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The Internet of Things, dynamic data and information processing capabilities, and operational agility

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ABSTRACT

Whilst there are promising links between the Internet of Things (IoTs), dynamic data and information processing capabilities (DDIPCs), and operational agility, scholars have not conducted enough empirical studies that offer convincing evidence for the use of the IoTs and relevant linkages. This study therefore examines the links between such constructs and provides managerial implications for contemporary data and information driven managers who adopt evidence-based decision making for better operational outcomes. The results obtained from structural equation modelling indicate that the use of the IoTs is the key determinant for operational agility and also plays a vital role in establishing DDIPCs that further reinforce it. Additionally, DDIPCs mediate the relationship between the use of the IoTs and operational agility. By persuasively building these links based on theoretical arguments and testing them by using a unique dataset, this study contributes to the deeper understanding of the mechanisms by which the use of the IoTs and DDIPCs strengthen operational agility.

1. Introduction

The Internet of Things (IoTs) has recently emerged as a key disruptive technology that not only plays a main role in daily activities, but also affects business operations and global economic systems as a whole (Atzori et al., 2010; Wortmann and Flüchter, 2015). With the use of the IoTs (i.e., the inter-networking of devices with the ability to send and receive data), business operations are becoming more agile and connected. Also, the data and information produced through the IoTs is used to generate knowledge that is ultimately employed to monitor and control business network operations. The companies that utilize the links between the IoTs and dynamic data and information processing capabilities (DIDPCs) achieve a better competitive advantage; they do so because their daily business operations become more agile as a result of these developments in their IT infrastructures (Christopher, 2000; Heisterberg and Verma, 2014; Lou et al., 2011; No et al., 2015). The significance of the IoTs and of its linkages with operational effectiveness, data, and informed decision making has been highlighted by key IT players. For instance, Microsoft believes that "the IoTs can make a difference to your business by beginning with the things in your business that matter the most. It's really the internet of your things, and it starts by building on the infrastructure you already have in place, using familiar devices and services in new ways, and incorporating the right technology to ultimately help you use data to create insights and make more informed business decisions" (Edson, 2014). As a result of this business appeal, "the IoTs, which excludes PCs, tablets and smartphones, will grow to 26 billion units installed in 2020, representing an almost 30-fold increase from 0.9 billion in 2009, and IoTs product and service suppliers will generate incremental revenue exceeding $300 billion" (Gartner, 2013). Also, the Vodafone IoTs Barometer claims that 76% of businesses view the IoTs as critical for the future, 90% of organizations have already integrated IoTs data into their existing IT systems, and 63% of such adopters have increased their growth by at least 20% (Forbes, 2016; Vodafone, 2016).

These statistics have provided growing evidence that the use of the IoTs is demonstrably crucial in creating data and information that are associated with the capabilities of organizations, providing them with insights related to operational agility and effective decision making. The impacts of the IoTs seem to be limitless, as the connected devices provide data and information about both internal and external operations. Despite the claims and statistics presented above, the academic studies on the links between the use of the IoTs, DDIPCs, and operational agility are just emerging; the research concerning the mechanisms through which the IoTs affects operational agility is still

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in its infancy. More specifically, the linkages between the use of the IoTs and DIDPCs to generate knowledge suitable to improve operational agility have neither been effectively researched nor statistically estimated. Above all, the field is still devoid of clear theoretical bases (Bresciani et al., 2017; Cram and Newell, 2016; No et al., 2015; Teece, 2014a).

Given that the academic research on the use of the IoTs is just emerging, the first contribution of this study is to develop a theoretical framework by building inter-relationships between the use of the IoTs and DDIPCs, and operational agility. Conceptually, the IoTs and DDIPCs seem well linked, but answering the question of how they impact operational agility substantially contributes to closing the knowledge gap in the operational and IT domains. Secondly, operational agility itself has not been well established. In the IT literature, operational agility generally focuses on quick responses, accurate actions, and cost-efficiency pertaining to both customers and internal operations; we provide evidence that it is also linked at the macro-level. Consequently, operational agility is a second-order construct that integrates both its internal and external aspects. Finally, we test the framework and provide significant evidence by following a comprehensive statistical procedure and using a unique dataset.

2. Theory and hypotheses

2.1. Literature and definitions

The term "*the Internet of Things*" is used for those devices that have network connectivity and the ability to send or receive data and information to other connected objects. It is a major developmental wave—after the desktop and web-based ones—in the information and communication technology (ICT) sectors (Atzori et al., 2010; Ma, 2011). The idea is essentially based on the device-to-device connections and communication that can be effectively established using smart devices (e.g., wearable devices and Chromecast, Samsung, and Apple smartphones), their functionalities (e.g., Wi-Fi, Bluetooth), cloud computing facilities, and sensors. These devices provide accurate and real-time data and information that are used to track and trace operational resources and personnel. This enhances visibility, leading to the development of agile operations among connected business networks (Lu and Ramamurthy, 2011; Miorandi et al., 2012; Yang et al., 2013). Yang et al. (2013) provided evidence that the IoTs enhances the effectiveness of response operations in terms of the accountability of resources, specialized actions, assessment of situations, resource allocation, and multi-organizational coordination. Similarly, micro-sensors can be used to monitor patient health and smart meters can be used to monitor electricity consumption. Also, the transportation data and information linked with any connected devices are collected and processed for effective traffic management or traffic supply chain visibility and agility (Elhenawy and Rakha, 2017; Uden and He, 2017; White et al., 2005).

