Big Data Capability, Customer Agility, and Organization Performance: A Dynamic Capability Perspective

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Abstract

This paper responds to the continual call from both academic scholars and industry professionals to theorize about the influence of “big data” on organization competitiveness and performance. To resolve the ambiguity surrounding “big data” term we propose a new construct called “big data capability”. We consider big data capability as a higher-level construct consists of three sub lower-level constructs: infrastructure capability, big data management capability, and big data science capability. We argue that big data capability improves customer sensing capability, and we clarify that this impact is moderated by both the organization market orientation and the data-driven decision making practice. We further stress that creating the competitive action that contributes to the organization performance requires the alignment and fit between the two components of customer agility: customer sensing capability and customer responding capability. The paper provides an important theoretical and practical contributions. From the theoretical perspective, the paper contributes to the strategic IS literature by extending the dynamic capability theory through introducing the big data capability as a precedent to customer sensing agility, the dynamic capability. The paper also extends the theory by introducing both market orientation and data driven culture as moderators to the impact of big data capability on customer sensing agility. From the practical perspective, the paper provides useful insights for business and IT leaders who are interested in building their big data capability to improve their organizations competitiveness in the market.

Keywords

Big data capability, customer agility, organization competitiveness, organization performance.
Introduction

Business organizations today are facing dramatic explosion of structured and unstructured data that are generated every second inside and outside their boundaries, whether from the firms’ internal transactions or from the customer’s interactions with public social media platforms. Business and IT leaders started realizing the significant potential of utilizing these data — referred to recently as big data — as a source of gaining business insights, sustaining competitive advantage, and improving their organization performance. Thus far, the results of leveraging big data for strategic advantage have been mixed. Some firms have been successful in radically transforming their business; others have only achieved convergent or incremental improvement; while others have not started yet (Ross et al. 2013). In this paper, we explain how successful business organizations are utilizing big data to sustain competitive advantage and improve their performance. To do that, we draw on the information systems and strategic management literatures.

The strategic management literature argues that in turbulent business environments, where the market is changing very rapidly and competition is increasing, in order for business organizations to survive they need to become more agile in sensing and responding to the newly arising opportunities. Agility has been proposed by many strategy scholars as an enabler of business organizations to sustain competitive advantage and improve organization performance (Cho et al. 1996; Day 2000; Goldman et al. 1995; McGaughey 1999; Overby et al. 2006; Setia et al. 2008; Sharifi and Zhang 1999; Yusuf et al. 1999). Sambamurthy et al. (2003) identified agility as a dynamic capability that reflects the organization’s ability to detect and seize competitive opportunities with speed and surprise. He further distinguished between three dimensions of agility: customer agility, operational agility, and partnering agility.

Information technology has been linked by many scholars to improved organization agility. Scholars in the field of information systems and strategic management have studied the impact of the different aspects of information technology on organizational agility (Allen and Boynton 1991; Chakravarty et al. 2013; Clark et al. 1997; Goodhue and Chen 2009; Lu and Ramamurthy 2011; Lucas and Olson 1994; Neumann and Fink 2007; N Roberts and Grover 2012; Sambamurthy et al. 2003; Weill and Subramhani 2002; Zaheer and Zaheer 1997). However, while information is increasingly becoming the most important factor for business organizations today, information technology is becoming just a mean to an end (Mithas et al. 2011). Big data, in particular, is now of great interest for both practitioners and researchers. Considering the diversity in information technologies and their utility to business organizations today, we argue that theorizing about the effects of IT Capability as a general concept on business performance does not adequately address the potential for big data to influence organizations. To provide more meaningful contribution for researchers and practitioners, related theory needs to be better contextualized to big data. This is particularly important because business and IT leaders are highly concerned with knowledge related to Big data (Boyd and Crawford 2012; Brown et al. 2011; Bughin et al. 2011; Chen et al. 2012; Davenport 2014; Floridi 2012; Michael and Miller 2013; Ross et al. 2013; Turner et al. 2013; Waller and Fawcett 2013). Some previous studies have attempted to respond to this gap by suggesting different conceptualization for Big data Capability (Dremel et al. 2017; Gupta and George 2016; Kung et al. 2015). In our work we propose another conceptualization for this important capability (i.e. big data capability). Furthermore, the relationship between big data capability and organization performance has not yet been investigated in the literature from the perspective of the alignment between customer sensing and customer responding capabilities except from studies that focused on typical business intelligence capabilities but not specifically on Big data Capability (Park et al. 2017) so we also try to bridge this gap by focusing specifically on Big data capability in this context.

