng, 1995). Therefore, semiconductor manufacturers need to offer their customers on-time delivery services, improved quality, lower costs, and more customized products. In order to achieve such business objectives, semiconductor companies have found information technology (IT) to be an important tool for competing in the global market and realizing greater efficiencies in their organizations as a result of creating a more agile supply chain (Meredith, 2004). ERP systems have therefore become critical for enhancing the competitive advantage of Taiwan's semiconductor industry by integrating internal information, increasing the speed of business processes, and reducing costs in manufacturing, human resources, and management (Lin et al., 2006). As the number of semiconductor companies that have implemented ERP systems increases, the volume of data stored in their databases increases, as well. Although ERP systems are good at capturing and storing data, they offer very limited planning and decision-making support capabilities. Therefore, the main purpose of a BI implementation is to enhance capabilities and to analyze business information stored in ERP systems in order to support and improve managerial decision-making (Elbashir et al., 2008). Therefore, the semiconductor industry is likely to be fruitful ground to address the objectives of this study.

The sample frame was obtained from a report published by the Taiwan Semiconductor Industry Association (TSIA) in 2013. According to this report, there were 328 companies in Taiwan's semiconductor industry. Initial telephone screening interviews were conducted with IS executives or senior managers from the 328 Taiwan semiconductor companies in order to confirm that the selected companies were indeed using BI system. Of these, 165 companies qualified and agreed to participate in the mail survey. A contact person was identified at each company and was asked to distribute the questionnaire to a key user who had plenty of experience and knowledge in BI systems and BSC. One hundred and sixty-five (165) survey packages were sent out. Each package contained a

Table 1. Characteristics of the sample (n = 139).

Categories	Frequency	Percentage
Industry segment		
IC packaging\testing	39	28.1
IC design	37	26.6
IC foundry	28	20.1
IDM (integrated device manufacturer)	16	11.5
Others*	19	13.7
Number of employees		
100 or less	2	1.5
101 to 500	25	18.0
501 to 1,000	26	18.7
1,001 to 5,000	46	33.1
5,001 to 10,000	17	12.2
Over 10,000	23	16.5
Annual revenue (NT$ Millions)		
Below 50	4	2.9
50 to below 100	5	3.6
100 to below 500	24	17.3
500 to below 1,000	33	23.7
1,000 to below 3,000	36	25.9
3,000 and above	37	26.6
Work position		
Top-level management/ Executives	76	54.7
Middle-level management	46	33.1
First level supervisor	15	10.8
Non-management/ Professional staff	2	1.4
Organization's BI Software		
Business Objects	41	29.5
Oracle	38	27.3
SAP	32	23.0
Microsoft	13	9.3
Cognos	3	2.2
Hyperion	3	2.2
Other suppliers	9	6.5
BI experience (year)		
Less than 1	4	2.0
1-4	65	46.7
Over 5	70	50.3
Duration of BI use each week (minutes)		
Less than 20	3	1.5
20-40	20	10.0
40-90	13	6.5
90-120	29	14.5
Over 120	74	67.5
Frequency of system usage		
Less than once a week	17	8.5
About once a week	4	2.0
2 or 4 times a week	26	13.0
About once a day	15	7.5
2 or 3 times a day	20	10.0
More than 4 times a day	57	28.5

Note: *The "Others" category included wafer fabrication equipment firms, wafer material firms, etc.
US$ 1.00 ≈ NT $32.84.

cover letter, a questionnaire, and a stamped return envelope.

A total of 154 completed questionnaires were returned. However, 15 responses had to be discarded due to missing data. There were 139 valid responses and therefore, the response rate was 84.2%. The demographics of the respondents surveyed are shown in Table 1. The distribution of the industry segments in the sample included 28.1% in IC packaging and testing, 26.6% in IC design, 20.1% in IC foundry, 11.5% in IDM (integrated device manufacturers) and 13.7% in material suppliers. As for the size of the firm in terms of the number of employees, 61.9 percent of the responses can be classified as large firms (more than 1,000 employees), 18.7 percent of the responses as medium firms (501 to 999 employees), 18.0 percent of the responses as small (101 to 499 employees), and the remaining 1.5 percent had less than 100 employees. The job positions of respondents included senior managers (54.7%), middle managers (33.1%), supervisors (10.8%), and non-managers (1.4%). Most of the participants worked in the IT department (33%), followed by those in the R&D department (29%), in the financial/accounting department (26%) and in the production department (12%). Concerning BI usage experience, those who had accumulated more than 5 years' experience comprised the majority, at approximately 50.3%. Nearly half (67.5%) of the respondents used BI systems more than 120 minutes per week. More than 28.5% reported using BI systems an average of more than four times per day.

