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Diffusion and Impact of Business Analytics: A Conceptual Framework

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***Abstract*—**We discuss a theoretical conceptual framework to help understand how the new business analytics technologies have diffused in firms. We draw on three theoretical perspectives for this purpose. They are innovation diffusion theory, IT Business Value and the technology-organization-environment theory. We develop a conceptual framework that helps understand the interlinkages among factors affecting diffusion of business analytics and its impact on performance.

***Keywords*—**Innovation diffusion, IT-Business Value, Technology-Organization-Environment, Business Analytics, Business performance

I. Introduction

DIGITAL analytics technologies and networks are overhauling the way that UK firms are generating and using data. By adopting new analytics technologies, firms are able to record and store a substantial amount of data in either numerical or text-based format containing potentially valuable information that they can analyze and use to operate and innovate more effectively. Examples of digital technologies include, but are not limited to, reaching and engaging consumers through social media, online advertising, ecommerce platforms, electronic data interchange, the internet, track and trace abilities, collaboration and communication tools such as wikis, efficient consumer response, radio frequency identification, collaborative planning, forecasting and replenishment, cloud computing, the vendor managed inventory and Customer Relationship Management. It has been estimated that use of digital technologies by businesses among partners can potentially save $223 billion [1] over a five year period for the US alone. However, there seems to be no detailed research study on the adoption of digital technologies and the innovative ways in which data obtained are utilized by firms, especially in the UK context. In this paper, we discuss a conceptual framework, derived from the literature, to understand the diffusion of data analytics in firms and assess the impact on company performance.

II. Literature

Digital technologies and business analytics can help businesses in terms of demand integration, supply integration, improved customer knowledge and increased processing power.

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Demand integration includes efficient delivery, delivery/ logistics communication, speed of delivery/route, inventory stocking points, and demand planning. Supply integration includes supplier reliability, multiple sourcing, responsive/flexible supply base, inbound logistics communication, and supplier planning [2]. Customer knowledge includes detailed data on spending patterns and preferences of customers. Processing power includes ability to communicate online using wikis and improved access to up to date software on demand via cloud. As a result of improving these organizational capabilities through the application of digital technologies, businesses may significantly improve their performance at both process level and firm level.

A. Impacts on business

Several research studies such as IT Business Value (ITBV) [3-5] in the past have explored the way investments in information technology (IT) and business analytics (BA) have helped companies improve performance. Though there is still a debate about the so called IT-productivity paradox [6], there is generally evidence that IT investments have positively influenced company performance. Brynjolfsson and Hitt [7] found that IT investment contributed significantly to firm-level output even considering depreciation and measurement errors. They insisted that information system spending has made substantial and statistically significant contribution to firm output. Shin [8] concluded the positive impact of IT on financial performance of most companies in his research with budget data of diverse firms from 1995 to 1997. Digital capabilities can enhance relationships with distribution channel partners [9] or cultivate supplier capabilities [10] by engaging information sharing and other forms of collaboration between customers and suppliers that address the issues of production planning and scheduling of their products [11]. Burca et al. [12] have developed a model to find the relationship between IT and performance via structural equation modeling with data from 231 companies. They have concluded that IT systems development improved performance in service sector. Dehning et al. [13] have studied the impact of IT based innovative supply chain management in US manufacturing firms. They have used essentially secondary data in the context of the US and found strong evidence for the positive impacts. Companies such as Dell have advantageously used digital technologies in the US to quickly share production/demand information between downstream and upstream partners to "trade inventory for information." Timely information sharing can quicken decision making processes, and will result in several benefits such as reduced lead times, more accurate demand forecasts, smaller batch sizes, etc. [14]. Kim et al. [15] have explored the role of innovation surrounding supply chain communication channels on performance.

Studies specific to investments in BA have also generally supported the view that these investments have helped improve

performance of firms [16-20]. However, studies on the impact of BA are relative recent and there is still very little conceptual analysis and empirical evidence to understand how BA has diffused and helped to improve performance in firms. We attempt to fill this important research gap in this paper. Specifically, we seek to develop a conceptual framework for understanding the diffusion of BA and impact on firm performance based on the theoretical perspectives of innovation diffusion (ID), ITBV and the technology-organisation-environment (TOE).

These theoretical perspectives are discussed in the next section.

III. Theoretical Perspectives and the Conceptual Framework

In order to understand the diffusion and performance impact of BA , we will first develop a conceptual framework based on literature review and a review of relevant past theoretical studies. Our conceptual framework is especially underpinned by theories developed for studying the innovation diffusion [21], IT adoption [22] and ITBV [3-5]. The framework is shown in Fig. 1. We elaborate the framework in the next few pages.

