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Abstract

We are in the era of big data, and businesses are trying to become more data-driven and increase their decision making efficacy. However, there is little research that explores the dimensions of data-driven decision making (DDDM) capability. The authors analyze existing literature and summarize four approaches to conceptualizing capabilities: unrelated, unidirectional, entanglement, and mixed. We then discuss the DDDM process and propose a multi-dimension construct of DDDM capability by following the process-based entanglement approach. The DDDM capability is conceptualized as a combination of data governance capability, data analytics capability, insight exploitation capability, performance management capability, and integration capability. Academic and managerial implications are also discussed.

Keywords

Data-driven decision making capability, data-driven decision making process, data governance capability, data analytics capability, insight exploitation capability, performance management capability, integration capability.

Introduction

In recent years, more organizations are considering how to run smarter, more agile, and more efficient businesses by using the right data to support efficient and effective decision making (Davenport, 2006). This is generally known as data-driven decision making or evidence-based decision making, which emphasizes making decisions based on the analysis of data rather than purely on intuition (Provost & Fawcett, 2013). To avoid confusion, we use data-driven decision making in this study. In the era of big data, organizations' data sets are characterized by volume, variety, and velocity (Russom, 2011). Data-driven decision making is especially useful and important when a business owns large datasets that are interconnected and that include time-series data reflecting past, current, and subsequent performance (Morrel-Samuels et al., 2009). Top management should realize the priority importance of data-driven decision making in their operation of business (Aksoy, 2013).

Previously, organizations mainly apply data-driven decision making to business activities such as product development, marketing, and pricing (Garvin, 2013). However, many organizations do not have the capability to perform data-driven decision making. For example, Kumar et al. (2013) reported that 29 percent of marketing leaders do not have enough customer data to perform data-driven decision making, and 39 percent of organizations that collect a large amount of data do not have the capability to convert their customer data into actionable insights. Manyika et al. (2011) also posited that there will be a shortfall of 1.5 million managers with knowledge of performing data-driven decision making by 2018 in the U.S. Thus, it is time to treat data-driven decision making as one responsibility of managers (Pfeffer & Sutton, 2006) and help them recognize the importance of data-driven decision making and support investment in building their data-driven decision making capability (Aksoy, 2013).

However, much past literature on data-driven decision making has not contributed in a practical manner to help organizations build routines of data-driven decision making (Garvin, 2013). Most literature focuses on the benefits of data-driven decision making in order to promote data-driven practices (Holloway, 2007), areas of research methodology and management education and training, and how to obtain, classify, and disseminate evidence or insight that will be used to support decision making (Baba & HakemZadeh, 2012). The findings are not systematically integrated, and few researchers explore the issue within the field of management (Baba & HakemZadeh, 2012), especially how to build data-driven decision making capability. More research is needed to explore how to help organizations build the data-driven decision making capability (Aksoy, 2013; Goeken, 2011). Conceptualization of data-driven decision making capability may be the foundation to drive such research forward.

This study investigates how to help organizations build data-driven decision making capability, asking the question “what are the components of data-driven decision making capabilities?” Little research has specifically explored the components of data-driven decision making capabilities. Thus, we undertake a detailed literature review on both capability conceptualization and data-driven decision making. We then summarize four approaches to construct capabilities, which are the unrelated approach, the hierarchy approach, the entanglement approach, and the mixed approach. Then, the data-driven decision making process is summarized, and five components of data-driven decision making capability are proposed by applying the process-based entanglement approach.

Literature Review

Different Approaches to Capability Conceptualization

Kim et al. (2012) summarizes three different approaches to conceptualize capabilities, which are the unrelated approach, the unidirectional approach, and the entanglement approach. IS studies about capabilities fits these three approaches and helps distinguish sub-categories of each approach. We also found a fourth approach that mixes at least two of those three approaches; we call this the mixed approach. Description and examples of each of the three primary approaches is summarized in Table 1.