To examine the possible presence of non-response bias, a time-trend test technique was used to test for significant differences between early and late responses (Armstrong and Overton, 1977; Lambert and Harrington, 1990). The results of the chi-square tests indicated no response bias in terms of the level of management, annual revenue, and the number of employees. Since the survey data was self-reported, Harman's one-factor test was conducted to test the possible common method bias (Podsakoff and Organ, 1986). This test requires loading all items from all of the constructs into a single exploratory factor analysis to determine whether the majority of the variance was accounted for by one general factor. The result shows that the first factor accounted for 37.2% of the total 79.5% variance, indicating no evidence of common method bias in this study.

Results

This study is confirmatory in nature and the proposed research model is built on the basis of findings of previous empirical research. The structural equation modeling (SEM) method is used to test the research model presented in Figure 1. To test the research model and hypotheses, PLS analysis is used. PLS is a components-based structural modeling technique that is well suited to handling complex predictive models (Wold and Joreskog, 1982). The choice is motivated by several considerations. PLS has several advantages that made it appropriate for this study, including its ability to deal with formative as well as reflective constructs and its small sample size requirement. Because the research model includes both reflective and formative measures and the sample size is fairly small, PLS is an appropriate choice. The study utilizes the four decision criteria developed by Jarvis et al. (2003) for determining whether a construct should be conceptually modeled as reflective or formative. The first decision rule assesses the theoretical direction of causality between each construct and its measures. The construct is reflective if the direction of causality is from the construct to the measurement items. If causality is directed from the items to the construct, the construct is formative. The second rule states that the items in the formative construct are not interchangeable, but they are in the reflective construct. The third rule refers to whether the indicators should covary with each other. Reflective indicators are required to covary with one another, but formative indicators are not. The fourth rule determines whether or not the indicators have the same antecedents and consequences. Reflective indicators should have the same antecedents and consequences because they are interchangeable. However, formative indicators need not have the same antecedents and consequences because they capture different facets of the whole latent variable. These decision rules suggest to us that the constructs should be modeled as formative. In the research model, each of the four performance perspectives is mainly viewed as an explanatory combination of its indicators, for example, profitability, revenue growth, and cost structure indictors for financial performance construct. Moreover, covariance among indicators for each main construct is not necessary. Therefore, the four performance perspectives should be modeled as formative constructs, which are further determined from a combination of the first order formative indicators. Accordingly, a second-order measurement model is built to validate the scale and further, PLS is appropriate to be used in analyzing it.

PLS analysis involves two stages: (1) assessment of the measurement model, including the item reliability, convergent validity, discriminant validity, and (2) assessment of the structural model.

Measurement model

To ensure data validity and reliability, the composite reliability, convergent validity, discriminant validity, and validity of the second-order construct are examined. As illustrated in Table 2, the composite reliabilities range from 0.804 to 0.949. Furthermore, all the Cronbach's alpha values exceeded the 0.70 cutoff level (Nunnally, 1978), demonstrating adequate internal consistency. Both the composite reliability estimates and the Cronbach's alpha estimates clearly indicate reliability. Fornell and Larker (1981) suggested that the convergent validity of the measurement model is evaluated based on the average variance extracted (AVE). As shown in Table 4, AVE estimates for all the dimensions are above 0.50, as suggested by Hair et al. (1998). These results indicate that the measurement model exhibited reasonably adequate convergent validity. Finally, the discriminant validity of the measurement model is examined. To evaluate discriminant validity, Fornell and Larcker (1981) suggested a comparison between the square root of the AVE for each construct and the correlations between constructs in the model. In Table 3, the diagonal elements are the square roots of the AVEs. Off-diagonal elements are the correlations among constructs. All diagonal elements are greater than the corresponding off-diagonal elements, indicating satisfactory discriminant validity of all the constructs.

Structural model

This research uses SmartPLS 2.0 software (Ringle et al., 2005) to test the hypotheses. Bootstrapping

Table 2. Reliability and convergent validity.