ID theory studies how innovations are communicated through certain channels over time and within a particular social system. Rogers [21] identified five attributes that may affect the rate of adoption of an innovation: relative advantage, compatibility, complexity, trialability, and observability. According to Wang et al. [23], ID theory is consistent with the technology-organization-environment (TOE) framework proposed by Tornatzky and Fleischer (1990).

The TOE framework studies the adoption of technological innovation. Tornatzky and Fleischer[22] suggested that the decision to adopt a technological innovation is based on factors in the organizational and environmental contexts, also the characteristics of the technology itself. Hence this framework investigates the adoption and implementation of technological innovations in the technological, organizational, and environmental contexts.

Compatible with the TOE framework, ITBV research suggested that the extent of the impact of IT on organizational performance is determined by a number of organizational factors [3, 4, 24]. Brynjolfsson [25] made it clear that IT "makes little direct contribution to the overall performance of a company or the economy until it's combined with complementary investments in work practices, human capital, and organizational restructuring" (p. 42-43).

A. Technological Factors

The technological context refers to the technologies that are relevant to the firm and the firm specifics characteristics that may affect the adoption of technologies. This includes the existing technologies and emerging technologies relevant to the firm [23]. Many characteristics of the technology can influence its adoption. The five technological characteristics in the ID theory: relative advantage; compatibility; complexity; trialability; and observability, can be viewed as the technological context in the TOE framework [23].

We first discuss the components of ID theory relevant to BA [21-23, 26].

Relative advantage offered could be a facilitator for adopting BA. For example, BA can improve profitability better than other pre-existing informal analyses, if any. BA could be used to identify more market opportunities compared to simply relying on informal techniques e.g., market segmentation. Firms using BA effectively could save more money. Effective use of BA can help firms understand customer preferences better and can lead to higher levels of customer satisfaction. Effective use of BA can help identify profitable customers better by using BA compared to simply relying on informal techniques.

The level of compatibility of BA applications with other existing infrastructure could affect adoption in firms. For example, firms may not be ready to adopt BA if they were forced to change their IT infrastructure drastically or if they were forced to recruit new manpower with additional analytical skills. On the other hand, adopting BA is easier in firms that already have compatible infrastructure and manpower, and have experience in implementing similar systems. More importantly, for BA to be successfully adopted by firms, it is important that the changes introduced by BA are consistent with the firm's existing beliefs/values.

Firms may be able to adopt BA better if they can conduct trials and observe its benefits. If there are examples of successful case studies of firms that have benefited using BA, other firms may consider implementing BA with more enthusiasm. It will further improve the adoption of BA by firms if the firms can observe that effective use of BA help improve customer satisfaction, reduce costs, improve revenues in the long run, through trials or otherwise.

Sometimes, firms can perceive complex procedures associated with implementing BA as a possible barrier to adoption. Specifically, high skilled manpower needed for implementing BA may not be readily available. Capturing confidential data of customers and storing them securely could be viewed as a complex process. Implementing BA may require investments in complex IT infrastructure and software.

We now turn to the theory of ITBV for understanding the diffusion of BA in firms.

Effective implementation of BA requires investments in IT infrastructure and related manpower. Human aspects of IT assets can significantly influence adoption of BA [23, 26]. The success of BA greatly benefits from the technical IT skills of its human resources and the ability to generate good business insights by analyzing BA data. Problem solving orientation of skilled BA staff can also greatly help with the implementation and adoption of BA.

Similarly, correct investments in technology can facilitate adoption of BA [22, 23, 26].. As highlighted earlier, a compatible existing technology platform can definitely facilitate adoption.

If the firm has already adopted compatible database standards, it will help with the implementation and adoption of BA.

ITBV theory also emphasizes the importance of relationships in a firm. For example, partnerships within or outside a supply chain can help with the implementation and adoption of BA.

B. Organizational Factors

The organizational context describes the characteristics of an organization, which include firm size, complexity of its managerial structure, complementary investments available in the firm, quality of human resources, and amount of slack resources available internally [22, 23]. Variables such as changes to strategy, company structure, processes and culture are important organizational factors.

We include application domains of BA as another organizational factor as a firm that uses BA in more domains will be able to harness the power of BA better than those that do not use BA so widely. The domains of applications of BA in a firm include human resources, finance, research and development, purchasing/procurement, inbound logistics, outbound logistics, operations, customer relationship management and marketing, and sales.

