

Success or Failure of Big Data: Insights of Managerial Challenges from a Technology Assimilation Perspective

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Abstract. The popularity of big data analytics (BDA) as one of the leading digital technologies in organizations has increased tremendously. However, organizations, currently encounter various barriers to the successful adoption of BDA. Grounded in technology assimilation theory, this study goes beyond a binary view of BDA adoption and describes crucial managerial challenges along the more complex process of assimilation by conducting an exploratory and international Delphi study in collaboration with 21 experts. To exploit the full potential of BDA our results reveal that the assimilation process requires 1) appropriate organizational structures and 2) well defined business cases and business value from the very beginning (initiation phase) and on a continuous basis. From an academic perspective, the study sheds light on crucial challenges that influence the assimilation of BDA on its pathway to maturity. In addition, this study contributes to assimilation theory by providing a new perspective for BDA.

Keywords: Big Data Analytics, Assimilation, Challenges

1 Introduction

The increasing evidence for the potential benefits of big data analytics (BDA) has led the majority of all Fortune 500 companies (85%) in the US, to invest in BDA [1]. These organizations expect to create new business models, as well as products and services that support, optimize and automate organizational decisions and processes by analyzing large amounts of data [2]. BDA is increasingly incorporated in organizations in order to establish a more agile and efficient decision-making process and is often seen, as “one of the major innovations in the last decade” [3, p.1]. It enables organizations to transform towards a data-driven company and is therefore one of the leading digital technologies to support the digital transformation of companies [4].

However, as for many new technologies or information systems (IS), the process of implementing BDA in organizations poses challenges. According to Gartner [5], 60 percent of BDA projects fail because they are not completed within budget or on schedule, or fail to deliver certain features. Other practitioners see organizational change issues and insufficient access to data as relevant barriers [6]. Further reports claim that due to these various challenges more than half of BDA projects fail to go

farther than piloting and experimentation with Big Data [7]. Prior research has also started to observe some of the challenges of introducing BDA. For example, studies have identified technical issues, such as data security and privacy issues, and data integration complexities [8]. Other authors emphasize structural challenges, such as insufficient resources in general or a lack of skilled personal [9]. Overall, research and practical publications both highlight a diverse spectrum of managerial challenges that may be relevant for successful BDA projects.

However, it still remains unclear why BDA projects fail during different stages of introduction. Typically, the stated barriers are mainly examined with the assumption that there is just a single point of introduction. But the introduction of any technological innovation is usually not binary, being instead multi-staged and often a highly complex phenomenon [10]. Various issues which occur before, during and after implementation can put the success of BDA at risk. Furthermore, current research lacks adequate analysis of the prioritization of potential barriers, which need to be addressed primarily to leverage the full potential of BDA initiatives. Therefore, our study goes beyond viewing the implementation and use of BDA in a binary manner and instead analyzes the more complex phenomenon of BDA assimilation by drawing on the technology assimilation theory [e.g. 11, 12] to identify the most crucial barriers along the multi-staged process. Thus, this paper addresses the following research question: *Which crucial managerial challenges need to be addressed for a successful assimilation of Big Data Analytics in organizations?*

In order to answer this question, we build on the literature of BDA and the theory of technology assimilation as a theoretical foundation. We decided to perform an exploratory Delphi study in the field of BDA, because we recognized there was a lack of prior knowledge to build upon. Our study provides insights into the introduction of BDA in organizations and its related managerial challenges. It highlights crucial barriers of a digital technology along the assimilation process in organizations.

The paper is organized as follows: First (section 2), we present the background for our study by describing BDA and the technology assimilation theory. Next (section 3), we explain our methodological approach and describe the four-phase Delphi study applied to our context. In the results and discussion section (section 4 and 5), we present and discuss the managerial challenges identified, prioritized and highlighted along the assimilation stages by our experts. Finally, we suggest implications for research and practice and state the limitations of our research (section 6).

2 Background

This section briefly discusses the literature of BDA and related managerial challenges as well as the technology assimilation theory that is used to structure our Delphi study and interpret its results.

