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A resource orchestration perspective of organizational big data analytics adoption: evidence from supply chain planning

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Abstract

Purpose – This paper investigated the organizational adoption of big data analytics (BDA) in the context of supply chain planning (SCP) to conceptualize how resources are orchestrated for organizational BDA adoption and to elucidate how resources and capabilities intervene with the resource management process during BDA adoption.

Design/methodology/approach – This research elaborated on the resource orchestration theory and technology innovation adoption literature to shed light on BDA adoption with multiple case studies.

Findings – A framework for the resource orchestration process in BDA adoption is presented. The authors associated the development and deployment of relevant individual, technological and organizational resources and capabilities with the phases of organizational BDA adoption and implementation. The authors highlighted that organizational BDA adoption can be initiated before consolidating the full resource portfolio. Resource acquisition, capability development and internalization of competences can take place alongside BDA adoption through structured processes and governance mechanisms.

Practical implications – A relevant discussion identifying the capability gap and provides insight into potential paths of organizational BDA adoption is presented.

Social implications – The authors call for attention from policymakers and academics to reflect on the changes in the expected capabilities of supply chain planners to facilitate industry-wide BDA transition.

Originality/value – This study opens the black box of organizational BDA adoption by emphasizing and scrutinizing the role of resource management actions.

Keywords Technology adoption, Case study, Big data analytics, Theory testing, Resource orchestration theory, Supply chain planning

Paper type Research paper

1. Introduction

Big data analytics (BDA) – defined as the application of advance analytics to big data to obtain knowledge and actionable insight through structured data processing and deployment – has captured increasing attention in operations and supply chain management research (Andersson and Jonsson, 2018; Kache and Seuring, 2017; Kamble and Gunasekaran, 2020; Roβmann *et al.*, 2018). Given that supply chain planning (SCP) decisions highly rely on the analysis of massive amounts of data, particularly in complex and uncertain contexts, the implications of BDA for SCP are believed to be significant and revolutionary (Brinch *et al.*, 2018; Jonsson *et al.*, 2007; Xu *et al.*, 2021).

SCP prepares supply chains for upcoming events. Through identification and evaluation of potential alternatives, it tackles capacity planning and asset coordination within and between supply chain members to optimize the delivery of goods, services and information by matching supply and demand with a forward-looking perspective (Stadtler and Kilger, 2005; Supply Chain Council, 2017). In a wider sense, SCP dedicated to the definition and assessment of decisions in processes including sourcing and procurement, production and distribution, as well as demand planning leveraging quantification, sizing, optimization and heuristic methods (Stadtler, 2005; Stadtler and Kilger, 2005). The detailed activities within SCP, with reference to the flow of goods and information, can be distinguished according to the *focal process* (i.e. procurement, production, distribution and sales) and the *time horizon* of planning (i.e. long-term, mid-term and short-term) (Stadtler and Kilger, 2005).

Studies on the use of BDA in SCP forms a niche stream in research. Extant contributions range from the application of BDA in demand and sales forecasting (Boone *et al.*, 2018), spend analysis, supplier evaluation, selection and negotiation (Moretto *et al.*, 2017), transport planning (Ilie-Zudor *et al.*, 2015) to fast decision-making in production based on cyber-physical systems (Zhuang *et al.*, 2018). Meanwhile, BDA has been acknowledged as a strong lever in response to sustainability challenges (Hazen *et al.*, 2016), to inform decisions on energy management in plants and to guide (re-)manufacturing system design (Corbett, 2018; Xu *et al.*, 2019; Zhang *et al.*, 2020).

However, despite the wide-spread consensus among scholars and practitioners (e.g. Dubey *et al.*, 2019; Fosso Wamba *et al.*, 2019; Yu *et al.*, 2018), BDA, in reality, is still far from being fully routinized in organizations on a daily basis (Hazen *et al.*, 2016). There is an evident gap between the actual need for BDA and the current investments, especially in the field of SCP (Brinch *et al.*, 2018). While the documented organizational transitions towards BDA-driven SCP are relatively few, significant challenges are present in understanding, compiling and storing the huge variety and volume of data. These challenges have inhibited BDA exploitation to the benefit of organizations (Richey *et al.*, 2016). To this end, research urges further investigation to fill this gap (Hazen *et al.*, 2016), providing further clarification on the process and prerequisites for smooth BDA adoption and implementation (Dutta and Bose, 2015).

Therefore, this paper, with reference to the context of SCP, addresses the BDA adoption and implementation process from a resource orchestration perspective. In particular, as organizations often face constraints in resources and capabilities (Kamble and Gunasekaran, 2020), we aim to answer the question of *"how resource management and orchestration facilitate organizational BDA adoption and implementation, in the context of SCP"*. To achieve this, we combined literature from (technology) innovation diffusion with the resource orchestration theory (Sirmon *et al.*, 2007, 2011). The former informs the process of organizational innovation diffusion – covering stages of exploration and understanding, formation of adoption decisions, implementation and diffusion (i.e. post-adoption), that can be further conceptualized into *acceptance*, *routinization* and *assimilation* (Fichman, 1999; Hazen *et al.*, 2012; Zhu *et al.*, 2006a, b). The latter extends knowledge on the role of management actions during the BDA adoption and implementation process (Sirmon *et al.*, 2007, 2011). Owing to the high reliance of SCP on data and analytics, we take reference to this process as an appropriate context of investigation. Using the resource orchestration lens, our paper contributes to the discussion of business value creation in BDA adoption (Brinch, 2018; Brinch *et al.*, 2018; Lamba and Singh, 2018) and elucidates how companies can capitalize BDA diffusion to realize its promised benefits (Dutta and Bose, 2015; Maroufkhani *et al.*, 2020; Mishra *et al.*, 2018).

The remainder of this paper is organized as follows. Section 2 presents the theoretical background and related literature. Section 3 introduces the research design and methods for data collection and analysis. Section 4 and Section 5 present and discuss the results for the

BDA adoption–related resources and capabilities and the resource orchestration process for organizational BDA adoption, respectively. Finally, the paper reflects on the results of the current study and concludes with potential future research directions.

2. Theoretical background

2.1 BDA adoption in supply chains

Much research on BDA in supply chains refers to *BDA adoption* as synonymous with *BDA use*, where general discussion is developed on the impact of BDA utilization on organizational and financial performance (Fosso Wamba *et al.*, 2017; Maroufkhani *et al.*, 2020), showing limited contribution to the adoption process. One branch of the literature tackles BDA adoption by investigating the determinants for BDA adoption decisions. For instance, the key success factors for BDA adoption in supply chain management include *systems integration*, *improved forecasting/decision-making* and *human capital* as the most relevant elements (Richey *et al.*, 2016). Further extensions present *top management commitment*, *financial support for big data initiatives*, *big data/data science skills*, *organizational structure* and *change management programme* as the five critical BDA enablers in supply chains (Lamba and Singh, 2018). Positive relationships are observed between BDA adoption intention and *perceived benefits of the BDA system* and *top management support* (Lai *et al.*, 2018), while *awareness of BDA benefits* and *change management and human resources* are identified as challenges for BDA adoption (Kache and Seuring, 2017; Queiroz and Telles, 2018; Xu *et al.*, 2021).