The unrelated approach posits that a type of capability is composed of different, independent capability components, and there is not causal relationship among them (Kim et al., 2012). Most current empirical research adopts this approach to conceptualize capabilities (Kim et al., 2012). There are two sub-categories in this approach. The first sub-category is the one-layer unrelated approach that constructs capability as a composition of several first order capabilities. For example, Lu and Ramamurthy (2011) proposed that IT capability is composed of IT infrastructure capability, IT business spanning capability, and IT proactive stance. The second category, the multi-level unrelated approach, views a capability as a multi-level construct. One example is Kim et al. (2012), who proposed that IT capability is composed of IT management capability, IT infrastructure capability, and IT personnel capability. Each capability is composed of different types of lower level capabilities. For example, IT management capability is composed of planning, investment, coordination, and control capabilities (Kim et al., 2012).

In unidirectional conceptualization, there are unidirectional causal relationships among different elements of a capability (Kim et al., 2012). It also has two sub-approaches: same-level and different-level. The first sub-approach emphasizes that there are causality relationships among same level capability dimensions. Kim et al. (2012) discuss an example of this approach in which IT capabilities are composed of IT management capability, IT personnel capability, and IT infrastructure capability. IT management capability and IT personnel capability each have a positive relationship with IT infrastructure capability. The second sub-approach involves the causality relationship among different levels of capabilities. For example, Grant (1996) posited that organizational capabilities are hierarchical and organizations should have lower levels of capabilities in order to build higher level capabilities (Rai et al., 2006).

The third approach is the entanglement approach. This approach involves the interrelatedness of a capability (Lu & Ramamurthy, 2011) and there exists a complementarity effect among those components. However, the relationships between different components of a capability are not causality. There are also two subcategories in this approach. The first one is the spanning approach. It emphasizes that the complementarity and spanning among different components of a capability, or spanning capability, should be viewed as a separate component of the capability. For example, Wade and Hulland (2004)

Approach	Sub-categories	Characteristics	Examples	Other similar research
Unrelated approach	One-layer	(1) Components of a capability are independent. (2) No causality among those components. (3) The capability is composed of one layer of specific capabilities.	Li et al. (2010) posited that firm capabilities involve marketing capability, R&D capability, and operations capability.	Fink (2011); Wang et al. (2012); Ravichandran and Lertwongsatien (2005);
	Multi-layer	(1) Components of a capability are independent. (2) No causality among those components. (3) The capability is composed of at least two layers of capabilities.	Sarker and Sarker (2009) constructed firm agility as a combination of resource agility (people-based, technology-based); process agility (methodology-based, environmental awareness-based, temporal bridge-based); and linkage agility (cultural mutuality-based, communicative relationship-based).	Carte and Chidambaram (2004); Sarker and Sarker (2009); Setia et al. (2013)
Unidirectional approach	Same-level	(1) Components of a capability are interdependent, and there exists causality relationship between them. (2) The causality relationship exists between components that pertain to the same level.	Kim et al. (2012) proposed that IT capability includes IT management capability, IT personnel capability, and IT infrastructure capability. IT personnel capability will have a positive relationship with IT management capability. Then, IT personnel capability and IT management capability will have a positive impact on IT infrastructure capability.	Kim et al. (2011); Joshi et al. (2010); Bhatt and Grover (2005)
	Different-level	(1) Components of a capability are interdependent, and there exists causality relationship between them. (2) Lower level components are required to build higher level of components.	Grant (1996) proposed the hierarchy view of capability. Grant (1996) demonstrated that lower-level capabilities are required to build higher-level capabilities. For example, activity related capabilities are required to build broad functional capabilities, and broad functional capabilities are needed to build cross-functional capabilities.	Daniel et al. (2014); Rai et al. (2006)