Construct	No. of Items	Item loading	Cronbach's α	Composite reliability	AVE
Operations management process (OMP)	3	0.732、0.825、0.863	0.954	0.846	0.648
Customer management process (CMP)	3	0.852、0.826、0.791	0.916	0.860	0.673
Innovation process (IP)	5	0.782、0.930、0.901、0.924、0.916	0.944	0.949	0.791
Product attribute (PA)	3	0.883、0.946、0.921	0.865	0.938	0.834
Customer satisfaction (CS)	2	0.872、0.936	0.853	0.895	0.810
Firm image (FI)	2	0.932、0.915	0.918	0.916	0.846
Human capital (HC)	2	0.853、0.924	0.824	0.879	0.784
Information capital (IC)	3	0.934、0.882、0.949	0.919	0.940	0.840
Organizational capital (OC)	2	0.843、0.918	0.783	0.867	0.766
Profitability (PR)	3	0.775、0.732、0.789	0.926	0.804	0.578
Revenue growth (RG)	2	0.953、0.861	0.879	0.905	0.821
Cost structure (CST)	2	0.809、0.872	0.872	0.822	0.698
System usage (SU)	2	0.908、0.913	0.865	0.900	0.819

Note: AVE is calculated as: $\frac{\sum_{i=1}^{p}(\lambda_i^2)}{\sum_{i=1}^{p}(\lambda_i^2)+\sum_{i=1}^{p}(1-\lambda_i^2)}$, where λ_i is the standardized factor loadings for the indicators for a particular latent variable i, p is the number of items loading on each factor (Fornell and Larcker, 1981).

Table 3. Assessment of discriminant validity test[a].

Constructs	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. OMP	4.99	0.72	**0.81**												
2. CMP	4.51	0.89	0.66	**0.82**											
3. IP	4.43	0.94	0.50	0.67	**0.89**										
4. PA	4.59	0.87	0.49	0.62	0.63	**0.91**									
5. CS	4.69	0.99	0.60	0.61	0.59	0.72	**0.90**								
6. FI	4.86	1.02	0.55	0.48	0.51	0.62	0.66	**0.92**							
7. HC	4.72	0.87	0.45	0.47	0.52	0.53	0.47	0.41	**0.88**						
8. IC	4.94	0.83	0.55	0.42	0.38	0.40	0.54	0.42	0.52	**0.92**					
9. OC	4.72	0.86	0.49	0.46	0.51	0.53	0.53	0.58	0.60	0.61	**0.88**				
10. PR	4.58	0.83	0.43	0.53	0.53	0.57	0.55	0.50	0.48	0.43	0.52	**0.76**			
11. RG	4.49	0.89	0.40	0.55	0.57	0.59	0.58	0.51	0.47	0.43	0.49	0.64	**0.91**		
12. CST	4.64	0.89	0.49	0.46	0.45	0.51	0.56	0.46	0.39	0.41	0.39	0.50	0.71	**0.84**	
13. SU	3.69	1.21	0.06	-0.05	-0.10	-0.04	0.01	-0.05	-0.06	0.13	-0.08	-0.07	-0.09	0.01	**0.91**

Note: [a]Diagonal elements (in bold) represent square roots of the average variance extracted (AVE). Off-diagonal elements represent the correlations between factors.

analysis is conducted with 500 subsamples to test the statistical significance of each path coefficient using *t*-tests. Next, the coefficient of determination (R^2) for endogenous variables is estimated to assess the predictive power of the research model. The results of testing the PLS structural model are shown in Figure 2. All proposed paths among variables are significant as expected, except two paths: the path between learning and growth and customer performance (H9) and the path between learning and growth and financial performance (H10). The results of the proposed structural equation model analysis are also presented in Table 4. The results support hypotheses H1, H2, and H3, which state that BI system usage has a significantly positive effect on internal process performance, customer performance, and learning and growth (β = 0.829, $p < 0.001$; β = 0.738, $p < 0.001$; β = 0.770, $p < 0.001$). H4 is supported and indicates that BI system

Table 4. Summary of hypotheses testing.

Hypothesis	Path: from → to	Direct effect	Indirect effect	Total effect	Results
H1	BI system usage → Internal process performance	0.651*** (9.588)	0.178*** (3.431)	0.829*** (13.019)	Supported
H2	BI system usage → Learning and growth	0.738*** (12.806)	–	0.738*** (12.806)	Supported
H3	BI system usage → Customer performance	0.460*** (6.740)	0.310*** (5.245)	0.770*** (11.985)	Supported
H4	BI system usage → Financial performance	–	0.664*** (10.360)	0.664***	Supported
H5	Internal process performance → Customer performance	0.477*** (6.984)	–	0.477*** (6.984)	Supported
H6	Internal process performance → Financial performance	0.276*** (2.536)	0.243*** (5.089)	0.519*** (7.625)	Supported
H7	Customer performance →Financial performance	0.509*** (4.681)	–	0.509*** (4.681)	Supported
H8	Learning and growth → Internal process performance	0.241*** (3.550)	–	0.241*** (3.550)	Supported
H9	Learning and growth → Customer performance	−0.039 (−0.656)	–	−0.039 (−0.656)	Not supported
H10	Learning and growth → Financial performance	−0.034 (−0.422)	0.067** (1.964)	0.033** (1.542)	Not supported
	Number of employees → Financial performance	0.009 (0.166)	–	0.009 (0.166)	Not supported
	Annual revenue → Financial performance	0.098 (1.757)	–	0.098 (1.757)	Not supported