To date, despite the significant relevance of understanding how BDA can be diffused and implemented in organizations, very few publications have investigated BDA adoption beyond adoption intention. As Hazen states, "the mere adoption (intention) of an innovation by an organization does not necessarily imply that the innovation is actually being used or adding value to the firm and its trading partners" (Hazen *et al.*, 2012, p. 119). It remains unclear how the BDA adoption and implementation process unfolds in organizations and how resource and capability management facilitates the deployment of BDA as an integrated part of SCP (Zhu *et al.*, 2006b). Every BDA project must go through a sequence of internal processes before it can actually deliver value to the organization and supply chain; these may include strategic groundwork, data analytics and implementation (Dutta and Bose, 2015).

2.2 Resources and capabilities for adopting technological innovation

Successful implementation of technology innovation depends on individual, technological and organizational (ITO) dimensions in most contexts (Cooper and Zmud, 1990; Ivert and Jonsson, 2014). **Individual** resources and capabilities are skills possessed by personnel who directly interact with the new technology and process (Markard and Worch, 2009; Wade and Hulland, 2004; Watson, 2014; Zhu *et al.*, 2006b); these facilitate technology adoption in supply chains (Berglund and Karltun, 2007; Ivert and Jonsson, 2014). In the BDA context, *technology skills* and *analytics skills* – such as machine learning, data extraction and cleansing, visualization and discovery (Davenport and Harris, 2007; Gupta and George, 2016) – are prerequisites for operating business analytics systems (Cosic *et al.*, 2012). Domain knowledge and the understanding of the new system and process by business and management specialists, often called *business skills and knowledge*, are at least as relevant technological skills (Cosic *et al.*, 2012; Ivert and Jonsson, 2014).

Technological resources and capabilities are the technical prerequisites for the adoption of technology innovation (Ivert and Jonsson, 2014; Stadtler and Kilger, 2005). On the one hand, *technological know-how* contributes to the overall understanding of the technology (Markard and Worch, 2009), which is often accumulated through established organizational internal units related to technology innovation, or through the information system and R&D groups in general (Tarafdar and Gordon, 2007). On the other hand, the BDA context highlights the relevance of *advanced analytics* (Ivert and Jonsson, 2014; Pedro *et al.*, 2019; Watson, 2014) and *data management skills* (Cosic *et al.*, 2012; Halper and Krishnan, 2013), which contribute to the establishment of data-driven models to handle complex business objectives, as well as *knowledge of technology infrastructure* and *system integration*, which are necessary to ensure the effective operation of BDA by integrating existing information and operational systems (Wade and Hulland, 2004; Zhu *et al.*, 2006a) and cloud or distributed computing systems (Halper and Krishnan, 2013) inside and outside organizational boundaries (Cosic *et al.*, 2012; Ivert and Jonsson, 2014; Zhu *et al.*, 2006b).

Finally, **organizational** resources and capabilities affect whether the diffusion of technology innovation takes place in an organized and structured manner, considering the organization as an aggregation of individuals (Berglund and Karltun, 2007; Ivert and Jonsson, 2014). Smoother implementation is typically expected when technology adoption stems from a clear business need and common understanding across the organization (Halper and Krishnan, 2013; Watson, 2014), because of its strategic *alignment with business strategy* (Cosic *et al.*, 2012; Ivert and Jonsson, 2014; Pedro *et al.*, 2019; Zhu and Kraemer, 2005). A *fact-based decision-making culture* is likely to further promote practices based on advanced analytics (Pedro *et al.*, 2019; Pfeffer and Sutton, 2006; Watson, 2014), while a *committed top management* steers the activation of cross-functional teams (Halper and Krishnan, 2013) and external partnerships (Ivert and Jonsson, 2014). Together with the *change management capability*, an enthusiastic *innovation culture* (Zhu and Kraemer, 2005) facilitates the continuous scouting, exploration and experimentation (Halper and Krishnan, 2013) of emerging technologies and capitalizes the diffusion of the knowledge of technology innovation across all functions in the organization (Wade and Hulland, 2004). Table 1 summarizes the resources and capabilities from the literature for the adoption of technology innovation with reference to the ITO framework.

2.3 Resource orchestration theory and supply chain research

Companies operating with BDA often achieve superior operational and financial performance (Dubey *et al.*, 2019; Fosso Wamba *et al.*, 2019; Yu *et al.*, 2018). While the resource-based view presumes that technological competencies and assets shape organizational competitive advantage and consequently affect organizational performance (Chae *et al.*, 2014; Zhu and Kraemer, 2005), the resource orchestration perspective challenges the traditional resource-based view, stating that the mere possession of valuable and rare resources does not necessarily lead to competitive advantage (Sirmon *et al.*, 2007, 2011). In a nutshell, the theory posits that insufficient management activities may shift the outcome despite having the same input (Sirmon *et al.*, 2007, 2011; Sirmon and Hitt, 2009).

The resource orchestration theory argues for the managerial acumen to realize superior firm performance, emphasizing the role of management activities in combination to the possession of resources (Chadwick *et al.*, 2015; Hughes *et al.*, 2018). Thus, the roles of managers in structuring, bundling and leveraging the firm's resources (Hitt, 2011; Sirmon *et al.*, 2007, 2011) deserve further investigation, since what a firm does with its resources is as important as what resources it utilizes in determining the business performance (Hansen *et al.*, 2004; Ketchen *et al.*, 2014).

The resource orchestration theory considers resource management as taking place in a sequence of processes that aim to develop and establish firms' resource portfolio (i.e. *structuring*), stabilize and enrich the resources and capabilities developed (i.e. *bundling*) and deploy the capabilities for creating and maintaining competitive advantages (i.e. *leveraging*) (Sirmon *et al.*, 2007, 2011; Zhu *et al.*, 2020). In supply chain management,