Table 1. Approaches of Capability Conceptualization

Approach	Sub-categories	Characteristics	Examples	Other similar research
Entanglement approach	Process-based	<p>(1) Components of a capability are closely interrelated and complementary.</p> <p>(2) Those components are in line with different steps of a process, such as knowledge management process.</p>	<p>Zhu (2004) posited that e-commerce capability can be viewed as a firm's ability to deploy and leverage e-commerce resources to support these order cycle activities (share information, facilitate transactions, improve customer service, and strengthen back-end integration). EC capability includes information capability, transaction capability, customization capability, and back-end integration capability.</p>	<p>Zhu and Kraemer (2002); Wu and Hu (2012); Malhotra et al. (2005); Liu et al. (2013)</p>
	Spanning	<p>(1) Components of a capability are closely interrelated and complementary.</p> <p>(2) Spanning among specific capabilities is included in the model as a separate component of the capability.</p>	<p>Wade and Hulland (2004) proposed a three-dimension capability framework, which includes outside-in capability, inside-out capability, and spanning capability. Spanning capability involves the integration of organizations' inside-out and outside-in capabilities.</p>	<p>Wu and Hu (2012); Roberts et al. (2012); Lu and Ramamurthy (2011)</p>
Mixed approach	Mixed	<p>This approach mixes at least two approaches during conceptualizing a specific capability. However, it is not considered mixed approach if it includes two sub-approaches from a certain approach.</p>	<p>Gold et al. (2001) posited that knowledge management capability includes knowledge infrastructure capability and knowledge process capability. Knowledge process capability is composed of acquisition, conversion, application, and protection capabilities. This conceptualization mixes the unrelated approach and the process-based entanglement approach.</p>	<p>Doherty and Terry (2009); Setia and Patel (2013); Malhotra et al. (2005)</p>

Table 1. Approaches of Capability Conceptualization (Continued)

proposed a three-dimension capability framework, which includes outside-in capability, inside-out capability, and spanning capability. Spanning capability involves the integration of organizations' inside-out and outside-in capabilities (Wade & Hulland, 2004).

The other sub-category of the entanglement approach, the process-based approach, constructs a capability from the view of a process. The process includes different steps, and different capabilities are required to finish each step. One example of this method is the conceptualization of e-commerce capability. E-commerce has several steps such as sharing information, facilitating transactions, improve customer service, and strengthening back-end integration, and thus, e-commerce capability is conceptualized as a combination of information capability, transaction capability, customization capability, and back-end integration capability (Zhu, 2004; Zhu & Kraemer, 2002). Conceptualization of absorptive capability is another example of this approach. Absorptive capability involves processes such as acquisition, assimilation, transformation, and exploitation of external valuable knowledge, and thus, absorptive capability includes acquisition capability, assimilation capability, transformation capability, and exploitation capability (Malhotra et al., 2005; Roberts et al., 2012; Sherif & Menon, 2004). Another example of this approach is the construction of knowledge capability, which is composed of acquisition capability, transfer capability, integration capability, and application capability (Gold et al., 2001; Tanriverdi 2005; Wu & Hu, 2012). This also reflects the knowledge management process, such as knowledge creation, transfer, integration, and leverage (Venkatraman & Tanriverdi, 2004).

A Framework of Data-Driven Decision Making Capability

Data-Driven Decision Making Processes

In this study, we construct data-driven decision making capability based on the process-based conceptualization approach. Thus, the data-driven decision making process is discussed first. There are several data-driven decision making models that cover the complete process of decision making (Abbott, 2008; Easton, 2009; Mandinach et al., 2006, 2008; Robbins et al., 2008). The framework by Mandinach et al. (2006, 2008) is proposed based on their analysis of practitioners and describes the cognitive skills that are involved in data-driven decision making. Mandinach et al. (2006; 2008) includes three basic elements, which are data, information, and knowledge. There is an ordered cycle of processes that realize the data-driven decision making. These processes include “collect, organize, analyze, summarize, synthesize, implement, and feedback” (Mandinach et al., 2006; 2008)). However, this framework does not consider the assessment and evaluation of decision implementation and the embeddedness of decision making in core business processes.

By adapting the framework of Mandinach et al. (2006, 2008), we proposed a data-driven decision-making process model. As shown in Figure 1, data-driven decision making is a continuous process that includes collecting data, transferring data into information and ultimately knowledge, making decisions based on knowledge, monitoring the implementation of decisions, and providing feedback for each process (Mandinach et al., 2008; Easton, 2009). In addition, an organization does not make decision isolated from the society but affected by different stakeholders such as supply chain partners. The model not only includes the focal organization, but also integrates its supply chain partners and external environment through data screening and data disclosure.