2.1 Big data analytics and related managerial challenges

Big Data as a term refers to the process of managing large amounts of data that come from several, heterogeneous data sources (e.g. internal and external, structured and unstructured) that can be used for collecting and analyzing enterprise's data [13]. In this paper we adopt a definition of BDA as techniques (e.g., analytical methods) and technologies (e.g., databases and data mining tools) that a company can employ to manage and analyze large-scale, complex data for various applications intended to augment a business's performance [14]. This definition comprises high-tech data storage, management, analysis capability, and visual technologies as essential parts of BDA [1]. BDA is about the extraction of unknown patterns, correlations and information across multiple sources of data to enrich the information depths and produce new insights for decision makers [15]. Subsequently, the implementation and use of BDA can enable both efficient managerial decisions as well as leverage process improvements [16].

However, the introduction of BDA in organizations poses challenges that need to be addressed to fully leverage its potential. In previous IS-related studies on the adoption of BDA several generic factors affecting the adoption process [e.g. 17], as well as detailed determinants (e.g. data privacy issues [8]) have been discussed. Typically the identified barriers are related to people, technology, strategic or organizational domains of a company. We follow Alharti et al. [18], who reported that the adoption barriers of BDA fall into three categories: technological, human and organizational.

Organizational barriers are typically those factors in the organization's structure and culture that are not compatible with the new technology. These can include, among others, communication, authority flows, and show how the company has traditionally been working. Typical symptoms are a failure to perceive the strategic benefits of investment and a lack of co-ordination and co-operation due to organizational fragmentation [19]. Human barriers can be related both to employees lacking appropriate data analysis skills, and to challenges related to privacy and protection of personal information within and outside of organizations [18]. Technical barriers are factors in the information technology itself, such as finding a solution that integrates the new big data technology with existing legacy IT systems or solving the integration complexity of heterogeneous data sets [18].

2.2 Theory of technology assimilation

The theory of technology assimilation can be understood as an organizational process "unfolding in a series of decisions to evaluate, adopt, and implement new technologies" [20, p. 897]. It is defined as "the extent to which the use of the technology diffuses across the organizational projects or work processes and becomes routinized in the activities of those projects and processes" [21, p. 121]. Since the early applications of the technology assimilation theory to IS research, it has been applied and adapted in many ways. The range of application fields reaches from material requirements planning [11] to e-business [22] and cloud computing [10].

The theory of technology assimilation suggests that there is not just a single point of introduction of a new innovation in an organization. It is rather a multi-staged, sequential process, which is often far from simple and rarely unfolds in a linear and smooth manner [10]. There are often several different points in time where the assimilation may intensify or deteriorate and various obstacles and challenges need to be addressed [12]. Potential users, for example, face difficulties in learning about a new technology and in understanding how they must adapt their work-process activities to be able to use the new technology in an efficient way [23, 24]. In this context, potential users are more likely to use technologies that are perceived as user-friendly, having a clear benefit over existing ways of doing their job, being rather less complicated to use, and being suitable with the existing work processes and work domain [25].

In the IS literature several researchers have proposed various process and stage models describing the technology implementation process in organizations. These models are valuable in analyzing the context in which events (such as barriers) occur and show the causal linkages and temporal relationships between them [12]. Amongst the most cited is that of Gallivan [12], who created a six-staged assimilation model, based on the work of Zmud and colleagues [11], shown in table 1.

Table 1. Innovation assimilation stages [12]

<i>Stages</i>	<i>Description</i>
Initiation	A match is identified between an innovation and its intended application in the organization.
Adoption	The decision is made to invest resources to accommodate the implementation effort.
Adaption	The innovation is developed, installed and maintained, and organizational members are trained both in the new procedures and in the innovation.
Acceptance	Organizational members are committed to using the innovation.
Routinization	Usage of the innovation is encouraged as a normal activity in the organization.
Infusion	The innovation is used in a comprehensive and sophisticated manner which leads to increased organizational effectiveness.

3 Method: A Delphi-study design

The Delphi method is based on expert knowledge and aims to reach consensus on a specific research question via a structured process of iterative questionnaires with controlled feedback [26-28]. In IS research, the Delphi method has a long history of applications [29] and has been applied in the context of BDA recently [30]. This methodological approach enables an effective communication process through iterative rounds of feedback and prevents the direct confrontation of participants that could lead

to potential biases [26, 29]. The expert panel size typically ranges between 10 to 30 experts [29].

The Delphi method is a useful explorative approach to gain insights from the collective experience of practitioners, in particular when the literature lacks sufficient empirical studies [27, 31]. Therefore, the Delphi method appeared to be the most useful approach in order to address our research question. By following the procedures and quality criteria stated by several authors [e.g. 26, 27, 28], we aimed to meet the call for higher methodological rigor in Delphi studies as well as this method's soundness [27].

