Factors contributing to Business Intelligence Success: The impact of Dynamic Capabilities

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Abstract:

Business Intelligence (BI) has become one of the highest priorities of CIOs today and a significant investment for many organizations. While there are a few models that are emerging to provide guidance as to factors that support successful BI, how BI systems are used has not been extensively studied relative to the benefits realized. We propose a model that would account for the nature of BI system use on BI benefits, incorporating direct measures of those benefits.

Introduction:

Business intelligence (BI)/analytics has been the largest IT investment area for CIOs over the past five years, and in the top two for nine out of the last ten years (Kappelman et al. 2013). Stories about “big data” and analytics have moved beyond a few technical publications to be featured in mainstream media on a regular basis. Given all the stories about the use or value of BI and the level of expenditures on it, one would expect that organizations are realizing significant value from these systems. While there are success stories regarding BI (Olszak 2013; Wixom et al. 2011), many organizations have yet to see value from their investments. In fact, a recent study found that only about “30% of potential users in an organization adopt CIO-sponsored analytic tools” (Kanth 2013).

Given the amount of money spent on BI, it is important to understand how to assure that the money being spent is providing benefits, or that it is successful. How to determine the success of an information system has been studied extensively. The major models developed have used characteristics of the technological artifact itself, such as information quality or system quality (Gable et al. 2003; Goslar 1986) or whether the resulting information system was used by its intended users (DeLone 1988; Ein-Dor et al. 1981; Raymond 1985; Raymond 1990; Sabherwal et al. 2006). The level of user satisfaction with the resulting system was found to be another important measure (Gallagher 1974; Ives et al. 1983; Kaye 1990; Melone 1990; Raymond 1985; Raymond 1990; Sabherwal et al. 2006), while outcomes such as impact on the organization using financial or operational measures was also found to be significant (Ahituv 1980; Dedrick et al. 2003; DeLone 1988; Gallagher 1974; Kwon et al. 2006; Meier 1995; Melville et al. 2004; Mirani et al. 1998; Oh et al. 2007; Ross et al. 1996; Wang et al. 2008).
All of the models of IS success include a measure of “user satisfaction” and “use” as antecedents of perceived net benefits, which is another way to say systems success (DeLone et al. 1992; DeLone et al. 2003). While it is reasonable to assume that if users use a system and are satisfied with it that it will generate benefits for most categories of operational information systems, BI systems are different. Just using and being satisfied with such systems are not sufficient to assure success. The outputs of BI systems consist of reports, graphs, and/or recommendations that must be followed for those systems to have benefits. In other words, just generating the outputs is not sufficient to realize benefits; the actions that users take relative to those outputs has an impact on whether benefits are realized. Therefore, it is important to include some measure of how BI outputs are used when trying to evaluate whether such systems are successful.

Even if the outputs of these systems are used effectively, the quality of the process by which the outputs were generated can impact whether they are making the appropriate recommendations. In other words, how models are built and applied using BI systems can impact whether the resulting outputs have value. As such, it is important to understand the nature of the use of those elements of these systems when evaluating their success and this must also be accounted for in our model.

Due to the unique nature of BI solutions in the mechanisms by which they deliver benefits, a model that explains how organizations can realize benefits from BI needs to be different from generalized models of information systems benefits. We hope to fill that gap through this research effort. We will develop a comprehensive model that considers antecedents to effective BI use and will evaluate the relationship between those antecedents and the real benefits realized by organizations implementing BI.

**Theoretical Background:**

In order to develop our proposed model, we begin with a view of the factors that have been recognized as contributing to BI success. A number of authors have proposed models that specifically address antecedents to BI success (Hartono et al. 2007; Hawking et al. 2010; Schieder et al. 2011; Wixom et al. 2011; Wixom et al. 2013; Yeoh et al. 2010). These models address the data used by such systems, the models or modeling tools used their linkage to business strategy, and overall organizational governance as leading to increased usage and therefore increased net benefits. All of these models incorporate the Resource Based View of a firm (Wade et al. 2004) at some level, which suggests that a firm’s resources are an important factor in how that firm retains their competitive position.