	Resource and capability	Examples
Individual	Technology skills	Technology skills and knowledge [1]; Information system technical skills [2]; IT professionals possessing the knowledge and skills to implement BDA [3]
	Business skills and knowledge	Business skills and knowledge (of business specialist), management skills and knowledge (of management specialist) [1]; Knowledge and understanding of the system and process [5]; Tacit knowledge and skills [4]
Technological	Technological know-how	Presence of internal function related to technology or digital transformation [4]
	Advanced analytics	Business analytics technology for reporting and visualization, discovery business analytics technology [1], [6]; Right analytical tools [6], [7]; Appropriateness of analytics model design (how well a system handles complexity and fulfils the aim) [5]; Advanced analytics (predictive, prescriptive and descriptive), working with data (structured, semi-structured, unstructured), routinization into daily business, real-time data analytics [8]
	Data management	Management of integrated and high-quality data resource [1]; Access to accurate data *[5]*; Strong data infrastructure [6], [7]; Data storage, data collection, data architecture, data life cycle management strategy, data sharing and collaboration [8]
	Technology infrastructure	Information system infrastructure [2]; Technology infrastructure: technologies that enable BDA [3]; Infrastructure: information management standards, available platforms and databases, complexity management [8]
	System integration	Seamless integration of BA systems with operational systems to exploit the capabilities of both systems [1]; Technology integration [3]; System integration [to existing systems] (e.g. ERP and APS) [5]
Organizational	Alignment to company strategy	Strategic alignment [1]; Alignment to company strategy: common understanding of terminology and corporate definitions, business and analytics strategic Alignment [6]; Clear business need, alignment between the business and IT strategies [7]; Business strategy [8]; Compatibility of innovation being consistent with the existing values, past experience and needs of the potential adopters [9]
	Evidence-based management	Evidence-based Management, Embeddedness [1]; Fact-based decision-making culture [6], [7]; Holistic use for decision-making [8]
	Innovation culture	Entrepreneurship and Innovation of technology, business, and management personnel [1]; (Constant) exploration and experimentation [8]
	Change management	Change management: people management in view of technological and process changes, flexibility and agility: organizational level of change readiness [1]; Information system planning and change management [2]; Change management capability [6]
	Top management commitment	Executive leadership and support, decision rights [1]; Top management commitment as a moderator [2]; Executive involvement [5]; Strong committed sponsorship [6], [7]; Executive sponsor [8]
	Cross-functional involvement	Cross-functional involvement [5]; Organizational wide support [8]
	External collaboration	Information system business partnership, external relationship management [2]; Collaboration with external partners (past and future plan) [5]

References
[1] (Cosic *et al.*, 2012), *[2]* (Wade and Hulland, 2004), *[3]* (Zhang *et al.*, 2016), *[4]* (Markard and Worch, 2009) *[5]* (Ivert and Jonsson, 2014), *[6]* (Pedro *et al.*, 2019) *[7]* (Watson, 2014) *[8]* (Halper and Krishnan, 2013), *[9]* (Kapoor *et al.*, 2014), *[10]* (Zhu and Kraemer, 2005), *[11]* (Damanpour, 1991), *[12]* (Tornatzky and Fleischer, 1990)
Source(s): Table by authors

Table 1.
Literature perspective on resources and capabilities for technological innovation adoption

the typical resource orchestration process starts with the establishment of the necessary resource portfolio through well-coordinated processes that facilitate cross-functional communication and information exchange with external partners (Gong *et al.*, 2018; Wong *et al.*, 2015). The consolidated resource base contributes to nourishing new competences to develop and deploy the emerging practices both at breadth (internal and external orchestration) and depth (multi-tier collaboration). Finally, the cycle closes when the resources and capabilities generated are utilized to create distinctive competence with a well-framed strategy and governance structure (Gligor *et al.*, 2021; Gong *et al.*, 2018).

Operations and supply chain management research witnesses an ample use of the resource orchestration theory, including topics on supply chain integration (developing synergies and leveraging critical IT competency) (Liu *et al.*, 2016), supply chain resilience (managing resilience through internal and external integration) (Li *et al.*, 2020) and strategic human resource management (top management orchestration of middle-level resources) (Chadwick *et al.*, 2015). Although little evidence has been shown for its application to technology adoption and implementation (Gligor *et al.*, 2021), the explanatory power of resource orchestration can contribute to further the understanding of how organizations may approach emerging technologies by developing and managing their resource base in strategically.

3. Research design and methodology

A multiple case study method was adopted to explore the resource orchestration process in BDA adoption and implementation to elucidate the phenomenon across a variety of cases in the context of SCP (Ketokivi and Choi, 2014; Seuring, 2008; Yin, 2018). Given the paucity of research that has examined BDA adoption and implementation, our research design makes it possible to clarify how resources and capabilities are developed and deployed during BDA adoption and implementation within a real-world context (Yin, 2018).

3.1 Data collection

The research team performed *ex ante* screening of listed manufacturing companies with public information (e.g. company websites) to pre-filter cases of BDA adoption in SCP. We further restricted our sample to European companies to facilitate informants' discussing the topic in their familiar language. While assuring in-depth inquiry for each case (Voss *et al.*, 2002; Yin, 2018), this study assures external validity by selecting cases with both literal and theoretical replication (Gibbert *et al.*, 2008; Seuring, 2008). The final sample purposefully covered multiple cases with various BDA project status (i.e. early stage, undergoing implementation, full routinization) and the primary foci of SCP process (i.e. demand planning, production planning and distribution planning) (Stadtler and Kilger, 2005). The spread of samples is considered to identify general patterns from the BDA adoption and implementation process in SCP processes. Saturation was observed during data analysis since evidence and patterns were frequently repeated, indicating that the integration of further cases was not likely to add further insights. Table 2 summarizes the case information.

Reliability is guaranteed by having the interviews conducted following a pre-defined semi-structured interview protocol (Gibbert *et al.*, 2008; Seuring, 2008) with a retrospective perspective (see Appendix 1). The protocol was structured into sections of *1)* introduction to the focal BDA adoption case; *2)* discussion of the relevant resources and capabilities, as well as their interaction with the BDA adoption process, considering the specific context; and *3)* future development of the BDA adoption project. Questions were designed to be broad and open-ended to facilitate active discussion, allowing new concepts to emerge. Construct validity was assured by involving a variety of informants, including the roles specialized in

Table 2. Case study overview

Case	Company description	Revenue (in bln EUR)	HQ/Branch in Italy	BDA project objective/description*	Project status	Position of the interviewees
AUTO	A manufacturing company of automotive	50–100	Headquarter in Italy	*Demand forecasting*: In the context of elevated variety and complexity, the focal BDA project aims to integrate big data in future demand forecast and in design of product offer packages	In implementation	*Focal firm*: Head of Data Science; Regional Head of Supply Chain and ICT
BEVE	A manufacturing company of food and beverage	50–100	European company with branch in Italy	*Cross-functional*: Integration of BDA competence into the entire supply chain planning span following a company-wide target. All dimensions of demand planning, production planning and scheduling, and distribution planning are covered in the plan	Recently in implementation	*Focal firm*: Head of Data Science; Head of Demand Planning *Tech partner*: Client manager; Product technical leader
CHEM	A manufacturing company of chemical materials and products (chemical, plastics, rubbers, renewable chemistry)	10–50	Headquarter in Italy	*Production planning and control*: Integration of BDA into predictive maintenance as part of the firm's applied research on BDA *Distribution planning*: Integration of BDA into the management and scheduling of ship transportations	In implementation	*Focal firm*: Head of Data Science; Head of ICT; Head of Digital Competence Centre; Head of Digital Product Delivery; Data Scientist
ELEC	A manufacturing company of electronics and semiconductors	10–50	European company with branch in Italy	*Production planning and control*: Integration of structured big data into the manufacturing control tower and establishing a big data ecosystem for production decision-support and productivity optimization	In implementation	*Focal firm*: Head of Digital transformation; Head of Digital Competence Centre; Head of Demand and Operations Planning

(*continued*)

Table 2.