In spite of the great importance of this phenomenon, little knowledge is available to guide business and IT leaders in their decisions regarding “big data capability”. Based on these opportunity, in this manuscript, we further enrich the information systems and strategic management literature by first conceptualizing

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1 According to IBM, more than 2.5 Exabytes has been generated each day in 2012, with more than 2.5 million pieces of content shared by Facebook users every minutes, 300,000 tweets generated by Tweeter users, 220,000 photos posted by Instagram users, 72 hours of new video content uploaded by YouTube users, 50,000 apps downloaded by smart phone users, and 200 million messages sent by email users.
what constitutes “big data capability” for business organizations. Second, we propose a model that illustrates the causal mechanisms in which big data capability can improve organization performance through improving the firm’s customer sensing agility. The work provides theoretical contribution by extending the dynamic capability literature by introducing and testing the role of big data capability as a precedent to customer sensing agility. It also investigates the moderating effect of both market orientation and data driven decision making culture on the proposed relationship providing in that valuable extension to the theory. From a practical perspective, the work provides significant value to business and IT leaders by explaining the dimensions of big data capability and the factors that affect the impact of this capability of organizational customer agility and consequently on the organization competitiveness and performance.

**Conceptualizing Big Data Capability**

When studying the impact of information technology on organization performance, scholars have followed various approaches in conceptualizing the IT artifact (Garud et al. 2006; Lee et al. 2015). With the growing diversity in information technologies and its applications in business organizations today, the expected impact of adopting specific technology on organization performance from one side, and the mechanism in which this specific technology lead to the expected impact from the other side, are both becoming more dependent on the technology under investigation (Melville et al. 2004). Different information technologies are used to support different business objectives and consequently lead to different business impacts (enterprise resource planning, customer relationship management, supply chain management, human resource management, and business intelligence, and so on) (Turner and Lucas 1985; Weill 1992; Weill and Subramani 2002). It is clear now that approaching IT as a general concept that represents a range of technical, Human, and IT applications when studying the impact on organization competitive advantage will not provide a meaningful contribution neither to theory nor to practice. In order for the research to provide meaningful insights it is becoming more pressing for IS scholars to theorize about the specific technologies under investigation, in our case “Big data” (Orlikowski and Iacono 2001). Based on this, we have narrowed the scope of our IT artifact by focusing on big data capability. Gartner Group, the leader in information technology research, defined “Big Data” as: “high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making.”

In spite of the hype surrounding this term in both business and academic environment, the term is still not clear enough, especially when trying to articulate what identifies the “big data capability” for business organizations. To solve this ambiguity, we identify big data capability as a higher level construct consists of three sub-lower- level dimensions: big data infrastructure capability, big data management capability and big data science capability. See Figure 1.