A specific resource-based model of BI benefits was recently proposed as consisting of Business Strategy, Data, and Business Analysis tools as leading to use which then leads to business value (Wixom et al. 2013). They also include overall BI governance structure as another factor that is important for supporting effective BI. They identified several factors that could help improve the
pervasiveness of use of BI tools in an organization and which would improve the “speed to insight” from those tools (Wixom et al. 2013). Still, their model doesn’t directly address the impact of how the system is used in generating business benefits. It still assumes that the use of such systems leads to organizational benefits. As such, while all of these models can provide insight to our proposed model, additional factors must be identified that would allow us to account for the nature of the use of these systems and to directly consider benefits realized through such use.

Research has been done that addresses the impact of information system use on the impact of information systems. Soh and Markus (1995) found that in order for an organization to realize benefits from IT investments, not only must the associated system be used, but it must be used “appropriately” and effectively. The authors observe that “user skill – what users actually know how to do with their applications and infrastructure – is also a critical IT asset, since “without user skill, the potential of the portfolio and the infrastructure can never be realized” (Soh et al. 1995). Another way to define this concept of user skill is competence. If the way a BI system is used can be an important aspect as to whether the desired benefits are realized, effective use is influenced by user competence. Thus, we must find a way to include this element in our model to fully understand how BI benefits are realized (Chasalow et al. 2012).

In rapidly changing markets, resources by themselves are not enough to explain an organizations competitive positioning. A term that has been used to describe the way that organizations deal with changing markets is “dynamic capabilities.” Dynamic capabilities have been defined “as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece et al. 1997). The use of BI in organizations can be seen as a dynamic capability in that the outputs of such systems are used by organizations to react to changing competitive environments. As such, there should be a way to consider how the dynamic nature of BI tools impacts their effective use.

Dynamic capability theory has been specifically used to understand how information resources can impact benefits realized from information systems (Mithas et al. 2011; Vitari et al. 2012). One of the dynamic capabilities of BI systems by which they add value is the way that they generate new information from existing data. This process of newly generated data has been referred to as “digital data genesis” (Vitari et al. 2012). In their work on digital data genesis, Vitari et al. (2012) tested a model that identified significant relationships between organizational processes, firm history, and a firm’s assets and the presence of digital data genesis dynamic capabilities. In their model they include measures that relate to the processes by which data is generated, how BI models are built, and outputs generated. This model of information systems resources and their relationship to the dynamic capability of digital data genesis can provide a core to understand the processes by which BI provides organizational benefits.
While dynamic capabilities represent a logical set of antecedents to BI benefits, we also seek to understand whether they actually contribute to the realization of those benefits. In order to do that, we must have a model to measure the effect of BI on firm performance. Such a model was proposed by Elbashir et. al. (2008). They identified specific measures of “Customers Intelligence,” Supplier Relations,” and “Internal Efficiency” that were found to have a significant relationship with organizational performance. As part of their research they developed an instrument to measure each of the elements that contribute to BI’s impact on firm performance (Elbashir et al. 2008). Their model and instrument provide a tool by which we can evaluate not just whether a BI system has been used, but specifically the impact of such use on the organization.

**Research Model:**

Combining the digital data genesis model with the BI performance measures gives us a theoretical model of BI impact on firm performance as shown in Figure 1 below:

![Figure 1. Research Model of BI dynamic capabilities on firm performance](image-url)
This model contains factors that measure the organizational capabilities that have consistently been considered to be antecedents to BI use. It also contains elements that evaluate the dynamic capabilities of digital data genesis, which represent how these systems are used. Finally, it includes measures that represent the impact of effective use of BI on an organization’s business success. This will allow us to extend existing models such that we don’t have to assume organizational benefits based on systems being used, but we can determine if effective use actually leads to those benefits.

