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Exploring the path to big data analytics success in healthcare

Yichuan Wang *, Nick Hajli *

Newcastle University Business School, 102 Middlesex Street, London, E1 7EZ, United Kingdom

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ABSTRACT

Although big data analytics have tremendous benefits for healthcare organizations, extant research has paid insufficient attention to the exploration of its business value. In order to bridge this knowledge gap, this study proposes a big data analytics-enabled business value model in which we use the resource-based theory (RBT) and capability building view to explain how big data analytics capabilities can be developed and what potential benefits can be obtained by these capabilities in the health care industries. Using this model, we investigate 109 case descriptions, covering 63 healthcare organizations to explore the causal relationships between the big data analytics capabilities and business value and the path-to-value chains for big data analytics success. Our findings provide new insights to healthcare practitioners on how to constitute big data analytics capabilities for business transformation and offer an empirical basis that can stimulate a more detailed investigation of big data analytics implementation.

1. Introduction

During the past decade, there has been a proliferation of research on health information technology (HIT), from both practitioners and academics, showing that HIT is essential for improving quality of care and financial performance (Agarwal, Gao, DesRoches, & Jha, 2010). The intensive use of HIT has generated the enormous variety of patient data that comes from medical recordings (e.g., electronic healthcare records; EHRs, biomedical data), as well as external data sources, such as insurance claims/billing, R&D laboratories, and social media (Ward, Marsolo, & Froehle, 2014). Such large-scale data galvanizes healthcare organizations toward making huge investments in big data analytics to acquire valuable insights and facilitate timely decision-making, minimize patient risk, and reduce clinical cost (Chen, Chiang, & Storey, 2012).

Computer scientists emphasize that big data analytics is capable of processing an immense volume, variety and velocity (3V) of data across a wide range of healthcare platforms, and has tremendous benefits on medical functions (Jiang et al., 2014; Srinivasan & Arunasalam, 2013). Big data analytics is increasingly advocated as one of the most important information technology (IT) innovations for healthcare organizations (Raghupathi & Raghupathi, 2014). Compared to other industries, such as retailing and banking industries, however, healthcare industry lags behind in taking advantage of thoughtful analytical tools and methods (Ferranti, Langman, Tanaka, McCall, & Ahmad, 2010; Fihn et al., 2014). Healthcare organizations are struggling with the implementation of big data analytics although they invest in numerous analytics technologies with the hope for healthcare transformation (Murdoch & Detsky, 2013; Shah & Pathak, 2014). Evidence from a survey also shows that 60% of healthcare organizations surveyed fail to develop a clear, integrated enterprise strategy and vision for analytics deployment across a broad range of functions (Deloitte Center for health Solutions, 2015). One of the reasons for these failures is a lack of understanding on the economic potential of big data analytics (Groves, Kayyali, Knott, & Kuiken, 2013; Murdoch & Detsky, 2013). Indeed, big data analytics is a double-edged sword for IT investment, potentially incurring huge financial costs for healthcare organizations due to poor governance (Watson, 2014). On the other hand, with appropriate governance, it has the potential to equip organizations with the tools they need to harness the mountains of heterogeneous data, information, and knowledge that they routinely gather (Bardhan, Oh, Zheng, & Kirksey, 2015; Basole et al., 2015; Bates, Saria, Ohno-Machado, Shah, & Escobar, 2014), support a wide range of medical functions at a lower cost (Raghupathi & Raghupathi, 2014), and develop a new portfolio of business strategies for their products and services.

According to a systemic review on the current state of big data research, by Wamba, Akter, Edwards, Chopin, and Gnanzou (2015), the constantly growing body of research on big data has mostly focused on addressing technical issues. However, organizations will not acquire the full benefits of leveraging big data analytics unless they are able to address managerial challenges effectively (Mcafee & Brynjolfsson, 2012), orchestrate strategic choices and resource configurations (Xu, Frankwick, & Ramirez, 2016), as well as understand the managerial, economic, and strategic impact of big data analytics (Raghupathi & Raghupathi, 2014; Ward et al., 2014). Without reasonable justifications, not only it is difficult to help healthcare practitioners focus priorities and

* Corresponding authors.
E-mail addresses: yi-chuan.wang@ncl.ac.uk (Y. Wang), nick.hajli@ncl.ac.uk (N. Hajli).

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efforts on driving value from the adoption of big data analytics, but it also cannot find sufficient evidence of how big data analytics investment can pay off (Murdoch & Detsky, 2013; Shah & Pathak, 2014). Moving a deeper understanding on the ways and means to create business value from big data analytics will result in reducing a resistance to adopt big data analytics and an ineffective use of analytics. Thus, exploring the path to big data analytics success for healthcare transformation is currently one of the most discussed topics in the fields of computer science, information systems (IS) and healthcare informatics. This study seeks answers to the following research question: *How healthcare organizations can capture business value from big data analytics?*

To answer this question, we base our exploratory analysis on a theoretical model - namely the big data analytics-enabled business value (BDAE-BV) model to explain how big data analytics capabilities can be developed and what potential benefits can be obtained by these capabilities in healthcare organizations. Specifically, we use the resource-based theory and capability building view to link big data architectural components, through analytics-enabled IT capabilities, to a big data analytics-specific benefits framework. This model was subsequently validated on a broader empirical basis by using 109 case descriptions of big data analytics implementation. Our findings offered theoretical and practical insights on big data analytics in the healthcare context; this can enrich the understanding of big data analytics' business value creation and can also provide guidance and evidence for healthcare practitioners for their business case justifications.