3.1 Panel selection

Since the results of Delphi studies are entirely based on the panelists' statements and indications, the selection of suitable experts is a critical factor. Okoli and Pawlowski [38] suggested a five-step approach for the selection procedure in Delphi studies. We followed this process by identifying experts with differing professional backgrounds comprising consulting, research, IT and information management, technical sales, as well as IT focused project management. Subsequently, we compared the qualifications of the potential participants to create a classification and ultimately a prioritization methodology for the experts by a category system in order to ensure profound expertise among the panelists. For instance, a mandatory factor for researchers was to be currently involved in big data research. For consultants, corporation employees and other types of occupations, we decided to only choose persons in senior positions with long work experience in the field of data analytics. For example, practitioners had to have contributed to the set-up or usage of BDA systems on a practical level. On a strategy level, they had to be involved in decisions of BDA initiatives.

Based on the selection criteria, the first potential panelists were contacted through the research teams' professional networks. In addition, the authors searched in business- and employment-oriented social networking services (e.g. LinkedIn) for practitioners with expertise in the field of BDA. We identified 284 potential practitioners and 12 potential academic experts, which were invited to take part in the study. We aimed for a panel size of 20 experts to account for possible drop-outs during the study period.

Altogether, 21 BDA experts committed to participating and completed the first round of the Delphi study (corresponding to a response rate of 7.4%). The panelists' primary functional affiliation ranged from big data initiatives in organizations (30% of panelists) to academic research (20% of panelists) to consulting (50% of panelists) in various industries (e.g. aviation, banking, energy, IT). All experts had been extensively involved in big data projects in the United States, Europe, Brazil or Australia. The average number of years working in managing information technologies (IT) within our panel was 20 years, with 5 years working specifically in the field of BDA. The panelists held various senior positions with responsibilities for BDA initiatives, including positions such as CEO, head of BI applications, or managing director at management consultancies. All academic experts held chairs at universities, except for one associate professor.

3.2 Data collection and analysis

The entire Delphi study was conducted with an online survey platform. We conducted a total of four rounds over the period from May-June 2017, allowing one week for the experts to respond to each round. Extending the Delphi procedure of Schmidt [28], this study segmented data collection and analysis in four distinct phases: Brainstorming (1), Selection (2), Ranking (3) and Assignment (4), see table 2.

Phase 1 (Brainstorming) serves to brainstorm and identify a broad range of relevant managerial challenges. To do this, we provided the panelists with our definition and understanding of BDA as outlined in the introduction and theoretical section of this study to ensure a common understanding. We asked the experts to name and briefly explain at least 5 managerial challenges associated with BDA in their organizations. In the interest of not limiting the diversity of the initial value set, we did not bound the number of possible responses [28]. After obtaining 107 suggested challenges, the research team consolidated the list by deleting duplicates and sharpening the descriptions. The compiled results were subsequently discussed collectively by the research team in order to create one reliable and consolidated list of managerial challenges. It was then sent to all experts for the purpose of validation. After incorporating the experts' feedback, the final list resulted in 25 BDA-related managerial challenges. Following Alharti et al. [18], the research team classified the list of challenges into organizational, human and technological barriers according to their interrelation.

Table 2. Overview of the data collection and analysis process

<i>Phase</i>	<i>Objective and panelists</i>	<i>Panelists</i>
Brainstorming (1)	Collection and validation of initial managerial challenges	21
Selection (2)	Selection of most crucial challenges	13
Ranking (3)	Ranking of most crucial challenges	13
Assignment (4)	Highlighting of most crucial challenges along the assimilation process	13

The second phase (Selection) served to identify the most important managerial challenges. For this purpose each participant was requested to state, in his or her judgement, the 10 most crucial challenges for a successful assimilation of BDA on a randomized list of all challenges. Subsequently, the research team further consolidated the list on the basis of the experts' selection. Following Piccinini et al. [32], we aimed to receive 12-15 crucial managerial challenges and therefore cut-off each challenge on the list that had been selected by less than 30% of the panelists. This procedure led to 13 crucial managerial challenges at the end of the selection phase.

In phase 3 (Ranking), the experts were asked to rank the shortened list of challenges in order of their importance for a successful assimilation of BDA. To do this, the shortened list of challenges was sent to the panelists in a randomized order. In order to investigate whether a consensus among the experts had been reached, the Kendalls' coefficient of concordance (W) was calculated [28]. According to Schmidt [28],

consensus levels are appraised as weak at $W = 0.3$, moderate at $W = 0.5$, and strong at $W = 0.7$. The ranked results in phase 3 implicate a Kendall's W consensus of 0.14.