Note: Significance level: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$. t-values are in parentheses.

usage is indirectly and positively related to financial performance through the mediating effect of internal process performance, customer performance, and learning and growth. The path coefficient of the indirect effect of BI system usage on financial performance is 0.664, which is significant at $p < 0.001$ level. H5 is also supported, which indicates that internal process performance positively influences customer performance ($\beta = 0.477$, $p < 0.001$). The results also indicate that both internal process performance and customer performance have significantly positive effects on financial performance after BI is adopted ($\beta = 0.519$, $p < 0.001$; $\beta = 0.509$, $p < 0.001$), supporting H6 and H7 are supported. However, the impact of learning and growth on financial performance is not significant, indicating no support for H10. The results also show that learning and growth positively affect internal process performance after BI is adopted ($\beta = 0.241$, $p < 0.001$), thus confirming H8. Although learning and growth does not directly influence on financial performance, learning and growth has an indirect positive impact on financial performance through internal process performance. However, the impact of learning and growth on customer performance is not significant. Therefore, H9 is not supported. Although learning and growth does not have a direct impact on customer performance, learning and growth has an indirect effect on customer performance through the mediating role of internal process performance.

In addition, the coefficient of determination (R^2) of the research model shown in Figure 2 indicates how well the antecedents explain an endogenous construct. The overall R^2 for the structural model was 0.576, indicating that 57.6% of the variance in financial performance is explained by the BI system usage, internal process performance, learning and growth, and customer performance. The results also show that BI system usage explains 71.4%, 54.5%, and 80.2% of the variance in internal process performance, learning and growth, and customer performance, respectively. With regard to the effects of the control variables, the results show that the control variables, namely the number of employees and annual revenue of the firm, do not

