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Big data analytics and firm performance: Effects of dynamic capabilities☆

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ABSTRACT

Drawing on the resource-based view and the literature on big data analytics (BDA), information system (IS) success and the business value of information technology (IT), this study proposes a big data analytics capability (BDAC) model. The study extends the above research streams by examining the direct effects of BDAC on firm performance (FPER), as well as the mediating effects of process-oriented dynamic capabilities (PODC) on the relationship between BDAC and FPER. To test our proposed research model, we used an online survey to collect data from 297 Chinese IT managers and business analysts with big data and business analytic experience. The findings confirm the value of the entanglement conceptualization of the hierarchical BDAC model, which has both direct and indirect impacts on FPER. The results also confirm the strong mediating role of PODC in improving insights and enhancing FPER. Finally, implications for practice and research are discussed.

1. Introduction

Big data analytics (BDA) is emerging as a hot topic among scholars and practitioners. BDA is defined as a holistic approach to managing, processing and analyzing the 5 V data-related dimensions (i.e., volume, variety, velocity, veracity and value) to create actionable ideas for delivering sustained value, measuring performance and establishing competitive advantages (Fosso, Akter, Edwards, Chopin, & Gnanzou, 2015). Some practitioners and scholars have gone so far as to suggest that BDA is the "fourth paradigm of science" (Strawn, 2012, p.34), a "new paradigm of knowledge assets" (Hagstrom, 2012, p. 2), or "the next frontier for innovation, competition, and productivity" (Manyika et al., 2011, p.1). All these assertions are primarily driven by the ubiquitous adoption and use of BDA-enabled tools, technologies and infrastructure including social media, mobile devices, automatic identification technologies enabling the internet of things, and cloud-enabled platforms for firms' operations to achieve and sustain competitive advantage. For example, BDA allows for improved data-driven decision making and innovative ways to organize, learn and innovate (Yiu, 2012); thus, reinforcing customer relationship management, improving the management of operations risk, and enhancing operational efficiency and overall firm performance (Kiron, 2013).

Yet prior studies of the business value derived from information systems (IS) investments have reported mixed results, resulting in the so-called 'IT productive paradox'. Indeed, some scholars have argued that IS investments do not necessarily lead to improved operational efficiency and effectiveness (Irani, 2010; Roach et al., 1987; Sharif & Irani, 2006; Solow, 1987; Strassmann, 1990), while others identified a positive association between IS investments and firm performance (Barua, Konana, Whinston, & Yin, 2004; Barua, Kriebel, & Mukhopadhyay, 1995; Brynjolfsson & Yang, 1996). Their findings suggest that the absence of a positive link between IS investment and firm performance found by prior studies may be explained by several factors including the unavailability of appropriate data, the existence of time lags between IS investments and the business value generated from these investments, the absence of an assessment of the indirect benefits of IT, and the level of analysis of IS-related benefits (Anand, Fosso, & Sharma, 2013; Brynjolfsson & Hitt, 2000; Brynjolfsson & Yang, 1996; Devaraj & Kohli, 2003; Irani, 2002; Irani, Ghoneim, & Love, 2006). In fact, within this stream of research, eminent scholars argue that the impact of IT on firm performance may be mediated by a number of intermediate variables (Mooney, Gurbaxani, & Kraemer, 1996). Furthermore, they propose applying a broader view of IT resources by integrating a multidimensional perspective into studies of the business value of IT or IT capabilities (Bharadwaj, 2000; Bhatt & Grover, 2005; Santhanam & Hartono, 2003). In this paper, we extend this stream of research by

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examining factors that contribute to improved firm performance as a result of BDA investments. More specifically, the study aims to examine the following research questions:

i. How are BDA capabilities measured and are their overall uses linked with firm performance?
ii. Do process-oriented dynamic capabilities (PODC) play a mediating role in the relationship between BDAC and FPER?

To address these research questions, this research draws on the emerging literature on BDA, IT capabilities as well as the resource-based view (RBV). The remainder of this paper is structured as follows: First, definitions of big data analytics are provided. This is followed by the presentation of selected studies on IT capabilities and big data analytics capabilities. Then, the research model and our research hypotheses are presented, followed by the research design. The subsequent sections present the data analysis and findings of the study, the discussion, and the conclusion and implications for research and practice.

2. Big data analytics as a new enabler of competitive advantage

BDA is now considered as a game changer enabling improved business efficiency and effectiveness because of its high operational and strategic potential. The emerging literature on BDA has identified a positive relationship between the deployment of customer analytics and firm performance (Germann, Lilien, Fiedler, & Kraus, 2014). For example, BDA allows firms to analyze and manage strategy through a data lens (Brands, 2014). Indeed, BDA is increasingly becoming a crucial component of decision-making processes in businesses (Hagel, 2015). BDA is now considered as "a major differentiator between high-performing and low-performing organizations," as it allows firms become proactive and forward-looking, decreases customer acquisition costs by about 47% and enhances firm revenue by about 8% (Liu, 2014). The literature provides the example of Target Corporation, which uses BDA through its loyalty card program to track customers' purchasing behaviors and predict their future buying trends. Amazon.com is another example of a firm that is capitalizing on BDA. Indeed, almost 35% of purchases made on Amazon.com are generated from personalized purchase recommendations to customers based on BDA (Wills, 2014). Another example discussed in the literature is GE, which is planning to use BDA to improve the efficiency of the 1500 gas turbines it monitors by means of software and network optimization, as well as to improve the dispatching of service and the coordination of gas and power systems. If realized, these benefits could lead to $66 billion in fuel savings over the next 15 years (Ward, 2014).

