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1 **Big Data Analytics Capability and Decision-Making: The Role of Data-** 2 **Driven Insight on Circular Economy Performance**

3 ¹Usama Awan, ²Saqib Shamim*, ³Zaheer Khan, ⁴Najam Ul Zia, ⁴Syed Muhammad Shariq,
4 ²Muhammad Naveed Khan

5 ¹ *The Lappeenranta-Lahti University of Technology LUT, Lappeenranta 5385, Finland*

6 ² *Kent Business School, University of Kent, Canterbury, CT11NP, UK*

7 ³ *University of Aberdeen Business School, King's College, Aberdeen AB243FX, Scotland, UK*

8 ³ *School of Marketing and Communication, University of Vaasa, Finland*

9 ⁴ *Faculty of Management and Economics, Tomas Bata University in Zlin, Czech Republic*

10 **Abstract**

11 Big data analytics (BDA) is a revolutionary approach for sound decision-making in
12 organizations that can lead to remarkable changes in transforming and supporting the circular
13 economy (CE). However, extant literature on BDA capability has paid limited attention to
14 understanding the enabling role of data-driven insights for supporting decision-making and,
15 consequently, enhancing CE performance. We argue that firms drive decision-making quality
16 through data-driven insights, business intelligence and analytics (BI&A), and BDA capability.
17 In this study, we empirically investigated the association of BDA capability with CE
18 performance and examined the mediating role of data-driven insights in the relationship
19 between BDA capability and decision-making. Data were collected from 109 Czech
20 manufacturing firms, and partial least squares structural equation modelling was applied to
21 analyze the data. The results reveal that BDA capability and BI&A are positively associated
22 with decision-making quality. This effect is stronger when the manufacturer utilizes data-
23 driven insights. The results demonstrate that BDA capability drives decision-making quality in
24 organizations, and data-driven insights do not mediate this relationship. BI&A is associated
25 with decision-making quality through data-driven insights. These findings offer important
26 insights to managers, as they can act as a reference point for developing data-driven insights
27 with the CE paradigm in organizations.

28 **Keywords:** Big data analytics, data-driven insights, big data analytics capabilities, decision-
29 making, circular economy, manufacturing firms

1 **1. Introduction**

2 Recently, big data analytics (BDA) has emerged as one of the most important factors for
3 generating meaningful insights for decision-making (Dubey, Gunasekaran, Childe, Blome, &
4 Papadopoulos, 2019). It is in such a context that there is a growing interest in linking BDA and
5 the circular economy (CE; Gupta, Chen, Hazen, Kaur, & Santibañez Gonzalez, 2019). The
6 power of BDA in the pursuit of more regenerative and restorative business operations has led
7 to emerging literature on the CE. The CE refers to closing loops in production and consumption
8 and increasing resource utilization (Murray, Skene, & Haynes, 2017). Due to the important role
9 of BDA in organizations, scholarly attention has focused on exploring the links between BDA
10 and decision-making performance in emerging market firms (Shamim, Zeng, Khan, & Zia,
11 2020). Despite BDA potential, however, there is relatively limited research that has empirically
12 explored the antecedents of data-driven insights for enhancing decision-making quality (Rialti,
13 Zollo, Ferraris, & Alon, 2019), and its impact on CE performance (Gupta et al., 2019).

14 BDA capabilities are increasingly becoming important for broader decision-making in the CE
15 and are gaining significant attention from academicians and practitioners (Gupta et al., 2019).
16 BDA refers to the data sets and analytical techniques in applications that are so large and
17 complex that they require advanced and unique storage, management, analysis, and
18 visualization technologies (Chen, Chiang, & Storey, 2012). The existing literature on the role
19 of BDA in facilitating and making informed decisions has largely focused on organizational
20 performance (Ghasemaghaei & Calic, 2019; Gunasekaran et al., 2017; Wamba et al., 2017)
21 and innovation competency (Ghasemaghaei & Calic, 2019). Although BDA extracts
22 meaningful information on production activities at different stages of the production cycle for
23 achieving the maximization of resource utilization (Gupta et al., 2019), what is not yet clear is
24 how manufacturers could improve their existing product and process knowledge to renew it
25 through data-driven insights (Ghasemaghaei & Calic, 2019). There is a growing recognition of
26 BDA for effective decision-making; however, scant attention has been focused on how BDA
27 shapes firm decision-making quality (Janssen, van der Voort, & Wahyudi, 2017).