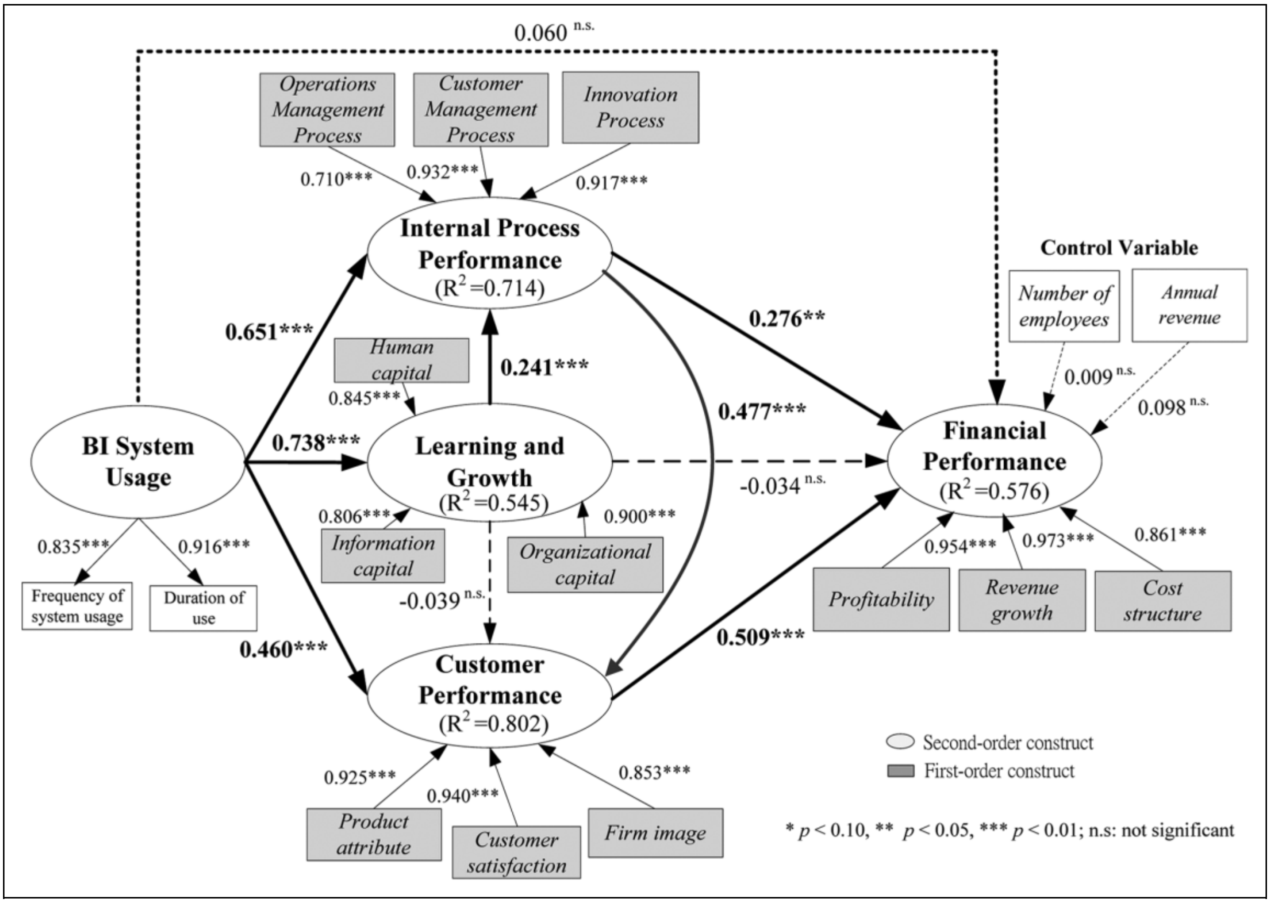

Figure 2. PLS analysis results.

significantly affect financial performance (β = 0.009, $p > 0.10$; β = 0.098, $p > 0.10$).

Discussion

Empirical studies that investigated the relationship between IS usage and organizational performance effects have reported contradictory results. The primary purpose of this study is to empirically examine whether organizations can improve their organizational performance after adopting BI systems through the use of a BSC approach. The study examines the following three research questions: (1) how does BI system usage influence internal process, learning and growth, customer, and financial performance? (2) How do internal process, learning and growth, and customer performance improvement influence financial performance after BI adoption? and (3) How does learning and growth performance improvement influence internal process and customer performance after BI adoption? Based on survey data from 139 respondents in the Taiwanese semiconductor industry, the research framework was examined using PLS method. Overall, these results provide strong empirical evidence that higher levels of BI system usage lead to improved internal process performance, learning and growth, and customer performance. This finding verifies the argument of Wixom and Watson (2010) and Chou et al. (2005), who suggested that the use of BI systems in organizations could increase customer satisfaction, improve internal communications and collaboration, and improve the quality and speed of information processing. Therefore, BI system usage could help companies sense the environment effectively, acquire, assimilate, and use knowledge by effectively coding, synthesizing, and sharing knowledge to generate new learning, and make information visible and accessible (Pavlou and El Sawy, 2010).

A review of the IT literature reveals mixed results with respect to an IT-financial performance linkage; however, overall there is no strong evidence for a direct relationship between IT and a firm's performance (cf. Brynjolfsson (1993); Mukhopadhyay et al. (1995); Hitt and Brynjolfsson (1996); Rai et al.

(1997); Mahmood et al. (1998). It is important to note that this study does not find "a direct link" from BI system usage to financial performance either. Rather, the impact of BI system usage on financial performance is indirect and heavily mediated by non-financial performance (internal process performance, learning and growth, and customer performance).

Following the process-oriented view of Soh and Markus (1995) and Mooney et al. (1996), which proposed that the use of IT is expected to create intermediary effects, such as improved business processes, which in turn could be expected to affect financial performance, this study further examines the intermediary effect of non-financial performance on the relationship between the usage of BI systems and financial performance. Consistent with Ravichandran and Lertwongsatien's (2005) findings, the empirical results indicated that non-financial performance (internal process performance, learning and growth, and customer performance) had significant mediating effects on the relationship between the usage of BI systems and financial performance. Therefore, this research proposes that managers should not expect the BI systems to directly impact financial performance, but they should be more concerned with intangible benefits associated with IS-enhanced non-financial performance. BI adoption in organizations helped individuals accomplish their tasks more effectively, increased their productivity, and improved their decision-making quality.

In addition, the results are similar to Lee et al.'s (2013) findings that the improvement in internal process performance leads to customer satisfaction, which in turn influences financial performance.