Empirically, ITBV research indicated that significantly higher business value could be created when a firm aligned its IT to the requirements of its business strategy [27], organizational processes [28, 29], organizational structure [30, 31], and organizational culture [32]. For example, Kearns [27] indicated that an organization that had aligned its IT to its business strategy created significantly higher business value than an organization that had not. Radhakrishnan et al. [29] suggested that when a firm effectively integrated IT resource into its operational and management processes, the firm enjoyed better process capabilities and firm performance when compared to other firms in the same industry. Chen [31] indicated that IT investment in more decentralized and less formalized firm related positively to crossfunctional team interaction, which in turn had a positive effect on the performance of new product development. Bradley et al. [32] demonstrated that IT plan quality had a greater impact on IT success in conjunction with an entrepreneurial culture characterized by spontaneity, flexibility and individuality than with a formal culture emphasizing control, stability, order and bureaucracy; whilst Ifinedo [33] demonstrated that ERP success was a positive associated with a supportive, cooperative and collaborative organizational culture.

C. Environmental Factors

The environmental context refers to the factors external to an organization that can present constraints and opportunities for technological innovations. This includes business pressure, environmental munificence, complexity, and, dealings with business partners, competitors and the government [22, 23, 26]. Adoption of BA by firms is affected by industry regulatory pressures and by turbulent business environment.

Similarly, external environment characterized by the level of competition, supply chains and governmental support also affect adoption of BA.

Drawing on ITBV research [34], in more stable and mature environments, firms are likely to emphasize technologies that may improve IT infrastructures, IT technical skills and IT operations; whilst in more turbulent environments, firms prefers to exploit technologies that may result in market responsiveness, IT business partnerships, and better external relationships management.

D. Level of Adoption of Business Analytics and Its Integration with other Organizational Factors

From the TOE perspective, it is argued that the technological, organizational and environmental factors will then affect the level of BA adoption and diffusion. In our context, the level of adoption and diffusion include stages of, future plan in, and future trend of BA adoption.

Drawing on ITBV research, BA can be seen to be closely associated with organizational factors such as process, structure, culture, and strategy. When BA and organizational factors reinforce each other, superior business value can be expected. When BA and organizational factors work against each other, it is likely that business value can be negatively affected [35]. Therefore, the integration of BA and other organizational factors is a key factor to be examined in order to understand the diffusion and performance impact of BA in businesses.

E. The impact of Business Analytics on Firm Performance

Finally, the impact of BA on business performance can be understood ‘at both the intermediate process level and the organisation-wide level, and comprising both efficiency impacts and competitive impacts [5]. For instance, empirical evidence in ITBV suggests that IT can be used to improve the efficiency of for example knowledge management process [36], process reengineering [37], management processes [29] and supply chain processes [38]. These process level improvements can then impact on firm performance [7-8].