Teece et al. (1997) present a three construct classification of the sources of organizational dynamic capability. These constructs are organizational processes, a firm’s assets, and firm history of capability. Following this framework, we posit that these constructs underpin the development of a firm’s dynamic business intelligence capabilities. We will now detail the development of this research model.

Organizational Processes

The organizational processes of sensing, learning, coordinating, and integrating can be the source of dynamic capability when the opportunity arises (Maritan 2007; Pavlou et al. 2006; Zahra et al. 2006). We argue that each of these processes has an impact on business intelligence dynamic capability. Organizational sensing is the organization’s understanding of the environment and identifying market needs and opportunities, while organizational learning relates to an organization’s developing new thinking and creating new knowledge to enhance existing resources. Organizational coordinating concerns an organization’s allocating and mobilizing resources, organizing tasks and coordinating organizational activities. Finally, integrating relates to an organization’s developing new patterns of interaction to respond to internal or external competitive changes and executing the resulting operational competency configurations. We hypothesize that companies with effective organizational processes in these areas will be better able to choose new business intelligence systems, integrate them, and manage the information the new systems produce. Thus,

H₁: Organizational sensing process has a positive impact on business intelligence dynamic capability.

H₂: Organizational learning process has a positive impact on business intelligence dynamic capability.

H₃: Organizational coordinating process has a positive impact on business intelligence dynamic capability.

H₄: Organizational integrating process has a positive impact on business intelligence dynamic capability.

Firm IT Assets
There are several different types of assets that can be sources of new dynamic capabilities: technological; financial; structure; and market-based; among others (Teece et al., 1997). With respect to business intelligence, we posit that IT assets are the most significant type of asset antecedents of the business intelligence dynamic capability (Tanriverdi, 2005). Business intelligence dynamic capability is based in IT-related and information-related processes of choosing and integrating business intelligence, managing the data, and reconfiguring in response. Thus, our focus on the firm’s antecedents of business intelligence dynamic capability is solely based on the firm’s IT assets.

There are two kinds of IT-based assets, IT infrastructure and information repositories (King et al. 1989; Piccoli et al. 2005). IT infrastructure is “the base foundation of the IT portfolio (including both technical and human assets), shared through the firm in the form of reliable services” (Broadbent et al. 1999) or functionalities (Fink et al. 2007; Pavlou et al. 2006). Business applications and services, such as those underpinning business intelligence can be built upon these infrastructures (Broadbent et al. 1997). As the extent of the infrastructure’s internal and external connectivity increases, the infrastructure’s ability to act as a source of dynamic capability increases (Broadbent et al. 1999). Similarly, as the scope of services the infrastructure can support increases, this ability to act as a dynamic capability source also increases. These aspects of the IT infrastructure influence the possibility and cost of integrating IT so as to integrate valuable business intelligence systems, and thus is an antecedent of business intelligence dynamic capability.

The second category of information technology assets is information repositories, which are “collections of logically related data, organized in a structured form, accessible and usable for decision-making purposes” (Piccoli et al. 2005). Business intelligence dynamic capabilities depend on organized data, and this data requires information repositories as antecedents. Thus, business intelligence dynamic capability is influenced directly by an organization’s information repositories. A substantial accumulation of organizational IT assets would consist of an IT infrastructure capable of supporting business intelligence dynamic capability’s technical requirements, including compatible generated business intelligence and existing infrastructure and data storage to effectively use the data. Therefore, we hypothesize:

**H₅**: The organization’s IT infrastructure has a positive impact on business intelligence dynamic capability.

**H₆**: The organization’s information repositories have a positive impact on business intelligence dynamic capability.

**Firm History**

A firm’s history outlines its existing strategic and operating position and its external relations with suppliers and complementors (Teece et al. 1997). This history will have an impact on
future opportunities for the firm, including the strategic alternatives available to it and potential returns on investment. A firm’s current dynamic capabilities will depend on its existing ones, which subsequently will constrain newer options. This is due to organizational learning tending to be local and related to existing processes (Teece et al. 1997; Zahra et al. 2006). Given that the antecedents of business intelligence dynamic capability are closely related to historically existing IT dynamic capabilities, we hypothesize that IT and information dynamic capabilities are the dynamic capabilities closest to the BI dynamic capability.