![Figure 1. Big Data Capability Dimensions](big_data_capability_dimensions.png)

**Big Data Infrastructure Capability**

*Big data infrastructure capability* is a sub-capability that reflects the organizational technical architecture that supports big data initiatives and includes required hardware, software and related technologies required for collecting, storing, integrating, processing and retrieving huge amounts of structured and unstructured data from different sources at rest and in motion. This capability is quite different from the traditional information management infrastructure capability in that it addresses (Mohanty et al. 2013): (1) different internal and external sources of data; (2) a large volume of data that traditional database systems do not deal with (usually larger than 1TB); (3) rapidly changing and fast moving amounts of data which

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need real time processing that traditional systems and algorithms cannot handle; and a (4) With diverse varieties of data types such as text, videos, sensor data, to name few, which need different techniques for acquisition, storage, integration, processing, and retrieval. Probably the most distinguished technologies that relate to big data infrastructure capability are the massive parallel-processing (MPP) databases, distributed file systems like Hadoop, and cloud computing technologies that complement the big data management (Mohanty et al. 2013). NoSQL technologies are an essential component of this new technical architecture, and we can distinguish between several types: Key-value, document store, wide column stores, and graph databases. However, there is no specific technology stack that fits all cases, different organizations need different technologies relative to the nature of their big data initiatives (Manyika et al. 2011; Mohanty et al. 2013).

**Big Data Management Capability**

Information management capability has already been defined and addressed by Mithas et al. (2011). However, in the big data era, there is a great need for new additional principles and skills to collect, integrate, model and process huge structured and unstructured data sets from different sources and provide these data to the relevant users in secure, certain and timeless manner. Managing big data requires new skills to deal with challenges related to the growing volume, increasing velocity and diverging variety of data. Big data management capability has to deal with all kinds of data including traditional structured data, semi-structured data, and unstructured data such as photos, videos, emails, logs, text, audio, and so on. These must be done in real time, which needs data discovery skills and new governance rules to locate, catalog, integrate and set access mechanisms to different data sources for different data consumers. Organizations must develop appropriate policies and governance strategies to prevent misuse of this data as well (Mohanty et al. 2013). We adopt and upgrade Mithas et al. (2011) information management capability definition in our study to address Big data needs as follows: the ability to (1) provide all types of big data and information, from different sources, to users with the appropriate levels of accuracy, timeliness, reliability, security, and confidentiality; (2) provide universal connectivity and access with adequate reach and range; and (3) tailor the infrastructure to emerging business needs and directions.

**Big Data Science Capability**

Between 2010 and 2015 we witnessed the emergence of some confusing terms like “big data”, “data science,” and “big data science” (Davenport, 2014). All of these terms came as a response to the dramatic explosion of data causing confusion to business and IT leaders who are trying to build their big data capabilities. However, data science is probably the most suitable term in this context. Provost and Fawcett (2013a) defined data science as the “set of fundamental principles that support and guide the principled extraction of information and knowledge from data” (p. 52). According to Provost and Fawcett (2013a) the most closely related concept to data science is data mining. Based on that, big data science capability can be identified as the firm’s ability to analyze and mine huge amounts of structured and unstructured data in motion and at rest using advance data mining and machine learning algorithms like association rules mining, database segmentation and clustering, anomaly detection, graph mining, social network analysis, text and web analytics, sentiment analysis as well as traditional statistical and other quantitative techniques to discover new patterns in the data that have not yet been discovered and that can support business activities and open new business opportunities (Chen et al. 2013).