28 There are growing concerns across developed and developing markets about productivity
29 improvements and design products and processes that incorporate regenerative and reusable
30 design (Sauvé, Bernard, & Sloan, 2016). In this situation, a fundamental issue is how BDA
31 assists decision-making in today's complex CE activities (Gupta et al., 2019b). There has been
32 no detailed investigation of how BDA capability matters in terms of helping firms to gain

1 insights that lead to improving decision-making (Acharya, Singh, Pereira, & Singh, 2018a;
2 Kowalczyk & Buxmann, 2014) and, consequently, firm outcomes (Ghasemaghaei & Calic,
3 2019). However, some researchers have proposed that increased BDA is likely to improve
4 decision-making ability (Dubey, Gunasekaran, Childe, Bryde, et al., 2019). In contrast, others
5 have suggested that increased BDA is likely to generate more data insights (Ghasemaghaei &
6 Calic, 2019). While a potential link between BDA and an improved decision-making process
7 has been identified (Božič & Dimovski, 2019a), extant research has ignored the specific role
8 of data-driven insights in decision-making. There is still little understanding regarding whether
9 BDA drives CE performance (Gupta et al., 2019). Specifically, the underlying mechanisms are
10 not well known in the extant literature. One such mechanism is data-driven insights that can
11 facilitate the relationship between BDA and decision-making quality—which, in turn,
12 improves CE performance.

13 This study contributes to the emerging literature on BDA capability and the CE (Gupta et al.,
14 2019) by exploring how internal data analytics lead to data-driven insights and decision-
15 making quality in organizations—which, in turn, affects CE performance. This study examines
16 the relevance of BDA for achieving enhanced CE performance in manufacturing firms from an
17 emerging country perspective. We specifically address the following research question: To
18 what extent is BDA capability relevant for enhancing CE performance? Specifically, we seek
19 to explore the roles of a manufacturer's BDA capability in enhancing their decision-making
20 quality and CE performance. Our study differs from previous studies investigating the links
21 between BDA capability and firm performance in important ways. First, prior research suggests
22 that the dynamic capabilities perspective matters for performance outcomes (Dubey,
23 Gunasekaran, Childe, Blome, & Papadopoulos, 2019; Mikalef, Boura, Lekakos, & Krogstie,
24 2019). Our study contributes to the literature by demonstrating that the knowledge-based view
25 (KBV) also plays a key role in enhancing decision-making quality. Our results suggest that to
26 enhance decision-making quality to gain CE outcomes in organizations, decision-makers need
27 to rely on data analytics to keep pace with the dynamic needs of knowledge creation in
28 organizations (Alavi & Leidner, 2001). Second, the study follows the call of Ghasemaghaei
29 (2019) and extends prior research by examining data-driven insights as a mediator between
30 BDA capability and decision-making quality. Previous research explicitly considers data-
31 driven decision-making as a predictor of environmental performance (Dubey, Gunasekaran,
32 Childe, Papadopoulos, et al., 2019). While Shamim, Zeng, Shariq, and Khan (2019) examined
33 BDA capability as antecedents of decision-making quality. Limited studies have empirically

1 examined the relationship between decision-making and CE outcomes. Third, the existing
2 literature only has a limited understanding of how decision-making quality can be improved
3 (Janssen et al., 2017). We suggest that firms, with better decision-making qualities, can transfer
4 data-driven insights and knowledge for the creation of reusable and recyclable products.
5 Therefore, this study complements previous research on the consequences of data-driven
6 insights on decision-making outcomes (Ghasemaghaei & Calic, 2019). The rest of the paper is
7 organized as follows: The next section reviews the literature on the CE and BDA. Next, we
8 describe the hypothesis development. Then we introduce the methodology. The last section
9 discusses the study contributions and closes the article with a discussion on limitations and
10 future research directions.