IT dynamic capability is the multi-dimensional and enterprise-wide dynamic capability to leverage IT (Bharadwaj et al. 1999). The historical dynamic capability to leverage IT will enhance an organization’s IT personnel ability to recognize the potential of emerging or enabling IT to generate and capture business intelligence data. Information dynamic capability is defined as the capacity to disseminate (Mathews et al. 2007), to apply and manage (Yoon 2005), or to process information (Lin 2005). A historically developed information dynamic capability will enable a firm to manage data and take advantage of its ability to generate business intelligence. Overall, we hypothesize that:

$$H_7:$$ The historical IT dynamic capability has a positive impact on business intelligence dynamic capability.

$$H_8:$$ The historical information dynamic capability has a positive impact on business intelligence dynamic capability.

**BI Dynamic Capability**

Business intelligence dynamic capability represents the ability of a firm to effectively gather and apply business intelligence data to enhance its competitive positioning, strategy, and operations. Business intelligence systems typically require specialized IT infrastructure in order to function effectively, including query, analysis, and reporting tools, and the underlying specialized databases (data marts and data warehouses). We define this capability as the organizational process to: 1) choose IT to generate business intelligence data; 2) integrate the business intelligence data into the appropriate business processes; and 3) managing the BR data produced so it is accessible, accurate, complete, and current (Vitari et al. 2012). The IT underpinning of a business intelligence initiative may be an emerging IT or enabling IT, either used by a firm in an innovative application.

The theory of business intelligence usage as a dynamic capability is based on two related suppositions. First, business intelligence consists of deploying “new configurations of operational competencies relative to the competition” (Pavlou et al. 2006). A firm with business intelligence dynamic capability can identify opportunities for business intelligence generation and for reconfiguring internal existing resources to adapt to changing environmental conditions. Second, the business intelligence dynamic capability includes the dynamic reconfiguring of
existing resource combinations for business intelligence generation (Pavlou et al. 2006). The degree to which and ineffective business intelligence process can be reconfigured into a more effective one that matches the environment more competitively than the competition determines the capabilities dynamic quality (Eisenhardt et al. 2000); therefore, the higher the degree of reconfigure ability, the more dynamic of the business intelligence dynamic capability is.

H0: Business intelligence dynamic capability positively impacts business process performance.

Business Process Performance

Drawing upon prior research, we argue that IT helps organizations create business value through its direct impact on business processes (Armstrong et al. 1999; Barua et al. 2000; Ray et al. 2004; Ray et al. 2005; Subramani 2004; Tallon et al. 2000) as IT typically provides automated support to business processes and process linkages (Barua et al. 1995; Mukhopadhyay et al. 2002; Subramani 2004) Thus, investigating process level benefits demonstrates not only that value is created, but also how that value is provided (Barua et al. 2000; Davern et al. 2000; Elbashir et al. 2008).

Business intelligence dynamic capability is the underpinning of business intelligence process performance, including operational efficiency enhancement (cost reduction and productivity enhancement) and operational effectiveness, the benefits from using business intelligence to support value chain activities (Porter 1996; Porter 1985). Process performance benefits include business supplier/partner relations benefits, internal process efficiency benefits, and customer intelligence benefits.