**Theoretical Framework and Proposed Model**

**Theoretical Foundations**

The concept of agility emerged in the 1990s. Organizational agility was defined by Setia et al. (2008) as “the organization’s ability to (1) discover new opportunities for competitive advantage; (2) harness the existing knowledge, assets, and relationships to seize these opportunities; and (3) adapt to sudden changes in business conditions” (pp. 6–7). Sambamurthy et al. (2003) distinguished between three dimensions of agility: customer, operational and Partnering. They defined customer agility as the “Co-Opting of customers in the exploration and exploitation of opportunities for innovation and competitive action moves” (p. 245). Operational agility was defined as the “firm’s ability to accomplish speed, accuracy, and cost economy in the exploitation of innovation opportunities” (p. 245). Finally, partnering agility was defined as the “firm’s
ability to leverage assets, knowledge, and competencies of suppliers, distributors, contract manufactures and logistics providers in the exploration and exploitation of innovation opportunities” (p. 245). Roberts and Grover (2012) extended the definition of the customer agility to the firm’s ability to sense and respond quickly to customer-based opportunities for innovation and competitive actions, and distinguished between customer sensing capability and customer responding capability as the two components of customer agility. They argued that in performing the competitive action, firms must be successful in both sensing customers related opportunities, and then in responding in speed and surprise to fulfill these opportunities and they introduced the agility alignment concept as a precondition to improve the competitive action efficacy. To understand the relationship between big data capability and organization performance, we rely on flexibility-based theories. More precisely, we focus on the dynamic capabilities theory, the hierarchy of capabilities and the resource picking and capabilities building processes in creating the competitive action and enhancing organization performance. We consider agility as a dynamic capability that enable the firm to sense and respond in speed and surprise to the changes in the turbulent business environment. We narrow our focus to the customer agility and we further adopt Roberts and Grover (2012) approach to distinguish between the two components of customer agility: customer sensing capability and customer responding capability and the alignment between them in creating the competitive action.

**Big Data Capability and Customer Sensing Capability**

*Customer sensing capability* reflects the firm’s ability to detect customer related opportunities for competitive actions (Atapattu and Sedera 2013; N Roberts and Grover 2012). Understanding customer needs through creating deep knowledge is the core attribute of customer sensing agility (Atapattu and Sedera 2013; N Roberts and Grover 2012; Nicholas Roberts and Grover 2012). Customers’ extensive interactions with business organizations through physical, web-based or mobile channels, plus their interaction with public social media platforms, are all increasing the volume, velocity and variety of data generated every day (Turner et al. 2013). From the business perspective, this data creates a great opportunity for firms in anticipating changing market conditions and customers’ preferences. Integrating and analyzing different customer data types from internal and external sources, in real-time, can help companies in detecting arising opportunities for acquiring new customers, early sensing the risk of customers’ attrition, and detecting new opportunities to increase customer’s share of wallet (Turner et al. 2013). This early sensing capability will enable the firm to early capitalize on these opportunities to enhance its customer related measures through acquiring new customers, decreasing customer attrition rate, or driving customer’s share of wallet. Setting the right price and assessing risk for example are the key success factors for competing in retail banking industry, integrating customer financial data with behavioral and demographic data and using big data predictive analytics may provide better and more accurate results for credit scoring than using traditional credit scoring mechanism depending mainly on the customer financial data like FICO scores. Thus we propose that:

*P1: High levels of big data capability will positively improve the firm’s customer sensing capability.*

**The Moderating Effect of Data Driven Decision Making Practice**

Data driven decision making is the firm’s business practice of emphasizing decision-making based on data and business analytics as termed and conceptualized by Brynjolfsson et al. (2011). Brynjolfsson et al. (2011) constructed their “data driven decision making practice” construct based on three aspects: 1) the organization practice of using data in the creation of a new product or service, 2) organization practice of using data when making business decisions in the entire organization and 3) the existence of data for decision making in the entire organization. The main argument was built on economic theory and suggested that, in a data driven decision making practice, decision makers put more weight on data as it becomes more fine-grained and current which consequently improves their decisions’ average quality. In such business practice, decision makers are moving from intuitive management into a more number-driven decision making (Brynjolfsson et al. 2011). Based on a systematic research and data analysis on 179 publicly traded large firms in the US, Brynjolfsson et al. (2011) found a 5-6% productivity improvement for firms with data driven decision making practices. Furthermore, firms with such practice showed significantly higher profitability and market value. Based on Brynjolfsson’s et al. (2011) findings we suggest that firms that already have a data driven decision making practice are more likely to utilize their big data capability.
when sensing or anticipating changes in their customers’ needs. We suggest that likelihood of big data capability to improve customer sensing capability will be higher for those organizations that are already adept in utilizing their data in making decisions (i.e. having a data driven decision making practice). We based on that propose that:

**P2**: The impact of big data capability on customer sensing capability is moderated by the data driven decision making practice of the firm.