Contrary to previous predictions, the results show no significant effect of learning and growth on customer performance. However, the study found that learning and growth had an indirect effect on customer performance through internal process performance.

The results clearly indicate the mediating role of internal process performance in the influence of learning and growth on financial performance. This finding confirms Kaplan and Norton's assertion that learning and growth, the most fundamental elements of the balanced scorecard, may influence internal process, in turn influencing the financial perspective (Kaplan and Norton, 2004).

Finally, the results show that the control variables, namely, the number of employees and annual revenue of the firm, do not significantly affect financial performance.

Theoretical and practical implications

As discussed earlier, while BI systems have become increasingly important to organizations in improving decision-making capabilities and in achieving competitive advantage (Hou and Papamichail, 2010; Chou et al., 2005; Friedman and Hostmann, 2004), few empirical studies have investigated the impact of BI system usage on organizational performance based on BSC. As an increasing number of companies have adopted BI systems, there is a need to understand their impact on organizational performance.

To summarize, this present study makes a variety of theoretical and practical contributions. The study enriches the literature by providing empirical evidence of the importance of BI system usage in improving organizational performance. It also contributes by identifying significant cause-and-effect relationships among three non-financial performance (internal process performance, learning and growth, and customer performance) and financial performance supporting the core premise of the BSC. Specifically, this study demonstrated that the use of BI systems is related to improved learning and growth in organizations, which in turn enhances internal process performance, which in turn increases customer performance, which finally improves financial performance. The results provide empirical support to process-based IT studies that propose intermediate IT impacts on financial performance.

From the aspect of practical contribution, the study should enable managers to gain a better understanding of the relationships between system usage, non-financial performance, and financial performance to assess the benefits of BI system implementation. In addition, the instrument of the study can be used as a diagnostic tool to evaluate organizational performance from four perspectives of BSC while a company is using BI systems. Furthermore, this research suggests that managers should not only focus on a traditional financially-oriented evaluation (e.g., return on investment, net present value) of their IS investment, but they should also be more concerned with intangible benefits (e.g., increased capabilities and efficiencies associated with IS-enhanced business process performance).

Conclusions and limitations

This work investigates the impact of BI systems on organizational performance, based on BSC. Empirical evidence provided by a survey involving 139 companies from Taiwan's semiconductor industry is consistent with the hypothesis postulating that BI system usage can indirectly influence financial performance positively through the mediating effect of non-financial performance (internal process performance, customer performance, and learning and growth). Therefore, the results should encourage non-BI adopting companies that are considering the implementation of BI systems. Moreover, the survey instrument of the study could be employed in the post-implementation phase of BI systems as a diagnostic mechanism to establish whether the usage of the new system improved the firm's financial and non-financial performance, to examine the extent to which anticipated benefits were realized, and to identify areas for improvement.

However, some research limitations in this study should be highlighted. First, this research was conducted in a single industry and, therefore, the generalizability to other industries may be questionable. Further research is needed to determine the applicability of the results of this study to other industries. Besides, this study was conducted in Taiwan and may not reflect the results of other countries. Thus, in order to reveal cultural and market differences, it would be interesting to repeat this study in different countries, such as the United States. Secondly, this study focuses on users' perceptual measures of performance rather than on objective measures, because most of the data required to measure organizational performance are intangible or qualitative. Although all responses were anonymous, it is still possible that the respondents misrepresented their organizations' past performance measure in the survey. Thus, the use of a single respondent from each organization may generate some measure of inaccuracy and lead to common method bias (Bhatt and Grover, 2005). Future research should seek to utilize multiple respondents from each participating organization to enhance the validity of the research findings. Thirdly, this study presents a cross-sectional research. Due to the availability of data and time constraints, the study did not test and account for the time-lag effects on organizational performance following the BI system usage. Several researchers have emphasized the need for collecting longitudinal data to measure IT payoff (Mahmood and Mann, 2000; Kohli and Devaraj, 2004). Thus, there is a need to further examine the impact of BI system usage on organizational performance over a longer period of time.

Appendix A. Prior BSC studies about the evaluation of IT/IS

Study	Key issues addressed	Research methods	Key findings
Shen et al. (2015)	Intend to construct a systematic performance measurement framework based on hierarchical BSC for ERP systems.	Mail survey to 72 senior IS managers and auditors from 6 different high-tech Taiwanese firms	The study proposes a comprehensive ERP performance measurement standard that takes account of individual performance indicators when analyzing the four BSC dimensions for each high-tech firm. Numerous factors that affect ERP performance are embedded in the balanced scorecard, which can thus increase both the precision of ERP performance measurement and the effectiveness of the subsequent decision-making on the successful implementation of an ERP system.