In phase 4 (Assignment), the experts were asked to highlight each of the 13 managerial challenges of the shortened list along the six stages of the process of technology assimilation (multiple answers allowed). In keeping with other Delphi studies [e.g. 33], the research team identified an assimilation stage as relevant for a managerial challenge, if the majority of panelists ($> 50\%$) assigned a specific challenge to one assimilation stage.

4 Results

In this section, we present the final results of our Delphi study. During the brainstorming and selection phases, crucial managerial challenges for the assimilation of BDA were identified, consolidated and condensed to the most important items. Table 3 shows the results of the selection phase of our study.

Table 3. Results of the selection phase of our Delphi study

<i>Category</i>	<i>Managerial challenges of BDA in organizations</i>	<i>Phase 2 – Selection*</i>
Organizational Challenge (OC)	Lack of long-term view of data as an asset and its potential future business value	69
	Lack of clear use cases to motivate big data projects	69
	Lack of an enterprise wide data strategy	62
	Lack of top management commitment to big data projects	62
	Insufficient commitment or resistance to change of non-IT project stakeholders	62
	Gaps in alignment of goals and expectations between IT and business units	54
	Risk averse culture	31
Human Challenge (HC)	Lack of BDA-related skills of employees	69
	Lack of knowledge of end users in how to interpret and transform data analytic results	62
Technological Challenge (TC)	Data integration complexity	77
	Data quality issues	69
	Insufficient data governance practices	46
	Selection of an appropriate BDA technology	38

Note: * indicates the % of panelists who selected this challenge as very important

Subsequent to selecting the most crucial managerial challenges, the experts were asked to rank the challenges according to their importance (phase 3) and to highlight the ranked results along the six-stages process of technology assimilation (phase 4), as shown in figure 1.

Especially noticeable is the aspect that the top ranked managerial challenges of assimilating BDA already occur in the first two stages of the assimilation process and belong to the organizational domain of barriers. Human challenges, such as lack of skills and knowledge, are not seen as that crucial and can be addressed during the adaptation, acceptance and routinization stage of BDA assimilation. Technological challenges are rather subordinated.

Phase 3 Rank (mean rank)	Cat.	Crucial managerial challenges of BDA along the assimilation process	Phase 4 - Assignment					
			1. Initiation	2. Adoption	3. Adaption	4. Acceptance	5. Routinization	6. Infusion
1 (4)	OC	Lack of top management commitment to big data projects	■	■				
2 (4,5)	OC	Lack of long-term view of data as an asset and its potential future business value	■	■				
3 (5,5)	OC	Insufficient commitment or resistance to change of non-IT project stakeholders					■	
4 (6)	OC	Lack of clear use cases to motivate big data projects	■	■	■			
4 (6)	TC	Data integration complexity			■			
6 (6,5)	OC	Lack of an enterprise wide data strategy		■	■			
6 (6,5)	TC	Data quality issues	■		■	■	■	■
8 (7)	HC	Lack of BDA-related skills of employees			■	■		
9 (7,5)	TC	Insufficient data governance practices			■	■	■	
10 (8)	HC	Lack of knowledge of end users how to interpret and transform data analytic results				■	■	
11 (10)	OC	Gaps in alignment of goals and expectations between IT and business units			■		■	
12 (11)	OC	Risk averse culture	■	■				
13 (11)	TC	Selection of an appropriate big data technology	■	■	■			

Kendall's coefficient (W): 0.14

Figure 1. Crucial managerial challenges of BDA along the assimilation process

5 Discussion

The findings of our study indicate that the managerial challenges of assimilating BDA are influenced by various factors, such as structural, technical, staffing and strategy-related issues which can be categorized according to the domains of technology, people and organization. In line with previous work [3] is the finding that introducing BDA in organizations is not a simple technical issue per se, but rather an organizational transformational challenge. Our panelists ranked most of the

organizational issues, such as lack of top management commitment, as the most crucial challenges to be addressed for a successful assimilation of BDA in organization. Technical issues and human barriers are subordinated in the ranking.