### The Moderating Effect of Market Orientation

The nature of market orientation (behavior-based vs culture-based) has been a topic of debate for several marketing researchers during the last decade (O'Cass and Ngo 2007). Market orientation, from a behavioral perspective, is described as reflecting market-driven behaviors (Hunt and Morgan 1995; Jaworski and Kohli 1993). Jaworski and Kohli (1993) explored the nature of market orientation as three sets of specific activities: 1) Organization-wide generation of market intelligence pertaining to current and future customer needs, 2) Dissemination of the intelligence across departments, and 3) Organization-wide responsiveness to it. From his perspective, Hunt and Morgan (1995) considered market orientation as an intangible resource that pertains to a behavioral process of gathering and analyzing information on customers and competitors, and responding to it effectively and efficiently (Hunt and Morgan 1995). This view of market orientation helps in putting the marketing concept into practice and providing the management with a practical guidance for performing the business. Market orientation, from this behavioral perspective is described as reflecting knowledge-producing behaviors (Baker and Sinkula 1999). From the cultural perspective, market orientation is described as an aspect of an organization’s culture which is created and maintained to provide individual norms for behaviors within organizations and reflecting market-driving characteristics (Deshpande and Jr 1989; Narver and Slater 1990). Based on this background, we argue that market orientation will moderate the relationship between big data capability and customer sensing capability. Organizations that have high levels of market orientation will concurrently utilize their big data capability to generate more intelligence about their customers’ related opportunities. Meanwhile firms with low level of market orientation, even if they developed high level of big data capability, will not fully utilize this capability to enhance their customer sensing capability, thus we propose that:

**P3**: The impact of big data capability on customer sensing capability is moderated by the firm’s market orientation.

### Sensing, Responding, and Competitive Activity

Competitive activity can be identified as the market-based moves which are taken by the business organization to challenge the status quo of the industry or market through innovations in products, services, channels, prices or alliances (Chen 1996; Smith et al. 2001). In a highly turbulent hypercompetitive business environment customer needs are evolving continuously and rapidly. In order for firms to sustain a competitive advantage they have to constantly sense and respond effectively and quickly to any changes in customer and market needs (Day 1994; Goldman et al. 1995). In fact, Nolan (1998) suggested that companies are shifting from traditional make-and-sell strategies to sense-and-respond strategies where they “continuously discover what each customer needs, sometimes even anticipating unspecified needs, and then quickly fulfilling those needs with customized products and services delivered with heretofore unavailable capabilities and speed” (p. 4). Marketing literature has long advocated the importance of responding to customer needs for the long-term sustainability of a firm’s competitive advantage (Jayachandran et al. 2004). While customer sensing capability was already identified previously in this paper as the firm’s ability to detect customer related opportunities for competitive actions (Atapattu and Sedaera 2013; N Roberts and Grover 2012). Customer responding capability is conceptualized by Jayachandran et al. (2004) as “the competence of an organization in serving customer needs through effective and quick actions”. According to Jayachandran et al. (2004), and based on a comprehensive review of the responsiveness to environmental changes literature (Chen and MacMillan 1992; Mullins and Walker 1996), this capability (i.e. customer response capability) is composed of two dimensions: customer response expertise and customer response speed. Customer response expertise refers to the extent to which the responses of an organization effectively meet customer needs, while customer response speed refers to the extent to which its responses to customer needs are rapid (Krubasik 1988). Big data capability can improve
the customer sensing capability by enabling the firm to create richer knowledge about its customers and being able to sense quickly any changing needs. Creating the competitive action requires the complementing responding capability that enables the firm from creating the competitive action and fulfilling this opportunity. In his Harvard Business Review Article “You Many Not Need Big Data After all” Ross et al. (2013) explained how a company used Big data in an attempt to enhance profitability failed in achieving its goal. He explained that the results of the big data analysis suggested that improving profitability requires running discounts before and after having the product on the floor. As the company did not have the required responding capability to reconfigure its supply chain internal and external processes to respond to this opportunity in speed, the firm couldn’t achieve the expected performance results (Ross et al. 2013). Roberts and Grover (2012) explained that by introducing the concept of aligning sensing and responding capabilities as a condition to improve competitive action efficacy. They further explained that sensing market opportunities without having the required responding capability will not lead to the desired competitive action. The same applies when responding to the wrong opportunity due to the lack of the required sensing capability. We follow Roberts and Grover (2012) and propose that:

\[ P4: \text{the higher the alignment between the firm's customer sensing capability and customer responding capability the higher the competitive activity of the firm.} \]

**Competitive Activity and Organization Performance**

Scholars have studied different dimensions of organization performance (Combs, Crook, & Shook, 2005; Mithat et al., 2011). In this study, and considering that we are focusing on customer agility as a mediating variable, we focus our attention on the customer related measures of organization performance (Mithas et al. 2011) and we argue that:

\[ P5: \text{higher levels of firm's competitive activity will positively improve the firm's customer related measures of organization performance.} \]

Based on our previous argumentation and propositions we draw figure (02) below that explain the mechanism in which big data capability improves organization competitive activity.

![Figure 2. Proposed Model for Big Data Impact on Firm Performance](image)

**Discussion and Conclusion**

As big data is increasingly becoming an important phenomenon for both academic scholars and business professionals. To solve the ambiguity surrounding this term (i.e., “Big Data”) our paper proposed a new construct called “big data capability.” We also conceptualized what constitutes the “big data capability” in business organizations by suggesting three sub-lower-level constructs that form the big data capability including: big data infrastructure capability, big data management capability, and big data science capability. To respond to the compelling demand for theorizing on the impact of big data on business competitiveness and organization performance, we proposed a theoretical model explaining the mechanism
in which “big data capability” improves organization competitive activity and enhances organization performance.

**Theoretical Implications**

Our research model is well positioned to extend the theories and related literature adopted in this study including the dynamic capabilities theory as well as the literature of strategic value of information systems, marketing and strategic management. First, we extend the IT capability literature by proposing a new construct that is more responsive to the current theoretical and practical demands (i.e., big data capability) and demonstrates the three dimensions of the construct including big data infrastructure, big data management, and big data science. Second, our theoretical model extends the dynamic capabilities theory by introducing big data capability as a precedent to the customer sensing capability, and by considering the moderating effect of both market orientation and data driven culture on the relationship between big data capability and customer sensing capability.

**Practical Implications**

This paper and associated theoretical model have important implications for both business and IT leaders who are interested in utilizing big data to improve their organizations performance. Our manuscript first identified the three dimensions that constitute the big data capability for business organizations. In doing so, we give guidance and directions to IT and Business leaders on what must be developed in order to claim the big data capability. Second, the paper focused on the use of big data to enable customer sensing agility. In other words, the paper sheds light on how big data initiatives support organization ability to sense customer related opportunities. Third, the paper stressed the importance of having the required organizational ability to respond to the detected opportunities in order to complement the impact of big data in enhancing organization performance. It also emphasized the importance of having the customer orientation and data driven decision making culture before thinking of improving big data capability. In other words, before investing in big data initiatives, business and IT leaders must make sure that their organizations are customer oriented and that they have the data driven decision-making culture. They also have to make sure that their customer responding capabilities are strong enough to respond in speed and surprise to the opportunities that big data can help the organization in detecting. If not, they must complement these initiatives with the required ones to enable the firm’s customer responding agility.

**Limitations and Future Research**

The biggest limitation of our work is that it is theoretical. More empirical research and testing have already been planned to be done. Future work will focus on developing the measurement instrument to measure big data capability and then an empirical study will be performed to test the proposed research model.

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