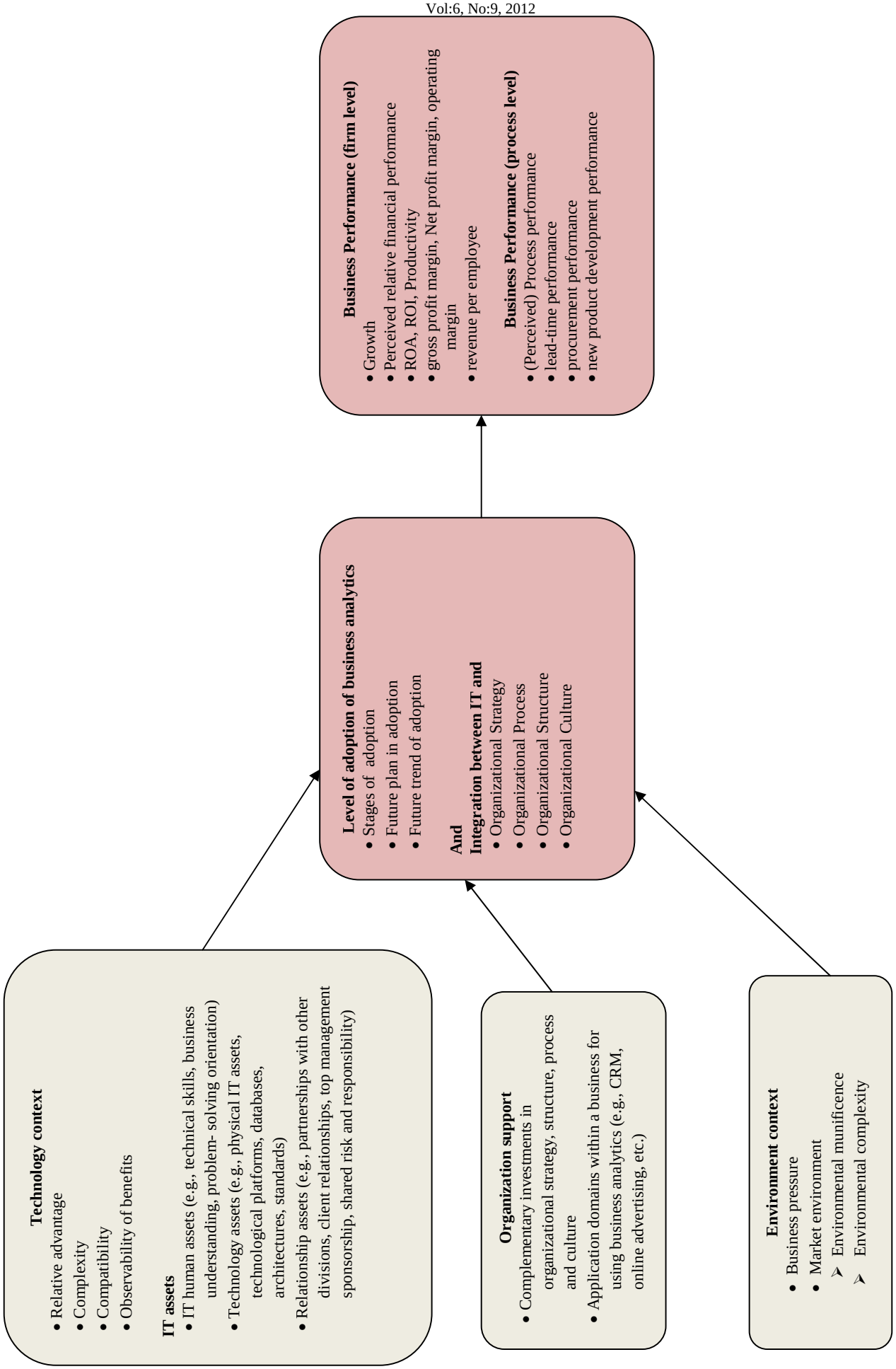

Fig. 1 A framework to understand the diffusion and performance impact of data and business analytics in businesses

Drawing on theories of ID, TOE and ITBV, the proposed conceptual framework can be used to understand the diffusion and performance impact of BA by considering how technological, organizational and environmental factors affect the stages of, future plan in, and future trend of BA adoption and the integration of BA and other organizational factors, which in turn impact on process level and firm level performance. Rather than looking at different aspects of BA diffusion and performance impact based on individual theories in isolation, the proposed conceptual framework provide a comprehensive way to develop a holistic understanding of BA diffusion and performance impact by examining the interrelationships among the aforementioned factors.

Our framework can be used as the first step in the analysis to understand the extent of diffusion of these technologies in the UK. We can then study the benefits (performance impact) and barriers for the adoption of business analytics, including complementarities of other investments such as e-commerce and ERP based on ITBV research.

IV. Research Issues

Thus the theoretical perspectives of ID, ITBV and TOE provide a rich framework for understanding the adoption and impact of business analytics. The framework can be used to recognize, among others, the following drivers of BA.

- Different digital analytics technologies being used presently, and the innovative ways in which these technologies are being used.
- The proportion of firms that is active in using these new technologies.
- Current uses of these techniques in supporting management and decision-making.
- Current levels of adoption of data and BA platforms.
- Differences across various manufacturing/service sectors in using business analytics.
- Reasons for non-adoption and strategies to improve the adoption rates.
- Benefits of using data and BA from UK business managers' point of view.
- Opportunities and barriers for further adoption of analytics and data-driven approaches to operation and management.
- Future use of data and business analytics
- Complementary investments and resources and organizational practices impinge on the effective access to and deployment of data by businesses.
- External factors on shaping the use and impact of data and business analytics.
- Ways in which data and BA help in achieving other business objectives (e.g., environmental sustainability, improving corporate image, meeting regulatory pressures, meeting the demands of stakeholders, cost minimization, risk management).

V. Conclusion

In this paper, we have combined three theoretical perspectives, namely the innovation diffusion theory, IT-Business Value and the Technology-Organization-Environment (TOE) theory, to develop a conceptual framework for understanding the factors affecting diffusion and impact of business analytics (BA) in firms. Based on innovation diffusion theory, our proposed framework helps understand how the relative advantage, complexity, compatibility, trialability and observability of BA impact the level of adoption. Rooted in IT-Business Value, our proposed framework helps to understand the role of organizational factors and complementary investments in enhancing the usefulness derived from BA-related investments. Drawing on the TOE theory, our proposed framework emphasises the role of technology-related factors (such as the ones highlighted by the innovation diffusion theory and IT-Business Value), organizational factors (managerial structure, support, complementary investments, human resources, slack resources, etc.) and environmental factors (business pressure, munificence, supply chain partners, etc.) in ensuring success of BA. Supported by these three theoretical perspectives, the proposed conceptual framework could be used to inform and develop a comprehensive understanding of the drivers behind adoption and impact of BA in firms. We hope to empirically test the framework to understand the diffusion and impact of BA in the UK. This forms scope for further work.

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