Furthermore the result of the Delphi study indicate that lack of senior management support or insufficient commitment of the top management team prevents the successful introduction of BDA directly at the beginning of the assimilation (initiation phase). Analogous to that is the implication of having no or insufficient use cases for BDA. Our experts perceive the lack of clear use cases as crucial. This often directly hinders any BDA initiatives in the initiation and adoption phase. According to Rogers [25] an assimilation of a new technology will be more successful when it has a clear relative advantage over the existing business system. Clear use cases could demonstrate their potential future business value and would lead to sufficient commitment from project stakeholders.

Additionally, Figure 1 shows that the majority of managerial challenges of BDA occur in particular during the first three assimilation stages, namely initiation, adoption and adaptation phases. This basically leads to two conclusions: First, several serious potential issues need be addressed even before the actual implementation process of a BDA initiative begins, otherwise every assimilation effort is strongly endangered. Second, the result may be indicative of the evolutionary stage companies are at on the BDA implementation journey. The majority of the crucial challenges are highlighted in particular within stages one to three of the assimilation process. Our expert panel is apparently mostly involved in managing those barriers in the first stages and perceives these as very important, which might suggest that many organizations are still at a pre-implementation or implementation stage of BDA initiatives. This finding expands Kiron and Shockley's [34] statement, that many organizations are still at a reactive stage, in which they deal with various issues of managing data itself while not necessarily adopting and using BDA in a comprehensive and sophisticated manner.

Our Delphi study reveals two additional results which have not, to the best of our knowledge, previously received appropriate attention in the current literature. Firstly, our study shows that the necessity of ridding a company of a risk averse culture is crucial right from, or even before, the beginning of a BDA initiative. Enabling a trial and error mentality, as well as an experimental setting to test various analytic approaches and derive potential use cases is necessary to be developed before the actual BDA implementation process starts. Secondly, in contrast to previous work which has often stated psychological challenges, resistance to loss of power or status while implementing complex information technologies [e.g. 19] does not play a crucial role in BDA initiatives in the view of our panelists.

6 Contribution, Limitations and future research

This study has several implications for research and practice. We make two specific contributions to the literature of innovation assimilation. First, our study extends the literature [e.g. 12] by emphasizing the context in which assimilation events, namely crucial managerial challenges, occur, and shows the sequential relationship between

them. Second, although some overlaps to other studies analyzing the barriers of technology assimilation do exist, such as the fact that successful assimilation requires senior management support [22], our study reveals that organizational challenges are the most important barriers to be addressed. This contradicts Conboy and Morgan [10], for instance, who state that the biggest barrier to the technology assimilation is people-related. We also contribute to the contemporary BDA research by providing an overview of crucial BDA barriers in a sequential, multi-staged way while analyzed along the assimilation process.

For practitioners, our study sheds light on the question of why the majority of BDA projects fail [5] and which obstacles need to be addressed primarily. Our results suggest that companies often lack relevant organizational and structural aspects during the initiation and adaption stage. To exploit the full potential of a BDA project in the long-term, an organization has to successfully address the following challenges directly at the start of any BDA initiative: 1) Demand top management commitment from the very beginning and on a continuous basis 2) Create clear use cases upfront to motivate every project stakeholder and to demonstrate its future business value. People related challenges, such as training efforts and knowledge management are subordinated and can be addressed during the adaption, acceptance and routinization stage. The priority ranking of the selected challenges forms the starting point to set up BDA projects accordingly, bring relevant stakeholders to the table and direct their resources toward addressing the most important challenges in each assimilation stage.

Furthermore, we acknowledge that our Delphi study has some limitations. As with any Delphi-type study, the results rely on the experience and opinions of a limited number of individuals, in our case 21 experts. Although the panel size is comparable to other IS-related Delphi studies [31, 35] and is not required to be statistically representative [26], we must be reserved when generalizing the results [35]. A further limitation of the study is related to the relatively low level of consensus regarding the ranking phase of our study, indicated by a Kendall's W of 0.14. It might be explained by the broad diversity of our panelist's experiences concerning BDA initiatives in organizations as shown in other contemporary IS-related Delphi studies [e.g. 32].

In spite of the limitations, we are confident that our results serve as a fruitful starting point for empirically analyzing the challenging assimilation process of BDA in organizations. Our study lays the groundwork for research projects on how to overcome the identified challenges in each assimilation stage and find potential solutions. In a next step the panel could be extended to reach a broader group of experts, including different stakeholders such as potential recipients of BDA projects. Furthermore, the approach could change to one that is more in-depth, such as case studies to understand how BDA is being used in different industry settings at a more granular level, such as in the energy sector, or for specific divisions in organizations.

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