This process is closely related to the knowledge process and the absorption of external valuable information. In knowledge management practice, organizations create or capture valuable knowledge, then assimilate it in their organizations and apply it to new areas such as making new product development decisions (Gold et al., 2001; Tanriverdi, 2005). An organization's absorption process includes acquisition, assimilation, transformation, and exploitation (Malhotra et al., 2005). As a summary, data-driven decision making, knowledge management, and absorptive processes all have similar core components such as data, information and knowledge and involve an ordered cycle of using data, information, and knowledge to make final decisions.

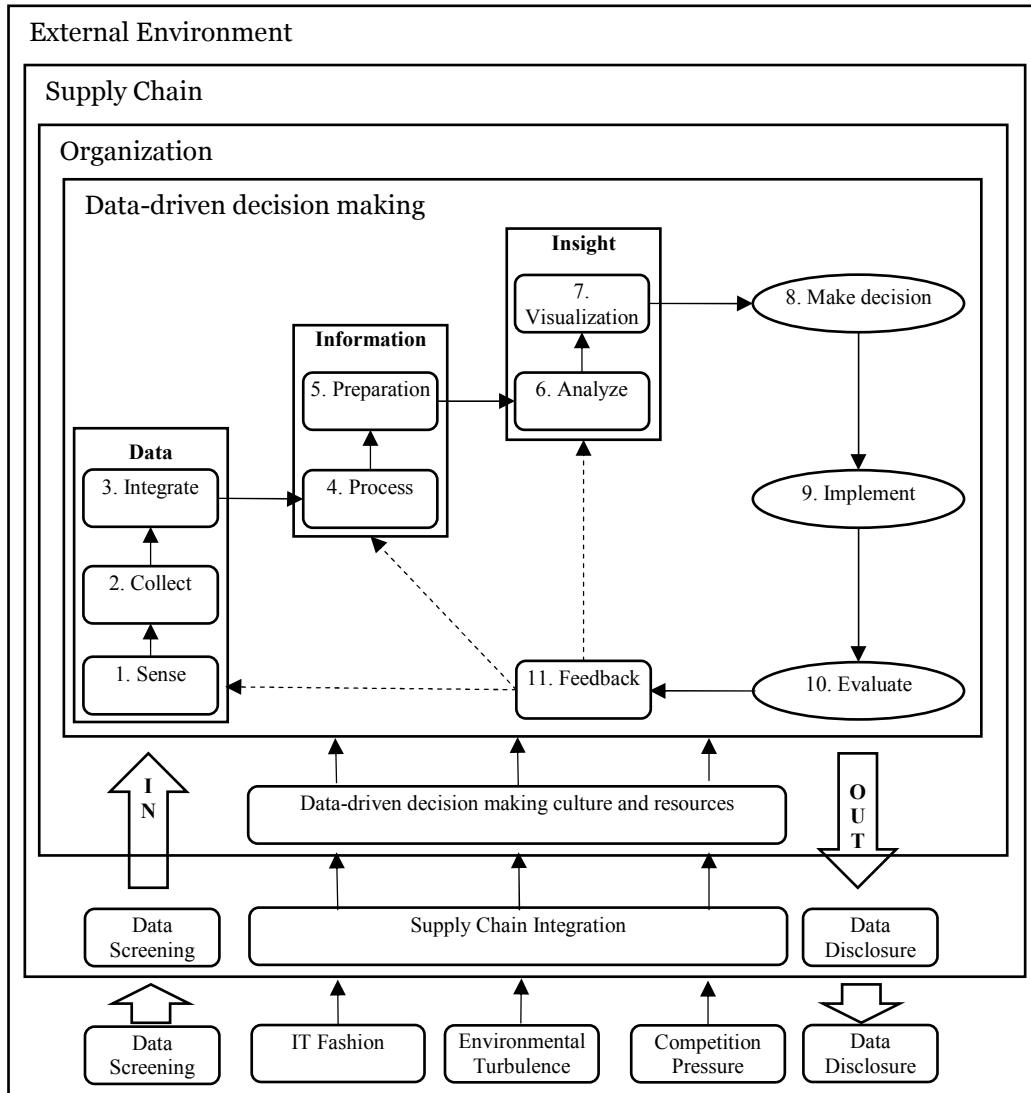


Figure 1. Data-Driven Decision Making Process

Definition of Data-Driven Decision Making Capability

We have no knowledge of a definition of data-driven decision making capability in past literature. In this study, data-driven decision making capability is defined as the abilities of an organization to utilize data, information, and insight assets in a series of coordinated decision making processes in order to support, inform, or make decisions. The definition summarizes three different roles of data, information, and insight assets in decision making, which are to make a decision, inform a decision, and support a decision (Tingling & Brydon, 2010).