Method:

The best approach to measure dynamic capability is that the organizational process level (Li et al. 2009). Therefore, we targeted respondents who were business intelligence managers at their respective firms, or two had significant experience managing business intelligence processes. We developed a survey that measured the relationship between business intelligence dynamic capability, its antecedents, and business process performance. Measurement scales for all the contracts already exist and have been tested. Elbashir et al. (2008) developed a measure for the business process level performance impacts of business intelligence systems. We adopted these measures to form the survey. The survey instrument and literature source of the constructs are presented in Appendix A.

Preliminary Results:

We are currently in the process of collecting data. This data will allow us to evaluate the hypotheses developed above.
Discussion:

We expect the data to validate the concept that BI represents a dynamic capability of a firm and that such a capability will lead to measureable organizational benefits. Our model extends existing models of BI success by incorporating factors that represent the nature of the use of BI systems and that evaluate the benefits realized from such systems.

Conclusions:

Empirical research into factors contributing to BI success is still somewhat sparse (Arnott et al. 2008). With this work we hope to provide additional evidence on which to build a stronger practical and theoretical foundation supporting the use and benefits of BI. Much of the research to date on BI success measures success by whether the system is used. There is an implied assumption that “use” leads to perceived benefits. We hope to provide evidence regarding how and if use directly impacts benefits realized from BI.
References:


Kaye, G.R. "Information systems successes and failures: research findings from the compounding industry," *Journal of Information Technology* (Routledge, Ltd.) (5:2) 1990, p 73.


Appendix A: Survey Instrument

Organizational Capabilities in Business Intelligence

We request that you answer the following questions keeping in mind that: (1) with the term 'department' we refer to the smallest organizational unit you work in that is an autonomous business unit in its own BI investment decisions; and (2) the term 'business intelligence' refers to the use of tools and associated data to prepare reports and analysis for managers at various levels of the organization to assess organizational performance and to make operational and strategic decisions.

Please rate your level of agreement with the following sentences, on a seven point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 refers to 'yes, to a very large extent'.

not at all (1)   (2)   (3)   (4)   (5)   (6)   yes, to a very large extent (7)

- Our personnel effectively look for new business opportunities.
- Our personnel effectively observe customers' preferences.
- Our personnel effectively gather feedback from our partners.
- Our personnel put effectively into practice their recently acquired knowledge.
- Our personnel are effective in applying the new knowledge.
- Our personnel effectively employ the new knowledge about our customers.
- Our personnel effectively coordinate their different work activities.
- Our personnel set up a well-coordinated team.
- Each member of the department effectively coordinates with the rest of the department.
- Each member of the department effectively integrates his job with others towards a collective result.
- Each member of the department promptly contributes in the collective solution of the department's problems.
- Each member of the department is proactive in contributing to the collective output of the department.

Firm IT assets

We request that you answer the following questions keeping in mind that: (1) with the term 'department' we refer to the smallest organizational unit you work in that is an autonomous business unit in its own BI investment decisions; and (2) the term 'business intelligence' refers to the use of tools and associated data to prepare reports and analysis for managers at various levels of the organization to assess organizational performance and to make operational and strategic decisions.

Please rate your level of agreement with the following sentences, on a seven point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 refers to 'yes, to a very large extent'.
The range of communication technologies (e.g. Web sites, call centers, telephony) we use have widened over time.

The range of information technologies (e.g. applications, software, servers) we employ have widened over time.

The range of our network technologies (e.g. broadband, Intranet, Extranet) have widened over time.

Our data warehouses contain a long range of historical data.

Our data warehouses cover a broad range of business subject areas.

Our data warehouses have been in place for a long time.

Adding data to our data warehouses is a priority when new operational systems or capabilities are developed.

Our organization provides financial support for adding data to our data warehouses when new operational systems or capabilities are developed.

Firm history

We request that you answer the following questions keeping in mind that: (1) with the term 'department' we refer to the smallest organizational unit you work in that is an autonomous business unit in its own BI investment decisions; and (2) the term 'business intelligence' refers to the use of tools and associated data to prepare reports and analysis for managers at various levels of the organization to assess organizational performance and to make operational and strategic decisions.