Case	Company description	Revenue (in bln EUR)	HQ/Branch in Italy	BDA project objective/description*	Project status	Position of the interviewees
FIBE	A manufacturing company of fiber, cables, and power transmission systems for the telecommunication sector	10–50	Headquarter in Italy	*Production planning and control*: Integration of BDA into production process control (drift detection) and to enhance production process responsiveness and efficiency	Recently in implementation	*Focal firm*: Customer service manager; Supply Chain Manager; CIO; Head of Digital transformation
HLTH	A manufacturing company of healthcare product	<10	European company with branch in Italy	*Production planning and control*: Integration of BDA into production planning and scheduling (resolve over-saturation in production, assist real-time measuring and monitoring) to establish a decision-support system (action plan prioritization)	Bare initiation	*Focal firm*: Chief Supply chain officer
PHAR	A manufacturing company of pharmaceutics and life sciences	10–50	European company with branch in Italy	*Distribution planning*: Integration of BDA into the transportation process to empower supply chain transparency (single item tracing and delivery condition tracking) and for anomaly detection (real-time diagnostics and alerts)	Fully routinized	*Focal firm*: Regional Head of Supply Chain; Transport Manager; Order handling manager *Tech partner*: Client manager; Product technical leader
PIPE	A manufacturing company of steel pipes for the energy sector	<10	European company with branch in Italy	*Production planning and control*: Integration of BDA into production planning, to support lead time estimation with use of machine sensor data and historical production data and inform cost estimation for highly customized products	In implementation	*Focal firm*: Head of Data Science; Data Engineer; Supply Chain Manager *Tech partner*: Client manager

Note(s): See Appendix 2 for more detailed project description
Source(s): Table by authors

technology implementation in the focal company (e.g. head of data science, head of digital transformation) and the technology partners in the BDA project whenever possible to share their experience and knowledge concerning the cases. In total, nineteen interviews were conducted in the first half of 2021 through video-calls lasting between 60 and 90 min. All interviews were recorded, documented, transcribed and organized into a shared database that was consolidated with additional materials (e.g. BDA project reports and documentation, public press releases and interviews, annual reports and guest speeches in universities) for data triangulation (Gibbert *et al.*, 2008; Seuring, 2008). Clarification and amendment of the data collected were done through follow-ups.

3.2 Data analysis

The qualitative data analysis followed the procedure of Saldaña (2013) and was executed in MAXQDA20. The first attempt relied on a mix of structural and open coding for the first two cases, where the structural codes emerged from the literature of (technological) innovation adoption and the resource orchestration theory. The coding structure was then standardized before application to all cases; new concepts were defined as a result of the analysis (Marques *et al.*, 2019). The second round used axial coding by joining similar codes, adapting codes to theoretical concepts and variables and introducing dimensions to group the codes (Strauss and Corbin, 1998; Voss *et al.*, 2002). The iteration between data and concepts made it possible to establish mutually exclusive and complementary codes and to standardize the categories (Marques *et al.*, 2019; Wendler, 2012). Finally, the core categories and the codes were adjusted and finalized to apply to all cases (Voss *et al.*, 2002). We ensured internal validity of this study by iterating between empirical evidence and existing knowledge (Seuring, 2008).

Theories and the literature were used to support the interpretation of the codes and results through pattern matching and explanation building (Yin, 2018). In particular, the technology innovation adoption literature informed the analysis of resources and capabilities in BDA adoption, while the resource orchestration lens was used to interpret the process of resource development and management in BDA adoption. The process of data analysis and interpretation made it possible to validate the explanatory power of the resource orchestration theory in a new context of technology adoption, clarifying how the theoretical constructs could be adapted and further specified in a new context.

4. Findings

4.1 Resource and capabilities for BDA adoption in SCP

Our analysis suggests that, in the context of SCP, all cases relied on the development and deployment of an ample range of resources and capabilities during BDA adoption and implementation. However, irrespective of the focal SCP application scope, all the three clusters (i.e. individual, technological and organizational) of resources and capabilities actively interacted in the resource management process. Table 3 presents a synthesis of the resources and capabilities for the BDA adoption process; evidence from the coding is shown in the appendix (see Table A1).

Individual resources and capabilities are observed to be transversal to all stages. In particular, to envision BDA use for a specific business need, it is necessary to demonstrate *business knowledge and understanding* during resource structuring; while it helps to identify relevant stakeholders during resource bundling and to contextualize BDA learning, which then supports the communication of BDA system benefit during resource leveraging. With the potential to be acquired during resource structuring (e.g. talent acquisition or upskilling of current resources), *individual technological skills* show particular contributions to the stage of BDA system development. Depending on the scope of BDA system (e.g. analytics driven or

Table 3.
Resources and capabilities for organizational BDA adoption

	Code ID	Category/Code	AUTO	BEVE	CHEM	ELEC	FIBE	HLTH	PHAR	PIPE
Individual	***I1***	**Individual technology skillsets**	B/L	B	B/L	B	B	B	B	B
	I2	**Individual business knowledge and understanding**	B	B/L	B	S/B	B	B	S/B/L	B/L
	I3	**Individual analytical skills**		L	B	L		B	L	L
Technological	***T1***	**BDA system development resource**								
	T1.1	Access to accurate data	B	B	B	B	B	B	B	B
	T1.2	System integration	B	B	B	B	B		B	B
	T1.3	Technology infrastructure	B	B	B	B	B		B	B
	T2	**BDA system development capability**								
	T2.1	Technological know-how	B	B	B	B	B	B	B	B
	T2.2	Competence in analytics for model development	B	B	B		B		B	B
	T3	**Dynamic system management capability**								
	T3.1	Data management capability	L	L	L	L	L	L	L	L
	T3.2	Dynamic data analytics capability	L	L			L		L	L
Organizational	***O1***	**Business needs and consistency with strategy**								
	O1.1	Vision on business	S	S	S	S	S	S	S	S
	O1.2	Strategic alignment to company strategy	S	S	S	S	S	S	S	S
	O2	**Organizational culture and resource**								
	O2.1	Evidence-based decision-making culture	S	S	S	S	S	S	S	S
	O2.2	Innovation culture	L	L	L	L	L		L	L
	O2.3	Financial commitment	B	B	B	B	B	B	B	B
	O2.4	Coordination and governance structure	L	L	L	L	L		L	L
	O3	**Change management capability**								
	O3.1	Committed leadership and Executive involvement	S/B/L	S/B/L	S/B/L	S/B/L	S/B/L	S/B/L	S/B/L	S/B/L
	O3.2	Cross-functional involvement (Internal)	B	B	B	B	B		B	B
	O3.3	Collaboration and partnerships (External)	B	B	B	B	B	B	B	B
BDA project status										
Bare initiation								x		
Recently in implementation				x			x			
In implementation			x		x	x				x
Fully routinized									**x**	
Target SCP function										
Demand forecasting			x	x						
Production planning and control				x	x	x	x	x		x
Distribution planning				x	x				x	

Note(s): Note on abbreviations: S – Structuring, B – Bundling, L – Leveraging. An exception of the coding details is reported in appendix (Table A1)
Source(s): Table by authors

integrated into decision support system), *individual analytical skills* may or may not form part of the resource portfolio during system development, while it is always necessary to support BDA system deployment in interpreting the result from analytics.