Dimensions of Data-Driven Decision Making Capability

In the highly competitive world, the company that gets the right data first, analyzes it first and acts upon their insights first wins. Following the process-based entanglement approach of conceptualizing capabilities, we propose a data-driven decision making capability framework that is composed of data governance capability, data analytic capability, insight exploitation capability, performance management capability, and integration capability (Figure 2). This data-driven decision making capability framework coincides with Bernhardt's (2000) data intersections and the inquiry cycle, which includes establishing

the desired outcomes, defining the essential questions, collecting the targeted data and organizing it, making meaning of the targeted data, taking action based on the targeted data, and assessing and evaluating the actions taken (Rallis & MacMullen, 2000). Each capability in the framework coincides with different steps of the data-driven decision making process. For example, the data governance capability corresponds to step 1 to step 3 in Figure 1. In addition, there exists relationship between different dimensions of DDDM capability. The relationship can be causal, correlated, or bi-directional. In this study, the five dimensions of DDDM capability are linked by a circle with no arrows to express all possible types of relationship between two capabilities.

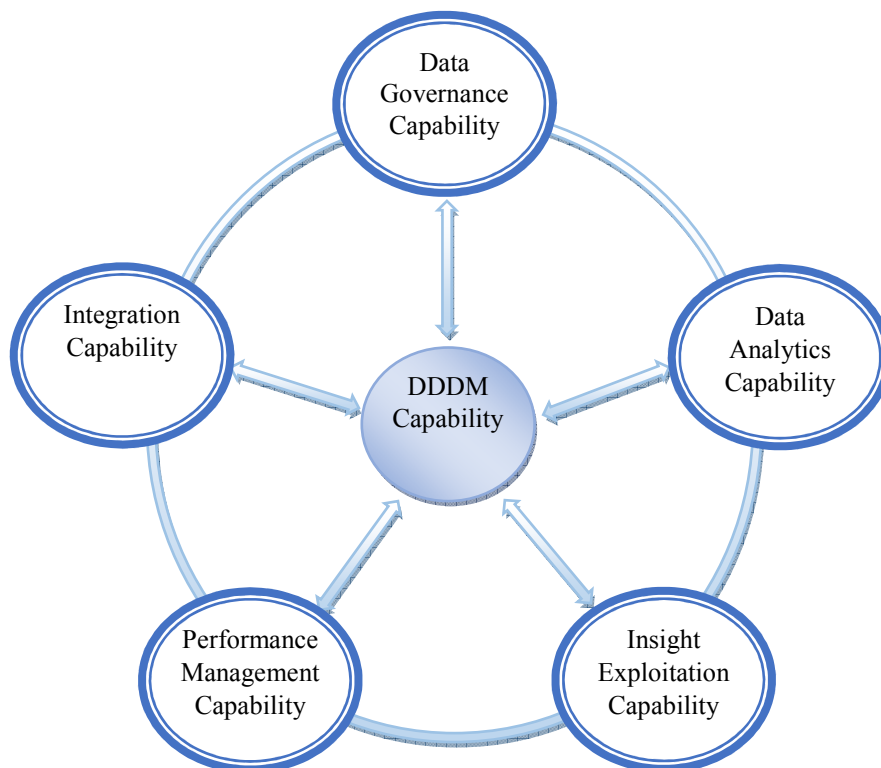


Figure 2. The Framework of Data-Driven Decision Making Capability

Data Governance Capability

Decisions should be made based on high-quality, well-organized data, or managers may make faulty decisions based on unrelated factors (Davenport et al., 2001). High quality data is an important prerequisite of data-driven decision making, and organizations' willingness to adopt data-driven decision making also increase their need for data governance (Kumar et al., 2013; Parsian et al., 2009). Without data governance with clear data quality policies, data quality management processes, data quality responsibilities etc., analytics tools and business models cannot contribute to organizations' data-driven decision making (Buhl et al., 2013). In this study, data governance capability refers to the ability of an organization to "provide data to users with the appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access and the ability to tailor these in response to changing business needs and directions" (Mithas et al., 2011, p. 238). Some elements of data governance capability are data collection, data integration, data quality, and data access. Data collection reflects an organization's ability to collect data from different sources, data integration refers to an organization's ability to aggregate data from different sources or in different format, data quality refers to an organization's ability to manage the quality of data, such as data cleaning, data standardization, and data access reflects an organization's ability to transfer the proper data to certain people who have the authority to get access to the data.

Data Analytics Capability

Analytics refers to the generation of knowledge and intelligence from data to support decision-making and strategic objectives (Goes, 2014). Kim et al. (2005) posited that analytic capability can provide high-quality analytical models and methods for managers and thus facilitate their data-driven decision making. In this study, data analytics capability is defined as a firm's capability to evaluate and interpret the collected data or information, which in turn combines with existing information to generate knowledge and intelligence to support decision making and