BDA is expected to have tremendous impacts within a variety of industries. For example, major retailing firms are presently leveraging big data capabilities to improve the customer experience, reduce fraud, and make just-in-time recommendations (Tweney, 2013). In the healthcare sector, BDA is expected to reduce operational costs and improve the quality of life (Liu, 2014). In manufacturing and operations management, BDA is considered to be an enabler of asset and business process monitoring (Davenport et al., 2012), supply chain visibility, enhanced manufacturing and industrial automation (Wilkins, 2013), and improved business transformation (Gardner, 2013).

3. IT capabilities and big data analytics capabilities

Eminent scholars argue that it is important to take a broader view of IT to better capture the business value of IS investments and deal with the IT 'productive paradox' (Bharadwaj, 2000; Bhatt & Grover, 2005; Santhanam & Hartono, 2003). They suggest focusing on IT capability, which is defined as the "firm's ability to mobilize and deploy IT-based resources in combination or co-present with other resources and capabilities" (Bharadwaj, 2000). Studies on IT capability have commonly used the RBV (Bharadwaj, 2000; Santhanam & Hartono, 2003), which originated from strategic management (Ryu & Lee, 2013; Zee & Jong, 1999). In this stream of research, studies argue that competitive advantage is achieved by deploying and using distinctive, valuable, and inimitable resources and capabilities (Bhatt & Grover, 2005). In fact, the concept of IT capability is based on the assumption that, while resources can easily be replicated, a distinctive set of capabilities mobilized by a firm is not easy to replicate and will lead to sustained competitive advantages (Santhanam & Hartono, 2003). Strategic management scholars argue that "investments into different IT assets are guided by firms' strategies and deliver value along performance dimensions consistent with their strategic purpose" (p.763) (Aral & Weill, 2007). For this stream of research, IT capability will be used to achieve strategic integration by applying the capability for IT functionality to both shape and support business strategy (Zee & Jong, 1999). Moreover, any original capability will always lead to sustained competitive advantage through its path dependency, causal ambiguity, and social complexity (Porter & Millar, 1985). Consistent with prior studies (Davenport, 2006; Davenport & Harris, 2007; Goes, 2014; Mcafee & Brynjolfsson, 2012b), we view BDAC as an important organizational capability leading to sustainable competitive advantage in the big data environment. The study also argues that original capability will always lead to sustained competitive advantage through its path dependency, causal ambiguity, and social complexity (Porter & Millar, 1985). Consistent with several earlier studies (Davenport, 2006; Davenport & Harris, 2007; Goes, 2014; Mcafee & Brynjolfsson, 2012b), in this study, we view BDAC as an important organizational capability leading to sustainable competitive advantage in the big data environment.

Many typologies of IT capabilities have been proposed. For example, Bhatt and Grover (2005) characterized IT capability through value, heterogeneity, and imperfect mobility. They argued that IT capability value and heterogeneity are "necessary conditions for competitive advantage," while imperfect mobility is "necessary for sustained advantage" (p. 258). They further conceptualized three different types of capabilities: value capability (e.g., quality of IT infrastructure), competitive capability (e.g., quality of IT business expertise), and dynamic capability (e.g., intensity of organizational learning) in order to better understand the sources of IT-based competitive advantage. Using a sociomaterialistic perspective in conceptualizing a firm's IT capability, Kim, Shin, and Kwon (2012) considered IT capability to be a function of IT management capability, IT personnel capability and IT infrastructure capability. They argued that sociomaterialism-based modeling underscores complementarities among the three IT capabilities identified, as opposed to the dominant traditional approaches in IS, in which IT capability was characterized in terms of "unidirectional and unrelated conceptualization" (p. 329). The authors also tested and found a positive relationship between IT capability and firm performance (business process and financial). This result is consistent with prior studies that assessed the relationship between IT capability and related outcomes (e.g., firm performance, firm agility, stock market returns) (Gibb, Thornley, Ferguson, & Weckert, 2011; Lin, 2007).

In a similar spirit to the IT capabilities literature, we conducted a review on big data analytics capabilities which presents us with three predominant dimensions, that is, management, infrastructure and personnel capabilities. For instance, McAfee and Brynjolfsson (2012b) put forward personnel management, technology infrastructure, and corporate decision making as critical capabilities across organizations in data economy. Similarly, Kiron, Prentice, and Ferguson (2014) identify organization culture, analytics platform, and employees' analytics skills as core dimensions of BDA. Furthermore, Davenport et al. (2012) highlight that management, people and technology dimensions are interlinked in big data environment, which help each other to enhance broader firm performance. These dimensions of BDA and their relationships are supported by Barton and Court (2012) who point out that management capability is important to optimize decision models; technology capability is essential to explore and manage variety of data; and

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