Technological resources and capabilities are primarily involved in resource bundling and leveraging, which enables BDA systems development, as well as the long-term maintenance and adjustment of the systems in operation. Organizational technological know-how can result from ongoing and previous projects, which facilitates the development of transversal or specific competence for BDA development and modelling. In particular, *BDA system development resources* and *capabilities* are fundamental to assuring system integration, access to accurate data and appropriate technological infrastructure establishment. The *dynamic system management capability* supports continuous integration and consolidation of data as BDA system input, assuring the long-term effectiveness of the system with continuous reviews and constant adjustment, as well as supporting system accessibility to all stakeholders.

Finally, organizational resources and capabilities are observed to be transversal to all stages. The combination of *business needs and consistency with strategy* and *organizational culture* concerning evidence-based decision-making guaranteed alignment between the BDA project and the business context. During resource structuring, essential decisions are made to ensure that BDA was the appropriate technology to tackle the business requirements. *Change management capability and resources* – in particular, committed leadership and executive involvement – facilitates the consequent financial and resource commitment for BDA development when establishing the resource portfolio. Internal and external collaborations may be consolidated to compensate as needed for any missing competence. Moreover, BDA diffusion is affected by the *organizational culture* of innovation, where dedicated innovation management structures generally led to a smooth transition, while coordination and governance structures set guided processes and protocol for BDA routinization.

In addition to the general patterns, the cases shed light on the variation in the precise resources and capabilities developed and leveraged, as well as along the resource orchestration process. On the one hand, although BDA project status does suggest influence on the resources and capabilities for BDA adoption in general, extreme cases in the spectrum of adoption (i.e. bare initiation, fully routinized) illustrate different behaviours. For instance, HLTH, being a company that has barely initiated their BDA project, showcases a limited resource portfolio while working to start envisioning the use of BDA in their business process – indeed, they try to elaborate on existing individual and organizational resource spilt over from previous projects. Meanwhile, at other end of the spectrum, PHAR, as a company that had fully routinized their BDA project for SCP, exemplifies a holistic portfolio of interacting capabilities and resources along the resource management process. On the other hand, despite the focal SCP function does not exhibit significant influence on the resources and capabilities for BDA adoption in general, the scope of BDA adoption seems to have certain implications. That is, as compared to integrating BDA for specific SCP activities, when BDA adoption targets an extensive integration into a holistic SCP landscape (e.g. BEVE), the development and possession of a wide range of resources and capabilities in resource orchestration for BDA adoption is highlighted as a strategic path. In this case, a complete portfolio of resources and capabilities is developed and deployed to sustain the BDA adoption journey, as a result of a more matured BDA adoption and implementation status.

4.2 Orchestration of resources and capabilities for BDA adoption in SCP

In the context of SCP, the BDA adoption and implementation process involves a wide range of resources and capabilities being developed and deployed. With reference to the resource orchestration theory and the literature on technology innovation diffusion, our analysis converged to the fact that resource orchestration process takes place in a similar pattern irrespective of the SCP application focus. This pattern can be further explicated into six phases under the macro-processes (i.e. resource structuring, bundling and leveraging) (Gligor *et al.*, 2021; Sirmon *et al.*, 2011). Table 4 presents the definition and synthesis of each phase with exemplary quotes from the cases.

Resource *structuring*, defined as acquiring, accumulating and divesting resources to form the firm's resource portfolio (Gligor *et al.*, 2021; Sirmon *et al.*, 2007, 2011), can be broken down into two phases for BDA adoption: *sense business need* and *accumulate BDA intellectual resources*. Based on domain knowledge of business processes, every BDA adoption project starts with the establishment of a company-wide understanding of the business need, envisioning how BDA would benefit SCP processes (*sense business need*). The sense of urgency for BDA adoption is catalysed by the presence of evidence based on a decision-making culture. Although companies may start with limited knowledge and technical skills, proactive BDA adoption with top management sponsorship facilitates the acquisition and accumulation of intellectual (individual) resources for BDA development through talent scouting from the market (e.g. case AUTO) and upskilling of existing resources (e.g. case ELEC). Cross-functional teams (internal collaboration) and business partnerships (external collaborations) are funded at this stage to support later organizational-level learning. Internal and external collaboration can also compensate for the lack of specific resources.

Resource *bundling*, described as the elaboration of the resource base to develop capabilities through stabilizing (incremental improvements to existing capabilities), enriching (extends current capabilities) and pioneering (creates new capabilities) mechanisms (Hitt *et al.*, 2016; Sirmon *et al.*, 2011), takes place in two phases for BDA adoption: *catalyse BDA learning for SCP-related problems* and *engage in BDA system development*. An effective learning process of BDA promotes the transformation of individual technical and analytical competences into organizational BDA development resources and capabilities following structured processes. The proactive learning approach includes experimentation with different approaches (e.g. CHEM), reflection on leading use cases (e.g. AUTO) and internalizing competences through external collaboration (e.g. ELEC and FIBE). Together with the support of multi-disciplinary knowledge from cross-functional teams and technology partners, organizational BDA development resources and capabilities actively engage in BDA system development.

Finally, resource *leveraging*, or the exploitation of the firm's capabilities through mobilizing (i.e. vision on requisite), coordinating (i.e. integrating capability configurations) and deploying (i.e. exploiting capability configurations) (Sirmon *et al.*, 2007, 2011), occurs in two phases for BDA adoption: *Communicate advantage and Promote continuous refinement* and *Institutionalize processes and systems and internalize BDA competence*. In transition towards BDA-driven SCP processes, the shared understanding and vision of BDA diffusion and implementation are fundamental inputs to facilitate development of requisite capability configuration. Well-communicated business benefits lead to less reluctance in adoption. BDA systems requires regular updates to adapt to the changing context while maintaining smooth access and integration between data sources that leverage and exploit long-term oriented data and system management capabilities. Wide diffusion of technological innovation is thus a consequence of institutionalized processes for BDA-driven systems and governance structure. An established organizational function for BDA management and governance (e.g. AUTO), clarified ownership and responsibility and standardized and documented processes for the day-to-day operation of the BDA-driven systems (e.g. PIPE, CHEM) are observed in companies that experience a smoother transition after the project handover. Finally, BDA adoption and implementation process ends with the insourcing of responsibilities and capabilities for BDA system governance, maintenance and upgrading from the technological partners. Owing to the fact that the deployment and sustainment of the BDA-driven SCP