Please rate your level of agreement with the following sentences, on a seven point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 refers to 'yes, to a very large extent'.*

not at all (1)   (2)   (3)   (4)   (5)   (6)   yes, to a very large extent (7)

• In the recent past, our personnel have proven effective in processing information.
• In the recent past, our personnel have proven effective in exploiting information concerning our organizational performance.
• In the recent past, our personnel have proven effective in leveraging the information concerning our failures.
• In the recent past, our IT personnel have proven effective in developing IT applications.
• In the recent past, our IT personnel have proven effective in exploiting IT.

BI dynamic capability
We request that you answer the following questions keeping in mind that: (1) with the term 'department' we refer to the smallest organizational unit you work in that is an autonomous business unit in its own BI investment decisions; and (2) the term 'business intelligence' refers to the use of tools and associated data to prepare reports and analysis for managers at various levels of the organization to assess organizational performance and to make operational and strategic decisions.

Please rate your level of agreement with the following sentences, on a seven point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 refers to 'yes, to a very large extent'.*

<table>
<thead>
<tr>
<th>Rating</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Our personnel have effective methods for choosing business intelligence tools.</td>
</tr>
<tr>
<td>2</td>
<td>Our personnel's choice of business intelligence tools supports organizational processes.</td>
</tr>
<tr>
<td>3</td>
<td>Business intelligence is successfully integrated into our organizational processes.</td>
</tr>
<tr>
<td>4</td>
<td>The integration of business intelligence into our organizational processes is effective.</td>
</tr>
<tr>
<td>5</td>
<td>Our personnel effectively handle the digital data that they obtain.</td>
</tr>
<tr>
<td>6</td>
<td>Our personnel effectively process the data that they obtain in digital form.</td>
</tr>
<tr>
<td>7</td>
<td>Our personnel have effective methods for managing the digital data that they obtain.</td>
</tr>
<tr>
<td>8</td>
<td>When our business intelligence must evolve, our personnel successfully steer its evolution.</td>
</tr>
</tbody>
</table>

Please rate your level of agreement with the following sentences, on a seven point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 refers to 'yes, to a very large extent'.*

<table>
<thead>
<tr>
<th>Rating</th>
<th>Sentence</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>When our business intelligence must evolve, our personnel effectively lead its reorganization.</td>
</tr>
<tr>
<td>2</td>
<td>Our personnel have effective methods for choosing the appropriate business intelligence solutions for their business processes.</td>
</tr>
<tr>
<td>3</td>
<td>The choices of business intelligence make their case for our decision process.</td>
</tr>
<tr>
<td>4</td>
<td>Business intelligence is successfully integrated into our processes.</td>
</tr>
<tr>
<td>5</td>
<td>The integration of business intelligence into our processes is effective.</td>
</tr>
<tr>
<td>6</td>
<td>Our personnel have effective methods for managing the digital data that they obtain.</td>
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</tr>
</tbody>
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*Business Process and Organizational Measures*
Since it first implemented business intelligence systems, the following business benefits have been achieved by my organization:

No basis for answering  Strongly disagree  Disagree  Somewhat disagree  Neutral  Somewhat agree  Agree  Strongly agree

- Reduced time-to-market products/services.
- Increase staff productivity.
- Increased inventory turnover.
- Reduced customer return handling costs.
- Improved efficiency of internal processes.
- Reduced inventory levels.
- Reduced operational cost.
- Reduction in the cost of transactions with business partners.
- Reduction in the cost of effective decision-making.
- Improved responsiveness to/from suppliers.
- Reduced marketing costs.
- Improved coordination with business partners/suppliers.

**Information on the respondent**

Please indicate the industry you work in currently: [Open text box]

How many years of experience do you have with BI/Analytics? [Open text for reply]

Do you or have you lead an autonomous business unit in its own BI investment decisions? Y/N

If so, for how long?