strategic objectives (Bernroider et al., 2014; Goes, 2014). Goes (2014) summarized some elements of data analytics capability: decision time, analytics, and techniques. Decision time refers to whether the analytics is performed in real time, close to RT, hourly, weekly, monthly, or yearly (Goes, 2014). Goes (2014) also summarized four types of analytics: visualization, exploration, explanatory, and predictive. Techniques reflect the analytics methods or models, such as statistics, econometrics, machine learning, computations, linguistics, optimization, and simulation, that an organization has (Goes, 2014).

Insight Exploitation Capability

Organizations do not need to collect and mine data to obtain insights if they do not exploit the insights obtained from data analytics (Davenport et al., 2001). Data-driven insights should be applied to business process and decision making routines in order to benefit organizations (Shanks & Bekmamedova, 2012). Insights should be transformed into action, such as modification of core processes such as strategic planning and daily operations (LaValle et al., 2011; Mitechell, 2006). In this study, insight exploitation capability is defined as an organizations' ability to harvest and incorporate insights into their decision making across core business processes such as guiding manufacturing, supply chain, software development, financial, and other important activities (Brown & Duguid, 1998; Mithas et al., 2011; Zahra & George, 2002). Mithas et al. (2011) summarizes several important processes such as manufacturing, supply chain, software development, financial, and other important activities. Similarly, LaValle et al. (2011) reported that top analytic performers apply analytics to financial management and budgeting, operations and production, strategy and business development, sales and marketing, customer service, product research and development, general management, risk management, customer experience management, brand and market management, workforce planning and allocation (from highest to lowest). There are six commonly discussed core business processes: manufacturing/operations activities, marketing activities, customer service activities, enhancing supplier linkages, sales activities, and financial management and budgeting.

Performance Management Capability

Past literature has paid much attention to the importance of performance management in implementing strategies of business firms (Nilsson & Kald, 2002), facilitating the achievement of organizational goals (Hall, 2008), achieving better performance (de Leeuw & van den Berg, 2011), keeping employees locked into organizational goals (Willson & Pollard, 2009), and facilitating decision making because performance management focuses on action and uses updated data information (de Leeuw & van den Berg, 2011; Johnston et al., 2002). Many organizations have paid attention to the potential usage of business intelligence systems to monitor, measure, and management performance in a more efficient way than ever before (Buytendijk et al., 2004), and performance management has become one of the critical applications of business intelligence (Hostmann et al., 2005). Huq et al. (2010) suggested that companies should build their data-driven decision making process based on performance management such as an objective measurement criteria to monitor processes and outcomes. In this study, performance management capability refers to the ability to develop a systematic and appropriate monitoring, evaluating, and control approach to observe and measure business performance, and then guide managerial actions accordingly upon the outcome (Lockstrom et al., 2010; Mithas et al., 2011).