Table 4. Resource orchestration in organizational BDA adoption

Process (*phases*) and definition		Quotes from cases
Structuring	Establish the resource portfolio through: (1) acquiring, (2) accumulating, and (3) divesting resources (Sirmon *et al.*, 2011)	
Sense business need	Building a company-wide understanding of the business need of BDA to support SCP processes	*"We approach data analytics within the supply chain starting with the business needs at the 1st place – it is the requirement; you would not start directly with a tool and say, "here is the tool and see how it can be useful", but it is rather more effective to start with the business problem, for instance, that I have a poor service level in the last year. [. . .] Implementing BDA has to be coherent with the overall strategy, and it is not correct to consider it as a nice-to-have tool that might support the current process."* (BEVE) *"The project was born by gathering the needs of the business, trying to understand which process to be involved, how it should be improved if there exists the fundamental data to enable a function of this type."* (CHEM) *"The challenge in most of the projects is to identify the benefits (to business). We need to identify how big data analytics can help us optimize processes to make them more efficient. It is a challenge since proposing solutions or changes requires a deep understanding of the current processes."* (PIPE)

(*continued*)

Table 4.

Process (*phases*) and definition		Quotes from cases
Accumulate BDA intellectual resources	Acquire and accumulate intellectual resources for BDA development through talent scouting from the market, training, and upskilling existing resources; establish internal and external collaborations and partnerships	*"It is important to maintain internal knowledge. As the ICT team we typically tend to rely on external partners to develop solutions, but in this specific context, we are convinced from the very beginning on investing effort to bring skills in-house."* (AUTO) *"The 'business translator' has domain competence and is supported by teams of business scientists and solution architects. These are resources that are part of the company, so these kinds of competences and skills are internal."* (ELEC) *"Most of the time, we have internal skills, which have been developed and accumulated through upskilling at the initial phase of the program. These are people who have already worked with business intelligence and have followed a training path toward emerging technologies. [. . .] In addition, we have also hired senior profiles on the market."* (ELEC) *"On a personal level, the desire to learn and get involved [are important]. After almost eight years in Argentina, I was open to moving, taking many online courses, to personally inform myself about the new group and the work that awaited me."* (PHAR) *"I do not see huge barriers in finding the know-how for this type of project. Despite we often find ourselves lacking internal knowledge, through the hiring and introduction of young figures with a mindset ready to solve problems, companies like mine can then conduct BDA projects with support by external technology partners."* (HLTH) *"Internally, we have very lean teams and, therefore, we are assisted by external technology consultants during the process."* (FIBE)
Bundling	Integrate resources to form capabilities through: (1) stabilizing (incremental improvements to existing capabilities); (2) enriching (extending current capabilities); and (3) pioneering (creating new capabilities) (Sirmon *et al.*, 2011)	

(*continued*)

Process (*phases*) and definition		Quotes from cases
Catalyze BDA learning for SCP-related problems	Set up internal BDA-related competence for the SCP process through: i) scouting/taking reference from comparable use cases (i.e. incremental improvement of BDA capabilities), and ii) learning through experiment and pilot projects (i.e. enriching existing BDA capabilities)	*"[. . .] we started clarifying which competencies are already existing [. . .] on the other hand, we organized ourselves to acquire skills and competencies that contribute to a better understanding of how data is processed and deployed differently from traditional IT systems. The knowledge can be transmitted to various business functions in helping them face challenges that may have not even arrived. [. . .] We have a wide range of activity from the industrial perspective, where a lot of predictive maintenance and detection is done. Therefore, we had the opportunity to put our hand on various disciplines of data science and try different solutions."* (CHEM) *"(The project benefits from) a fairly open vision of the Supply Chain director, who has always considered Amazon as a benchmark. We were in Seattle talking to Amazon data scientists, despite having a very different business from ours."* (AUTO) *"We have and would continue to work with high-profile technology consulting partners for optimizations and reviewing. And this offers the chance of refactoring from time to time."* (ELEC) *"(IT) system integrators are important when there is no methodology and when there is no internal know-how, but if you acquire that methodology and know-how in-house, in the end, you need the arms and not the brain."* (FIBE)

(*continued*)

Table 4.

Table 4.

Process (*phases*) and definition		Quotes from cases
Engage in BDA system development	Develop a BDA-driven SCP system and continuously improve BDA development and management know-how (i.e. extend current BDA capabilities and pioneer new capabilities)	*"Together with the vendor of the platform, we co-developed the first use case. Then from the success of that project, we continued to gain sensitivity within the company of what these solutions could further offer in the supply chain domain."* (AUTO) *"We have set up systematic workflows that automatically activate the owners of the process based on the problem detected. For instance, if two products are missing, who should step in? Should the system activate an investigation of inventory in the warehouse or not? If whenever the problem happens I opt for the same solution, then that is the way the system should proceed."* (PHAR) *"We have insourced the development process because we believe that the algorithmic is where you integrate your intelligence into the infrastructure. Therefore, it is right to keep that (BDA development) competence in-house as it is a differentiating value to compete in the market."* (FIBE)
Leveraging	Exploit capabilities and market opportunities through: (1) mobilizing (plan or vision for capabilities needed to form requisite capability configurations); (2) coordinating (integrating capability configurations); and (3) deploying (using resource advantage, market opportunity, or entrepreneurial strategy to exploit capability configurations formed by the coordinating subprocess) resources (Sirmon *et al.*, 2011)	

(*continued*)

Process (*phases*) and definition		Quotes from cases
Communicate advantage and Promote continuous refinement	Build a shared vision of BDA-driven SCP system implementation to facilitate diffusion and transition (i.e. mobilize BDA implementation); leveraging and exploiting long-term data and system management capabilities to sustain the BDA-driven SCP systems (i.e. coordinate capabilities for continuous improvement)	*"BDA creates changes that make the process faster and more accurate so that we can see the benefit of freeing up resources that we had devoted in the past to perform other tasks.[. . .] As the models need to be retrained every six months, we want to be able to do this by ourselves so the Data Science team offered their help to train our employees. Instead of waiting for the Data Science team doing that for us, we are now competent to train the model which makes the process faster and easier for both without distracting in general resources"* (PIPE) *"We need to pay attention as employee's acceptance can affect BDA implementation both in conscious and unconscious manners. It is unconscious when people perceive BDA brings additional daily activities, which may trigger resistance; and it is conscious when behavior is intentional against BDA, for instance, due to the disagreement in the tracking of activities."* (BEVE) *"There are obstacles when some people are very capable (in performing BDA-related capabilities) but do not know how to communicate, and I see this every day"* (ELEC) *"The models apparently work well the moment when you establish a BDA platform. But if there is no dedicated resource who constantly reviews the specifications and adapts the models to the changing reality, that model begins to lose its effectiveness and becomes useless over time."* (AUTO)

(*continued*)

Table 4.