11

12 **2. A digital-enabled circular economy**

13 A digital-enabled CE is an emerging concept for improving resource utilization, efficiency,
14 and productivity in organizations. Increasing resource scarcity concerns are pushing
15 manufacturing firms towards CE practices for achieving local and global sustainable
16 development objectives through the efficient utilization of digital technologies (Alhawari,
17 Awan, Bhutta, & Ülkü, 2021). There is a growing realization that companies must address the
18 issues of resource scarcity and dematerialization in their products' physical life cycle. The CE
19 is the understanding of how to improve production and consumption patterns to promote the
20 resilience orientation of materials (Awan, Kanwal, & Bhutta, 2020). Hu et al. (2011) argue that
21 the CE focuses on “resource-productivity and eco-efficiency improvement in a comprehensive
22 way, especially on the industrial structure optimization of new technology development and
23 application, equipment renewal and management renovation” (p. 221).

24 The CE is about managing and designing a linear-to-closed-loop industrial production and
25 consumption system (Awan et al., 2020). While Stahel and Reday-Mulvey (1981) interpret the
26 CE as a “spiral-loop system,” Geng and Doberstein (2008) focus on the reuse of a material that
27 is restorative or regenerative by intention and design (Ellen MacArthur Foundation, 2013).
28 Stahel (2016) emphasizes the need to bring the material back for a new use. Recent literature
29 highlights the business significance of circular business models, which enable firms to design
30 operations such as a take-back system (Bocken, Short, Rana, & Evans, 2014), and product
31 design aimed at closing and slowing resource loops (Bocken, de Pauw, Bakker, & van der

1 Grinten, 2016). Awan et al. (2020) defines the CE as a “set of processes for reducing the
2 material used in production and consumption, promoting material resilience, closing loops and
3 exchange sustainability offering in such a way that maximize the ecological system” (p. 30).
4 For example, organizations can use the exo-system and the chrono system to examine how they
5 can improve their CE practices over time. Conversely, the CE involves finding the best course
6 of action to design improved reuse of material and improved utilization of material recovery.
7 Hence, a digital-enabled CE enables an organization to uncover relationships from data and
8 information in a novel way to produce useful insights involving a series of techniques and
9 methods for data-driven decision-making.

10 The literature on the determinants of CE strategies is abundant (Bocken et al., 2016; Chiappetta
11 Jabbour, Fiorini, Ndubisi, Queiroz, & Piato, 2020; Fatimah, Govindan, Murniningsih, &
12 Setiawan, 2020). In contrast, little is known about the effect of BDA on CE performance (Gupta
13 et al., 2019b). BDA serves as a tool for resource management, improving the waste to resource
14 process (Bin et al., 2015), reducing production time and maximizing energy consumption
15 (Lacy, Long, & Spindler, 2020), and contributing towards improving resource efficiency and
16 productivity (Kristoffersen, Blomsma, Mikalef, & Li, 2020). The CE is a broad concept, and
17 in this study, we particularly focused on the management of the product life cycle
18 (Kristoffersen et al., 2020).

19

20 **3. Theoretical background and hypothesis development**

21 BDA plays a critical role in shaping organizations’ decision-making and can be beneficial for
22 CE performance. For example, BDA increases the likelihood of innovation performance
23 (Lehrer, Wieneke, vom Brocke, Jung, & Seidel, 2018). Similarly, Wamba et al. (2017) found
24 a positive relationship between BDA and organizational performance. A substantial amount of
25 the literature on decision-making deals with organizational learning. In line with Alavi and
26 Leidner’s (2001) view, knowledge resources are complex and difficult to imitate. Researchers
27 have laid the foundations for the application of organizational learning and KBV to understand
28 the data-driven insights and decision-making within organizations (Ghasemaghaei, 2019;
29 Ghasemaghaei & Calic, 2019).