2. Theoretical foundation for deriving big data analytics-enabled business value model

The theoretical foundation of our BDA-BV model comprises of two elements: resource-based theory (RBT) and capability building view. During the last two decades, RBT has been the principal theoretical foundation for explaining how resources can be transformed into a sustained competitive advantage (Barney, 1991, 2001). RBT assumes that a firm can be profitable as long as it can exploit a bundle of valuable, rare, inimitable, and non-substitutable (VRIN) resources in a highly competitive market (Barney, 1991). Drawing on the RBT, much of the works in the IS field have argued the different types of IT resources (e.g., physical, technical and human IT resources) can add value to firms' operations (Bharadwaj, 2000; Doherty & Terry, 2009; Karimi, Somers, & Bhattacherjee, 2007; Lin & Wu, 2014; Melville, Kraemer, & Gurbaxani, 2004). However, several research commentaries criticize RBT, stating that it lacks explanatory power on how IT resources are orchestrated, how specific IT systems can create unique and idiosyncratic IT capabilities and how they ultimately lead to competitive advantage gains (Kim, Shin, Kim, & Lee, 2011; Kohli & Grover, 2008; Mukhopadhyay, Kekre, & Kalathur, 1995).

Capability building view has been utilized to complement the pitfalls of RBT (Bharadwaj, 2000; Doherty & Terry, 2009; Karimi et al., 2007; Santhanam & Hartono, 2003; Saraf, Langdon, & Gosain, 2007; Wang, Liang, Zhong, Xue, & Xiao, 2012). Capability building refers to "the ability of firms to build unique competencies that can leverage their resources" (Karimi et al., 2007, p. 223). Capability building view suggests that firms have to build capabilities by selecting and deploying resources and assembling these resources into synergetic combinations, thereby transforming inputs into valuable outputs (Karimi et al., 2007; Weill & Vitale, 2002). Teece, Pisano, and Shuen (1997) have argued that such capabilities cannot easily be bought; they must be built (p. 529). Applying the capability building view in the IS field, Bharadwaj (2000) extend the notion of capabilities to a firm's IT function and defined a firm's IT capability as its "ability to mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities" (p. 160). Kohli and Grover (2008) further suggest that IT capabilities are often created by combining specific physical IT artefacts, human, and technological resources.

Drawing on the capability building view, a proliferation of research has explored IT functional capabilities by certain basic IT architecture, IT functionalities or system software, arguing that such capabilities can lead to better strategic value and organizational performance (Iyer & Henderson, 2010; Rai, Pavlou, Im, & Du, 2012; Ravichandran, Lertwongsatien, & Lertwongsatien, 2005; Mueller, Viering, Legner, & Riempp, 2010; Pavlou & El Sawy, 2010). By breaking down IT-leveraging capabilities into its three underlying IT system components, for example, Pavlou and El Sawy (2010) examine whether the effective use of project and resource management systems, organizational memory systems, and cooperative work systems can achieve organizational capabilities and competitive advantage in the new product development. Meanwhile, by developing a comprehensive service-oriented architecture economic potential model (SOA-EPM), Mueller et al. (2010) identify a set of SOA capabilities (e.g., reusability, interoperability, and flexibility), derived from its design principles for enhancing organizational performance.

In the healthcare context, Anand and Wamba (2013) propose a comprehensive model to assess the business value of radio frequency identification (RFID) applied in healthcare and elucidate how capabilities of RFID improve process level effects (i.e., automational, informational, and transformational) resulting in the gain of organizational performance. Singh, Mathiassen, Stachura, and Astapova (2011) disentangle the relationship between different types of IT-enabled capabilities and improved clinical and financial outcomes. By conducting a longitudinal study on a home care provider, they found that the abilities formed by remote patient monitoring (RPM) and home healthcare devices can facilitate the formation of transactional and transformational dynamic capabilities and performances. Ghosh and Scott (2011) describe how analytical capabilities facilitate data-driven decision making. Their case study shows that Veterans Health Administration's (VHA) big data analytics systems allow aggregating patient data to establish measurable improvements, which help healthcare managers to allocate resources (e.g., determine the resource utilisation for the facility and geographic distribution of patients' support service needed) and choose future treatments and policies (e.g., assess the outcomes of policy initiatives and develop medical protocols).

Guided theoretically by these aforementioned studies, we view big data analytics architecture as a specific technical IT resource based on the RBT. It is characterized by a set of big data analytics architectural components (i.e., data aggregation, data processing, and data visualization). Each big data analytics architectural component is constituted by the specific big data analytics tools and functionalities that are used to transform healthcare data from various sources into meaningful clinical insights through big data analytics tools. Building on the IT capability building view, each component could be logically expected to generate big data analytics capabilities and these capabilities are expected to induce the business value. We thus link the logical paths among the big data analytics architectural components, big data analytics capabilities, and potential business value driven by these capabilities.

The conceptualization of our model is illustrated in Fig. 1. The solid boxes in Fig. 1 are left blank at this stage, since the logic path between big data analytics capabilities and benefit dimensions is part of our exploratory work. Later, they are filled by first identifying big data analytics capabilities, then they are linked to the benefit sub-dimensions, based on the analysis of big data implementation cases. In the following subsections, we first elaborate on each big data analytics architectural component, followed by the definition of big data analytics capabilities, and the conceptualization of big data analytics' business value.

3. The constructs of big data analytics-enabled business value model

3.1. Big data analytics architecture as a technical IT resource

To identify the components of big data analytics architecture, we review over 10 big data analytics architectures from academic literature

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