Table 4.

Process (*phases*) and definition		Quotes from cases
Institutionalize processes and systems and Internalize BDA competence	Institutionalize BDA-driven SCP systems (i.e. deploy advantage of resources and capabilities); promote internalization of the resource configuration to sustain BDA-driven SCP systems in the long-term	*"Looking at the organization from a high-level, our business plan to deploy BDA is very structured. This brings advantages because when setting the strategy, we know the focus is worldwide and coherence is granted across the entire corporate. [. . .] Usually, the project may embrace single or multiple categories, and some managers follow the particular categories and who follow the dedicated project team."* (BEVE) *"It is important to have people within the company who work directly on business intelligence because the model you develop does not work well forever, it must be continually adjusted."* (AUTO) *"Another thing that is very important about these companies is to think about governance, that is, to think about how I govern this amount of data and how I give access to the various corporate structures to this amount of data. It is therefore a question of ownership of the data, that is, giving the possibility to those who own the data to document it, manage it, and guarantee security and privacy. The owner of the data must distribute knowledge about data in the company, an awareness that the data is there and must be managed."* (PIPE)

Source(s): Table by authors

system, while ensuring its long-term performance, remain an ongoing process, the internalization of the required capability configuration appears as an effective lever in resource orchestration to help promoting higher flexibility and agility in response to the constantly changing market environment (e.g. BEVE, PHAR, AUTO).

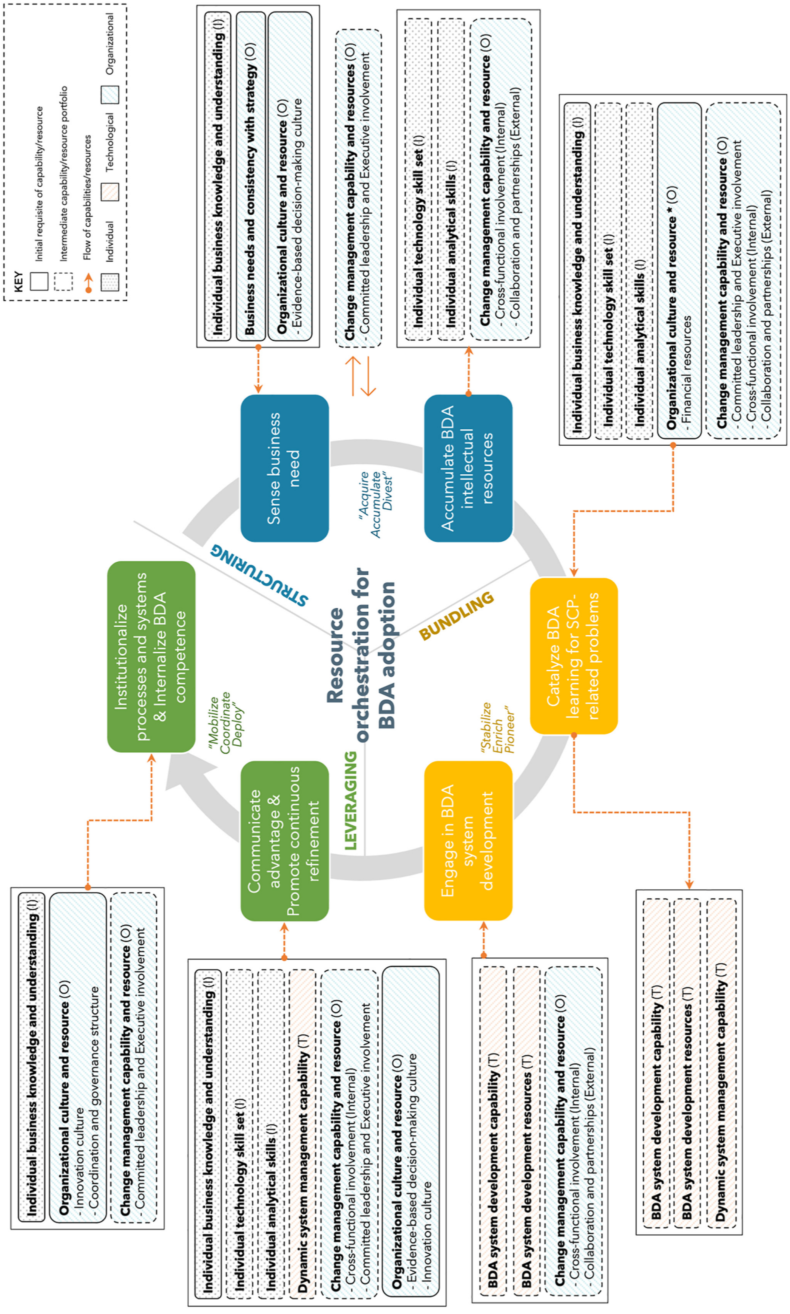
Remarkably, despite the way in which the organizations develop and accumulate resources and capabilities may vary, our sample does not suggest significant differences in terms of the phases comparing across the various foci of SCP applications. Moreover, while the macro-processes of resource management are sequential in nature (Sirmon *et al.*, 2007), the boundaries between the phases falling under the same macro-process may be blurred. For instance, companies that implement a learning-by-doing approach can practise BDA learning and system development in parallel or following several iterations.

5. Discussion

We demonstrated that resource orchestration theory (Sirmon *et al.*, 2011) can well explain the resource management actions in BDA adoption in the context of SCP, as the process of resource orchestration in BDA adoption fits into the general processes of resource structuring, bundling and leveraging. With reference to empirical data for BDA adoption projects in SCP, we further specified six phases under the macro scheme and discussed the development and deployment of resources and capabilities in each phase. Grounded in our observation in the context of SCP, Figure 1 depicts the proposed framework of the interaction between individual, technological and organizational resources and capabilities against the process of resource accumulation, stabilization and coordination in organizational BDA adoption. As shown, each phase requires specific resources and capabilities, that are generated and consequently deployed in successive processes.

The proposed framework conveys several messages. First, it rejects that organizational BDA adoption could start not until having established the whole resource portfolio. Despite three resources and capabilities are the "seeds" to the process (*individual business knowledge and understanding*, *business needs and consistency with strategy* and *evidence-based decision-making culture*), the rest of the resource portfolio can be developed with purposeful resource management actions including acquisition, accumulation, active learning and upskilling (Gligor *et al.*, 2021). Moreover, the orchestration of internal and external resources and capabilities is essential (Gong *et al.*, 2018; Li *et al.*, 2020) during BDA adoption. While organizations tend to orchestrate internal resources before approaching external ones (Gong *et al.*, 2018), the fast technological advancement of BDA often suggests inadequacy in the internal resources and capabilities that need to be sought from the outside.