30 This study draws key insights from the KBV perspective, suggesting that knowledge is the
31 most important strategic resource of organizations (Grant, 1996) and valuable knowledge

1 resources are embedded internally in information technologies and systems (such as the
2 internet, data warehouses, data mining techniques, and software agents; Alavi & Leidner,
3 2001). Scholars have devoted considerable attention to examining how BDA leverages
4 organizational performance (Rialti, Zollo et al., 2019), supply chain performance (Gunasekaran
5 et al., 2017; Wamba, Dubey, Gunasekaran, & Akter, 2020), operations and supply chain
6 management (Hazen, Skipper, Boone, & Hill, 2018), the optimization of resources (Zhao, Liu,
7 Zhang, & Huang, 2017), environmental sustainability (Dubey, Gunasekaran, Childe,
8 Papadopoulos, et al., 2019), manufacturing performance (Dubey, Gunasekaran, Childe, Blome,
9 & Papadopoulos, 2019), decision-making performance (Nisar et al., 2020; Shamim et al.,
10 2020), competitive advantage (Akter, Gunasekaran, Wamba, Babu, & Hani, 2020), and the
11 improvement of CE performance (Gupta et al., 2019). Recently, attention has turned to
12 examining the impacts of data-driven insights on decision-making (Ghasemaghaei & Calic,
13 2019).

14 This implies that BDA makes the application of knowledge more efficient by improving
15 organizational learning. We contend that in knowledge management and its sharing across the
16 boundaries of the firm, organizational learning plays an important role. BDA contributes to the
17 generation of valuable and hard-to-imitate knowledge resources—which, in turn, leads to the
18 development of sustainable competitive advantage. Organizational capacity to foster effective
19 decision-making is deeply rooted in firms' learning abilities. More recently, learning theory
20 has been examined as the basis of how organizations generate data insights (Ghasemaghaei &
21 Calic, 2019). Organizational learning theory is central to taking advantage of emerging
22 opportunities from external sources of knowledge, and it can create a competitive advantage
23 for organizations (Argote & Hora, 2017). Although the previous literature seems to support the
24 notion that BDA has improved resource utilization (Song et al., 2017), scholars have also
25 suggested that organizational learning capability could quickly generate data-driven insights to
26 improve decision-making efficiency (Ghasemaghaei & Calic, 2019). Studies have shown that
27 organizational learning may have both immediate and distant consequences (Bingham &
28 Davis, 2012). Firms have invested in BDA to generate different learning outcomes
29 (Papadopoulos et al., 2017).

30 Big data can be particularly useful in the context of large-scale decision-making (LSDM),
31 which is an emerging and rapidly developing research field and has become increasingly
32 popular in practical decision situations (Ding et al., 2020). LSDM research provides

1 appropriate insights to determine the best solution to solve practical problems and overcome
2 the noncooperative behaviour of key decision-makers (Palomares, Martinez, & Herrera, 2013;
3). LSDM is usually a complex and challenging process (Ding et al., 2020). LSDM is defined
4 as a situation in which more than 20 members are involved, and this number is not limited to
5 personnel within the organization (Liu et al., 2014). In the study of operations management and
6 electronic commerce, LSDM is commonly used to solve complex problems. Thus, in this study,
7 LSDM captures the extent to which participants from the same industrial cluster are involved
8 in solving complex problems of resource scarcity with the help of BDA. Recent efforts by Tang
9 and Liao (2019) to increase the move from conventional decision-making to LSDM in the big
10 data era illustrate this scenario. Big data has long been recognized as important in LSDM for
11 addressing the problems of natural resource scarcity. As McAfee, Brynjolfsson, Davenport,
12 Patil, and Barton (2012) observe, leading organizations can typically accept big data-driven
13 decision-making. Research in operations and management science has begun to look at the
14 potential benefits of using big data tools for decision-making (Tang & Liao, 2019). Previous
15 studies have highlighted the importance of LSDM using adequate preference representations
16 for the implementation of a data-driven large-group decision-support system (Ding et al.,
17 2020). LSDM can contribute towards solving complex problems that modern organizations are
18 facing; however, little research has been carried out on how big data tools and a decision-
19 support system can be applied in LSDM situations to solve complex problems.