(continued)

Appendix A. (continued)

Study	Key issues addressed	Research methods	Key findings
Wu and Chen (2014)	Propose a framework to examine the relationships between a stage-based diffusion of IT innovation and the four BSC performance perspectives	Mail survey to 187 Taiwanese firms	The three IT diffusion stages have different impacts on the four BSC performance perspectives. The findings have also confirmed the hierarchical relationship structure among the four performance perspectives in the BSC, that is, finance at the top, customer at the next, internal process at the third, and learning and growth at the bottom.
Lee et al. (2013)	Examine the causal relationships among the four BSC categories that explain the performance of SaaS (Software-as-a-service)	Telephone survey and personal interviews with 101 corporations IT staff members who used SaaS in Korea	The results indicate that learning and growth, internal business processes, and customer performance are causally related to financial performance. The results also show that these four key elements for SaaS success are interrelated, supporting the core premise of the BSC.
Asosheh et al. (2010)	Use BSC as a comprehensive framework for defining IT projects evaluation criteria	A case study: Iran Ministry of Science, Research and Technology	The proposed approach exploits BSC as a framework for defining IT project selection criteria. It is to be noted that proposed BSC for IT projects considers five perspectives – four original perspectives of BSC and an uncertainty perspective, which is added to emphasize its role in IT projects.
Lee et al. (2008)	Construct an approach based on the fuzzy analytic hierarchy process (FAHP) and balanced scorecard (BSC) for evaluating an IT department	Mail survey with 31 senior managers of IT departments in the manufacturing industry in Taiwan	This research adopts the concept of the BSC to develop a performance evaluation structure for IT department in the manufacturing industry. Fourteen most important performance indicators for IT departments are finalized. These BSC indicators can be a reference for IT departments in performance evaluation.
Chand et al. (2005)	Propose a BSC based framework for valuing the strategic contributions of an ERP system	A case study: a major international aircraft engine manufacturing and service organization in United States	The ERP valuation framework, called here an ERP scorecard, integrates the four Kaplan and Norton's BSC dimensions with Zuboff's automate, informate and transformate goals of information systems to provide a practical approach for measuring the contributions and impacts of ERP systems on the strategic goals of the company.

(continued)

Appendix A. (continued)

Study	Key issues addressed	Research methods	Key findings
Huang and Hu (2004)	Develop a framework (called the Web Services Balanced Scorecard Framework) to match potential benefits of Web services with corporate strategy in four BSC dimensions.	Case study	This BSC framework provides an example of how other IT investment initiatives could be aligned and integrated with a firm's business strategy.
Kim et al. (2003)	Develop a model for evaluation CRM (customer relationship management) effectiveness using the BSC.	A case study: an online shopping mall in Korea	The evaluation model is composed of four customer-centric perspectives: customer knowledge, customer interaction, customer value, and customer satisfaction. These four perspectives were identified by analyzing cause-and-effect relationships of the CRM process.
Sedera et al. (2001)	Uses the BSC approach to capture both financial and non-financial aspects of enterprise systems (ES) benefits measurement	A case study: the State Government of Queensland	The study proposes the BSC as an appropriate approach for measuring the performance of ES employed in the public sector.
Martinsons et al. (1999)	Develop a BSC for information systems (IS) that measures and evaluates IS activities from the following perspectives: business value, user orientation, internal process, and future readiness	A case study	The study suggests that a balanced IS scorecard can be the foundation for a strategic IS management system provided that certain development guidelines are followed and appropriate metrics are identified.
Van Der Zee and De Jong (1999)	Investigate the benefits and limitations of the BSC framework, and comparing them with other common frameworks.	Two case studies: a small European bank and a national food retailer	The study concludes that the BSC can be a valuable contributor to implementation of an integrated business and IT planning and evaluation process.

Appendix B. Questionnaire used in the survey

Part I. Basic information

Please check for your response to the questions. Please fill out your answer in the box provided to respond to open questions if need to answer.