Integration Capability

Organizational integration is "the process of combining some or all of the previously distinct and interdependent assets, structures, business processes, system, people, and cultures of the two firms into a unified whole" (Tanriverdi & Uysal, 2011, p. 704). In this study, integration capability is defined as a

firm's ability to combine some or all of the previously distinct and interdependent assets, structures, business processes, system, and people, either inside the same party or of different parties, into a unified whole (Tanriverdi & Uysal, 2011). Integration capability has mainly three categories: IT infrastructure integration capability, process integration capability (Angeles, 2009; Rai et al., 2006), and people integration capability. IT infrastructure integration capability refers to the degree to which a focal firms has integrated its IT infrastructure for the consistent and high-velocity transfer of information within and across its boundaries (Angeles, 2009; Rai et al., 2006), process integration capability reflects an organization's ability to integrate its information flows among different parties both inside and outside of the organization (Angeles, 2009; Rai et al., 2006), and people integration capability refers to an organization's ability to maintain the real-time communication and collaboration among its employees or with outside partners.

Discussion

Findings

This article summarizes four approaches to conceptualize different types of capabilities, which are the unidirectional approach, the unrelated approach, the entanglement approach, and the mixed approach. The unrelated approach emphasizes different components of a focal capability that may be interdependent or independent, and this approach has both one-level and multi-level approaches. Oppositely, the unidirectional and entanglement approaches demonstrate that different components of a focal capability are not disconnected. The unidirectional approach emphasizes the causality relationship among different dimensions of the focal capability and includes same-level and different level unidirectional approach. Meanwhile, the entanglement approach also emphasizes different components of a focal capability that are interrelated but that relationship is not causality. The mixed approach combines two or more approaches discussed above.

The process-based entanglement approach is adopted to conceptualize the data-driven decision making capability because the other approaches may underestimate the effect of DDDM capability as a whole (Kim et al., 2012). The data-driven decision-making process model is proposed first. The process model considers collecting data, processing data into information, transferring data or information into insight, applying insight to decision making, and acting based on performance management. The process also considers the integration of IT infrastructure, process, and people. Thereafter, the framework of data-driven decision making capability is proposed by following the process based entanglement approach. The framework includes data governance capability, data analytics capability, insight exploitation capability, performance management capability, and integration capability.

Implications for Researchers

The four approaches proposed and explained in this study inform academic researchers of possible approaches to conceptualize different types of capabilities in which they are interested. In addition, this study strengthens the understanding of what data-driven decision making is and what the core components of data-driven decision making capability are. This article serves as the foundation of data-driven decision making capability research and also encourages more research on how to build an organization's data-driven decision making capability.

Implications for Managers

This study helps managers increase their understanding of the data-driven decision making process. The data-driven decision making process gives them some practical suggestions on how to make data-driven decision making. In addition, the process model also encourages them to consider the intention with partners and the external environment during their data-driven decision making process. Moreover, organizations cannot benefit from data-driven decision making capability if they do not know the core components of this capability. According to the data-driven decision making framework, managers should focus on building the aforementioned five types of capabilities to support their data-driven decision making.

Limitation and Future Research

This article does not explore the tradeoff between intuition-based decision making and data-driven decision making. Intuition-based decision making is popular in many companies although they are willing to become more data-driven. If we make an analogy of decision making and driving, then data-driven decision making enhances a person's ability to make good decisions. Tingling and Brydon (2010) suggested that decision makers should have a clear understanding of the different roles evidence can and should play in a decision process. This implies that decision makers within the organization have the flexibility to determine what constitutes legitimate justification of a particular decision. However, they proposed only the framework for data-driven decision making but did not detail dimensions. We are exploring the elements of each dimension.

Conclusions

To the best of our knowledge, this study is the first to explore data-driven decision-making and its components. In this research, we summarize four approaches to conceptualize capability, which are unidirectional, unrelated, entanglement, and mixed approaches. Then, the data-driven decision making process is discussed. Adopting the process-based entanglement approach, a five-dimension framework of data-driven decision making capability is proposed. According to the framework, data-driven decision making capability is composed of data governance capability, data analytics capability, insight exploitation capability, performance management capability, and integration capability. This research deepens our understanding of what is data-driven decision making, steps of data-driven decision making process, and components of data-driven decision making capability and serves as the foundation of an understanding of data-driven decision making capability.

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