20 Thus, given the importance of BDA in organizations, its role in the CE is becoming an
21 important field of enquiry. According to Chen et al. (2012), BDA is an application of practices
22 and methodologies “that analyze critical business data to help an enterprise better understand
23 its business and market and make timely business decisions” (p. 1166). Raghunathan (1999)
24 uses the term “decision-making quality” and refers to it as “the quality of the decision made by
25 the decision-maker” (p. 280). Recently, Ghasemaghaei (2019) established a link between BDA
26 and decision-making quality through knowledge-sharing practices. Prior research has indicated
27 that knowledge sharing has important implications for decision-making outcomes
28 (Ghasemaghaei, 2019). In this study, we especially focus on exploring how BDA affects CE
29 performance through data-driven insights and decision-making performance. Although BDA
30 has been recognized as the critical source for generating business value and firm performance,
31 relatively limited research has examined the impact of BDA on decision-making quality. In the
32 last few decades, knowledge focus in data analytics has become a topic of interest in several
33 manufacturing firms (Alavi & Leidner, 2001; Ghasemaghaei, 2019), but research has yet to

1 uncover whether and under what conditions a firm is able to apply the existing knowledge to
2 create new knowledge and take effective actions (Alavi & Leidner, 2001).

3 *3.1. Business intelligence and analytics and data-driven insights*

4 Business intelligence and analytics (BI&A) and the field of BDA have become increasingly
5 important within the academic and business communities over the past two decades. The
6 concept of BI&A has been gaining attention from academicians and business practitioners over
7 the last few years (Chen et al., 2012). The previous literature recognizes BI&A as an important
8 resource for acquiring and assimilating intelligence on customer opinions and needs, leading
9 to the identification of new business opportunities (Božič & Dimovski, 2019a). BI&A refers to
10 “the techniques, technologies, systems, practices, methodologies, and applications that analyze
11 critical business data to help an enterprise better understand its business and market and make
12 timely business decisions” (Chen et al., 2012, p. 1166). The role of BI&A is well established
13 in previous research; however, there is limited understanding of how BI&A may enhance CE
14 performance through leveraging internal organizational capabilities. Business intelligence (BI)
15 identifies the patterns whereby a firm is able to use different ways to scan and absorb
16 information as a basis for predicting opportunities to reduce uncertainty (Gudfinnsson, Strand,
17 & Berndtsson, 2015).

18 Recently, Dubey et al. (2019) explained that BI&A is positively associated with the ability to
19 enhance innovation rather than firm performance. This implies that firms with better BI&A
20 will have more knowledge-accumulation resources that they can use when making a decision.
21 BI&A can enable firms to leverage a specific type of new knowledge to provide insights about
22 the common base of organizational knowledge and process in order to understand how a
23 particular task takes place (de Vasconcelos & Rocha, 2019). This implies that improved levels
24 of BI&A enhance tasks and lead to improving the data-driven insights among decision-makers.
25 To effectively collaborate and search for new knowledge from multiple points in time, firms
26 rely on BI&A to realize value from the technology to generate diverse data insights.
27 Conversely, although there exists some evidence that BI&A is evenly distributed across firms
28 and encourages the pursuit of data insights, some firms might not benefit from such insights,
29 given their weak data-related capabilities.

30 The concept of data-driven insights has recently gained attention by virtue of its potential to
31 generate deep data insights. Moreover, the use of BDA reduces the complexity of generating

1 insights from the data and increases the understanding of the optimal set of actions based on
2 descriptive, prescriptive, and predictive data insights (Ghasemaghaei & Calic, 2019; Sheng,
3 Amankwah-Amoah, Khan, & Wang, 2020). Data-driven insights are thus linked to three
4 approaches: descriptive, predictive, and prescriptive insights. Descriptive insights focus on the
5 importance of the relationship between historical (past data) and current tasks to gain insights
6 into tasks, whereas predictive insights emphasize predicting possible future outcomes resulting
7 from data and information originating from BI&A, and prescriptive insights emphasize the
8 decision-making process carried out to improve future outcomes (Ghasemaghaei & Calic,
9 2019). In line with this, however, following the KBV, knowledge embedded in information
10 technology requires that managers apply BI&A to deliver insights into what has happened in
11 the past and how to integrate new insights into existing resources to improve future outcomes.
12 This calls for managers and key workers to have greater learning capabilities and helps to foster
13 more effective data-driven insights. We can thus hypothesize that BI&A can build capabilities,
14 leading to building data-driven insights. Thus, we suggest the following:

15 *H1: Business intelligence and analytics positively relates to a firm's data-driven insights.*

16 Recently, Božič and Dimovski (2019b) highlighted the importance of BI&A for knowledge
17 creation. Studies have increasingly emphasized that BDA plays an important role in shaping
18 CE (Gupta & George, 2016). Data management insights shape analytics capabilities and
19 encourage managers to make quick decisions in real time to solve problems and deliver
20 innovative solutions. Kristoffersen et al. (2020) points out that digital technologies, such as
21 BDA, might promote circular strategies. We argue that to enhance CE performance in a
22 constantly changing environment, BI&A allows for faster decision-making based on past
23 material use and collection trends; in turn, the manager uses it to design a system to support
24 recycling, reuse, and remanufacturing activities. Hence, the use of BI&A allows an
25 organization to enhance the existing stock of knowledge resources—which, in turn, promotes
26 the design of new services—and products with better recyclability features. These arguments
27 are consistent with the KBV, as BI&A is a knowledge-intensive activity and leads to
28 knowledge-based capabilities such as CE performance. Therefore, we argue that BI&A is a
29 prerequisite for CE performance in extracting new insights about the material recovery rate and
30 generating value from end-of-life products. Based on the preceding discussion, we propose the
31 following:

1 *H2: Business intelligence and analytics positively relates to a firm's circular economy*
2 *performance.*

3 *3.2. Big data analytics and data-driven insights*

4 The literature recognizes that generating data-driven insights represents an important BDA
5 capability (Ghasemaghaei & Calic, 2019). BDA capabilities are increasingly becoming an
6 important component of the decision-making process in business (Hagel 2015; Shamim et al.,
7 2020). BDA has frequently been discussed by scholars with a dynamic capability perspective
8 to explore the relationship between BDA capabilities and organizational performance (Wamba
9 et al., 2017). Wamba et al. (2017) argue that BDA leads to improved firm performance and
10 BDA comes from BDA infrastructure flexibility, BDA management capabilities, and BDA
11 personnel expertise. BDA infrastructure emphasizes the importance of the relationship between
12 historical (past data) and current tasks to gain insights into tasks, BDA management capabilities
13 emphasize predicting possible future outcomes resulting from data and information originating
14 from BI&A, and BDA personnel expertise emphasizes the decision-making process carried out
15 to improve future outcomes (Wamba et al., 2017). For example, Akter, Wamba, Gunasekaran,
16 Dubey, and Childe (2016) show that BDA capabilities enable managers to quickly develop,
17 deploy, and support firms' resources. Akter et al. (2016) propose that BDA personnel
18 capabilities serve as catalysts to mobilize management to the understanding of different
19 business functions to address changing needs in the big data environment. By fostering BDA
20 management capabilities, firms can transform BDA for strategic use (Rialti et al., 2019).
21 Considering this new reality, the analysis of the impact of big data has become a priority for
22 executives who wonder how it can be used to generate insights from structured and
23 unstructured data for better decision-making.

24 Research indicates that firms with a high level of BDA capabilities tend to have more focus on
25 the generation of useful knowledge (Acharya, Singh, Pereira, & Singh, 2018b). By means of
26 BDA, firms can improve internal processes, operations, and organizational efficiency, allowing
27 them to identify opportunities from different kinds of data (Rialti et al., 2019) that could be
28 used for decision-making (Ghasemaghaei, 2019). Previous research has established a positive
29 association between BDA and organizational outcomes (Akter et al., 2016; Wamba et al.,
30 2017). The effect of organizational BDA, often in the form of data-driven insights, has been
31 debated in the information science literature (Ghasemaghaei & Calic, 2019). In data-driven
32 insights, organizational BDA can be an explanatory factor to learn from past behaviours and