Second, effective BDA adoption and implementation is strongly affected by the organizational confidence on the advanced data-driven planning systems (Schlegel *et al.*, 2020) which is dependent on the available BDA exemplars and peculiarities of the BDA technology. On the one hand, the scarcity of ready-to-use BDA solutions as standard market offerings (Sodero *et al.*, 2019) emphasizes the need for a clear understanding of the business objectives to guide and steer BDA development leveraging the knowledge of business and management specialists (Cosic *et al.*, 2012). Thus, BDA adoption projects are often initiated and catalysed by visionary individuals, whereas their business insights trigger the consequent establishment of organizational and technological resources and capabilities through structured and coordinated management actions. On the other hand, the peculiarities of BDA present several challenges. Even the most advanced organizations from a technological perspective may find themselves lacking specific knowledge related to BDA system development. Organizations should seek to undertake proactive approaches to close the gaps in skills and expertise for BDA adoption (Maroufkhani *et al.*, 2020). A viable path is shown to start with teaming up with strategic technology partners during the initiation of



Source(s): Figure by authors

Figure 1.
The resource orchestration process in organizational BDA adoption

BDA projects, as in supply chain information system outsourcing (Luzzini *et al.*, 2014; Maroufkhani *et al.*, 2020). Reaching out to technology providers or consultants at the initial phase significantly reduces the range and specificity of competence required, thus reducing the lead time for BDA adoption. Moreover, the features of BDA exert a particular emphasis on the need of internal competences to intervene with system maintenance, adjustment and governance in the long-term as a strategic lever. The value of internalizing the competences related to BDA-driven systems management is a common belief among all of the case companies. Over time, the acquisition of skills and competences from partners makes it possible to gain higher autonomy and flexibility in the management of BDA systems, facilitating the transition from "buy" to "make". The choice of capability internalization is coherent with the nature of the SCP process. As SCP is heavily affected by uncertainty, attention should be paid not only to the model design stage but also to the subsequent data management and model revisions in the long run (Ivert and Jonsson, 2014; Jonsson *et al.*, 2007). Capability development and competence internalization throughout the BDA adoption process are thus essential to facilitate constant updates and adaptations of the data and models to the changing business environment (Sodero *et al.*, 2019). In this last phase, the role of technology partners shifts from solution providers to technology consultants providing support on infrastructure that may serve as the foundation for future development.

Finally, opening the black-box of BDA adoption and implementation from the resource orchestration perspective, the framework suggests that organizational technology adoption closely relates to the human factor in supply chains (Sodero *et al.*, 2019; Xu *et al.*, 2021), shedding light on the individual-technology-organization interaction. BDA adoption and implementation introduces significant changes to the human-related factors including the skills and capabilities required. For instance, it is expected to lead to the replacement of human resources in repetitive, objective and clerical tasks beyond the processing capability of human beings (Alicke *et al.*, 2019). Our framework indicates that upskilling internal resources towards an ambidextrous focus on business knowledge and analytical skills could be a viable path, in order to benefit from existing business knowledge and avoid discharging operational personnel. Meanwhile, business and higher education should revisit the capability requirements of supply chain planners with a future-oriented perspective (Flöthmann *et al.*, 2018), associating organizational learning to technical and managerial skills at both the individual and organizational level (Gupta and George, 2016).

6. Conclusions and directions for future research

In the context of SCP, this study examined the process of organizational BDA adoption through the lens of resource orchestration theory. Our results indicate the necessary portfolio of individual, organizational and technological resources and capabilities, and illustrate the general resource management process of in organizational BDA adoption.

6.1 Contribution to literature and theory

Literature has rarely approached BDA adoption beyond the discussion of the determinants of adoption intention and impact on performance. Our paper advances the knowledge by scrutinizing the role of management actions during BDA adoption. With a proposed framework, we depict how individual, organizational and technological resources and capabilities intervene with management actions for resource orchestration, indicating when and how these resources and capabilities may be formed and deployed. The method and insights in this study may elucidate investigations on the adoption of other emerging technologies in supply chain, such as blockchain and augmented reality.

Moreover, this paper contributes to resource orchestration theory by validating and extending its explanatory applicability to the organizational BDA adoption context, drawing insight from the (technology) innovation diffusion literature. We suggest further specification of theory constructs in this setting, distinguishing six phases of the resource orchestration process (i.e. resource structuring, bundling and leveraging) based on the pattern observed from multiple case studies.

6.2 Managerial implications

The proposed framework for resource orchestration in organizational BDA adoption could be of interest to top management and supply chain practitioners. The framework illustrates the interaction between individual, organizational and technological resources and capabilities as a consequent of resource management, thus, can guide the identification of capability gaps with reference to the BDA project status.

Additionally, this paper shed light on how organizations could manage the challenges in acquiring these resources and capabilities by sharing experiences from exemplar firms at different stages of BDA adoption and implementation. While emphasizing the criticality of the internalization of resources at a later stage, we support that BDA adoption projects can be initiated before the establishment of a full resource portfolio. Besides, this study calls for attention from policymakers and academia to reflect on the changes in capabilities required for the new generation supply chain job titles to facilitate an industry-wide BDA transition.

6.3 Limitations and future research

We acknowledge this study could have some limitations. First, to control heterogeneity of the cases in terms of project nature and cultural aspects, this paper intentionally considers the context of BDA adoption process in SCP and sampled cases from the European manufacturing industry. This may lead to potential issues in the generalizability of the results. Second, due to limitations in access to data, our data collection followed a retrospective perspective relying on the informants' expertise in the project and no failure case was captured to demonstrate the contrasting perspective from counterexamples.

Therefore, future studies could focus on the following points. First, as our results appear convergent in the resource orchestration process in BDA adoption in SCP, it is necessary to validate if the result can be generalized also to other contexts different from SCP. Second, the proposed framework of resource orchestration process in organizational BDA adoption is resulted from a relatively limited sample. While we find strong evidence from the iteration of data and theory, further investigation is needed to validate and explicate the mechanism in each phase, integrating knowledge from failure cases.

Building on this paper, we also raise the question of how BDA adoption in one function (e.g. SCP) creates synergy with other organizational functions and whether it is necessary for any organization to complete the adoption lifecycle, especially in cases where BDA is not considered as a strategic lever. Moreover, it is still unanswered whether BDA adoption process is path-dependent (Sydow *et al.*, 2009), where the path of resource management and orchestration affect the final output of the system. Finally, despite our study opens up the discussion of the human aspects of BDA adoption from the perspective of capabilities, the human behaviour in supply chains is still rather an uncharted area (Schorsch *et al.*, 2017). Future research should further explore the behavioural issues to uncover the *ex ante* and *ex-post* roles of human factors in BDA adoption.

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Appendix

Supplementary material for this article can be found online at: https://polimi365-my.sharepoint.com/:b:/g/personal/10469756_polimi_it/EV0dZE2gYX5JqQmCEWpPF5ABJwz4qoJOWfmEyhxNH5fZWw?e=F2EmMG.

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