An organization's dynamic capabilities are viewed as its ability to promptly adopt changes and process data and information for actionable knowledge or analytics that enable the effective tackling of changes in the market (No et al., 2015; Ramírez et al., 2013; Teece, 2014a). Such capabilities help organizations to quickly turn structured and unstructured data into insights and knowledge that can be used to improve business operations. An example of such capabilities includes the complex text mining ability used to respond to consumer feedback or reviews and thus improve customer service (Kim et al., 2012; No et al., 2015). Organizations equipped with advanced electronic devices capture real-time contextual data and information that are frequently used in their daily supply chain operations. They also utilize individual speech recognition capabilities to speed up their warehouse operations. These dynamic capabilities are not only imperative for contemporary data-driven business operations, but also help to improve business network visibility and operational agility (Chou et al., 2007; Dweekat et al., 2017; Hazen et al., 2014; Reaidy et al., 2015).

In the information management literature, the term "*agility*" generally consists of three dimensions: operational, partnering, and customers. "*Operational agility*" focuses on quick responses, accurate actions, and cost-efficiency (i.e., cost economy). Importantly, it is not only related to internal processes, but also covers external operational processes. It is basically defined as the ability of organizations to swiftly react to changes and uncertainties. Secondly, "*partnering*" is the ability of organizations to leverage their network partners' knowledge and capabilities to assist in identifying problems and capturing opportunities to improve their performance. Finally, "*customer*" aspects emphasize learning from customers and acting accordingly (Huang et al., 2014; Izza et al., 2008; Sambamurthy et al., 2003). In other fields, such as supply chains and logistics (Tse et al., 2016), agility includes demand responses, customer responses, and joint planning. Huang et al. (2000) believed that agility can be used in many functions of networked enterprises, such as recovery, collaboration, partnerships, and logistics. Vickery et al. (2010) defined agility as a tool that improves responsiveness to customer needs.

In addition to its characteristics described above (quick, accurate, and cost-efficient), operational agility assists in adjusting operational changes and provides more flexibility in day-to-day operations (Langer and Alting, 2000; Pawson and Wade, 2003). It also enables the swift redesigning and building of new processes, ultimately enabling the exploitation of market opportunities that are part of external business environments (Seebach et al., 2011; Tallon and Pinsonneault, 2011). It is evident from the literature that there is no single definition of agility or operational agility, and that the latter mainly involves: 1) speed, 2) accuracy, 3) cost-efficiency, and 4) flexibility. Importantly, it encompasses both internal and external aspects in regard to the characteristics mentioned above. Correspondingly, we define operational agility as the ability of organizations to cope with demands and changes by considering the four aspects listed above both internally and externally. Thus, our definition of operational agility consists of two dimensions—internal and external operational agility—which are measured in terms of 1) speed, 2) accuracy, 3) cost-efficiency, and 4) flexibility.

2.2. Hypotheses

2.2.1. Use of the IoTs and operational agility

Due to its business benefits, the IoTs is regarded as one of the important digital revolutions of the modern age (Atzori et al., 2010; Del Giudice and Straub, 2011). It can act as an important storage and communication hub that links and transfers information between connected organizations and their networks (Liu et al., 2013; Uckelmann et al., 2011). Due to these characteristics, IoTs devices play a vital role in enabling modern day businesses to build better connectivity and progressive operations to improve their agility (Atzori et al., 2010; Del Giudice and Straub, 2011). The knowledge that comes through such connected devices offers agility, scalability, and reliability in the form of the timely processing of information for better decision making (Atzori et al., 2010; Del Giudice and Straub, 2011; Uckelmann et al., 2011).

The information collected through the IoTs enhances the productivity of business processes. In other words, the knowledge and analytical insights gathered through this connectivity enable business networks to make informed and evidence-based decisions, and play a vital role in building dynamic data and information processing capabilities (Grant, 1996; Teece, 2007, 2014a; Uden and He, 2017). Ultimately, such capabilities improve internal and external operational agility (Heisterberg and Verma, 2014), which has nowadays emerged as one of the key capabilities IT-oriented businesses need to survive and prosper (Braunscheidel and Suresh, 2009; Bresciani et al., 2017; Heisterberg and Verma, 2014). In a sense, the use of the IoTs is the key determinant that transforms the nature and ways of doing business, as it is noted that investing in IT infrastructure capabilities can be vital