1. Your title:
   □Top-level management (CEO/CFO/COO/CIO/President/VP/..) □Middle-level management (General Manager/Regional Manager/Divisional Manager/Plant Manager/..) □Low-level management (Department Manager/ Office manager/Supervisor/..) □Other: __________
2. Industry segment: (check any that apply)
   □IC Design □IDM (Integrated device manufacturer) □IC foundry □IC Packaging/testing
   □Others: _________
3. Number of employees (persons):
   □100 or less □101 to 500 □501 to 1,000 □1,001 to 5,000 □5,001 to 10,000 □Over 10,000
4. Annual revenue (NT$ millions):
   □Below 50 □50 to below 100 □100 to below 500 □500 to below 1,000 □1,000 to below 3,000
   □3,000 and above

5. Organization's BI Software
   □SAP □Oracle □Business Objects □Microsoft □Hyperion □Congnos □Information Builders □SAS □Other:____________
6. Years of BI operated in your organization
   □Less than 1 year □1 year to below 3 years □3 years to below 5 years □Over 5 years
7. System usage (SU): (adapted from Leidner and Elam (1993))
   (1) Duration of BI use each week (SU1): At present, how often do you use the BI system?
   □less than 10 mins. □10□20 mins. □20□40 mins. □40□60 mins. □1□1.5 hour □1.5□ 2 hour □More than 2 hour
   (2) Frequency of BI system usage (SU2): How much time you spend each week using BI system?
   □Less than once a week □About once a week □2 or 4 times a week □About once a day □2 or 3 times a day □More than 4 times a day

Part II. Organizational performance evaluation

Based on the balanced scorecard proposed by Drs. Kaplan and Norton, the organizational performance evaluation model is built to measure the organizational performance of the company. This model encompasses four perspectives, internal process performance, customer performance, learning and growth performance, and financial performance. For each survey item in the following tables, a 7-point Likert scale is used to measure the organizational performance from BI support. A scale of 1 to 7 is reproduced below, each number representing a level of performance (from 1="strongly disagree" to 7="strongly agree"). Please evaluate each attribute on the basis of this scale, and choose the appropriate number on the following table.

(1) Internal process performance (INP)
   1. Operations management process (OMP): (adapted from Solano et al. (2003) and Hoque and James (2000))
      OMP1 Improve efficiency in operational process.
      OMP2 Improve quality of operational process.
      OMP3 Enhance delivery dependability of operational process.
   2. Customer management process (CMP): (adapted from Kaplan and Norton (2004))
      CMP1 Facilitate target customer selection.
      CMP2 Facilitate customer acquisition.
      CMP3 Facilitate customer retention.
   3. Innovation process (IP): (adapted from Hoque and James (2000); Kaplan and Norton (2004))
      IP1 Identify the opportunities to develop new products or services.
      IP2 Develop new products or services more effectively.
      IP3 Reduce the cycle time of new product development.
      IP4 Extend product portfolio through collaboration.
      IP5 Increase effective production of new products.

(2) Customer performance (CUP)
   1. Product attribute (PA): (adapted from Hoque and James (2000); Kaplan and Norton (2004); Chand et al. (2005))
      PA1 Improve product or service quality.
      PA2 Enhance product or service functionality.
      PA3 Anticipate new requirements of existing customers or new customers.
   2. Customer satisfaction (CS): (adapted from Kaplan and Norton (2004))
      CS1 Reduce customer complaints.
      CS2 Shorten customer response time.
   3. Firm image (FI): (adapted from Kaplan and Norton (2004))
      FI1 Promote image and reputation.
      FI2 Increase recognition rate of corporate brand.

(3) Learning and growth performance (LGP)
   1. Human capital (HC): (adapted from Kaplan and Norton (2004))
      HC1 Improve employee skills.
      HC2 Improve know-how capabilities of employees.
   2. Information capital (IC): (adapted from Kaplan and Norton (2004))
      IC1 Improve accessibility of various information.
      IC2 Improve availability of various information.
      IC3 Improve capabilities of data analysis and interpretation.
   3. Organizational capital (OC): (adapted from Kaplan and Norton (2004))
      OC1 Increase communication by sharing of knowledge.
      OC2 Improve awareness of share vision, objectives, and value.

(4) Financial performance (FP)
   1. Profitability (PR): (adapted from Hoque and James (2000); Yeniyurt (2003))
      PR1 Increase return on investments.
      PR2 Increase return on asset.
      PR3 Increase profit margin.
   2. Revenue growth (RG): (adapted from Hoque and James (2000); Yeniyurt (2003))
      RG1 Increase sales revenue.
      RG2 Increase market share.
   3. Cost structure (CST): (adapted from Hoque and James (2000); Yeniyurt (2003))
      CST1 Reduce operating cost.
      CST2 Increase material or asset utilization

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