1 understand their impact on future outcomes. In the literature, organizational BDA is considered
2 an important capability (Akter et al., 2016) that impacts organizational performance. In the
3 context of this study, BDA is a knowledge-based capability (Shamim et al., 2019b), and it is
4 important for the effective utilization of business analytics to better plan and adapt to changing
5 conditions (Wamba et al., 2017). Thus, we propose that enhancing the level of learning
6 capabilities within organizations can help managers to improve their understanding of past and
7 present trends and predict future trends. Based on this discussion, we suggest the following:

8 *H3: Big data analytics capabilities positively relate to a firm's data-driven insights.*

9 As highlighted in the literature, technological infrastructure such as sensors and RFIDs are
10 increasingly being employed with electronics equipment that may enable a product to be traced
11 for recycling, and effective utilization of new technologies can support remanufacturing,
12 recycling, and reuse of parts or components at the end of the product's life (Okorie et al., 2018).
13 The existing literature reveals that by integrating technological infrastructure, enhancing
14 management capabilities to trace real-time material in the product life cycle, and integrating
15 personal skills, several benefits can be generated in terms of reuse of the material—improving
16 material efficiency and circularity of product design (reduction of waste from the production
17 process and reuse of the material), among other sustainability-related benefits.

18 Anecdotal evidence suggests that BDA capability can improve tangible and intangible
19 organizational productivity (Akter et al., 2016). Recently, Wamba et al. (2017) noted that BDA
20 capability can assist organizations in aligning resources with long-term and short-term
21 strategies; this is because BDA is acknowledged as an essential enabler of the CE (Awan,
22 Sroufe, & Shahbaz, 2021; Kristoffersen et al., 2020). This follows the interpretation of Gupta
23 et al. (2019), who argued that the effective utilization of BDA is important for the enhancement
24 of the circulation of resources—increasing the effectiveness of the material and, thereby,
25 increasing the effectiveness of business operations. We argue that BDA capabilities enable
26 firms to successfully utilize infrastructure and manage personal expertise to develop processes
27 and products compatible with reuse and recycling. Therefore, we propose the following:

28 *H4: Big data analytics capabilities positively relate to a firm's circular economy process.*

29 3.3. *Data-driven insights and decision-making quality*

30 The effective utilization of resources and effective decision-making among managers are sets
31 of actions to be performed in relation to tasks (Ghasemaghaei, 2019). Decision-making quality

1 ensures that managers understand what to do and what they are trying to achieve. Recently,
2 Ghasemaghaei (2019) argued that decision-making in a digital environment is embedded in a
3 better understanding of data or key information. Knowledge resources may lead to making
4 better decisions inside organizations. The KBV also supports these arguments, given the vital
5 role of knowledge in enhancing firms' competitive advantage (cf. Grant, 1996). Raghunathan
6 (1999) defines decision-making quality as a decision-maker's ability to make the correct
7 decision, referring to it as the quality of the decision made by the decision-maker. In contrast,
8 decision-making effectiveness focuses on decision outcomes (Alavi & Leidner, 2001).
9 However, there is little understanding of how the depth, breadth, and quality of organizational
10 knowledge resources improve decision-making quality (Alavi & Leidner, 2001).

11 The acquisition of data resources sets the direction and action to be performed in relation to
12 minimizing waste and recycling of the products. Based on the KBV, the acquisition of different
13 types of data resources and knowledge could help a firm to extract the right insights on the
14 design out of waste from process and products and enable products to be reused. The authentic
15 and valuable insights generated from the data are important for the firm, as they can be chosen
16 to formulate appropriate decisions to create new courses of action. Valuable insights generated
17 from diverse data sources to understand past and present trends, as well as predict future trends,
18 can positively influence decision-making quality.

19 *H5: Data-driven insights positively relate to a firm's decision-making quality.*

20 *3.4. Big data decision-making and circular economy performance*

21 Previous studies have increasingly highlighted the importance of effective decision-making for
22 the management of the product life cycle (Kristoffersen et al., 2020). Data-driven insights
23 create a good understanding of effective decision-making. For example, according to
24 Ghasemaghaei (2019), an organization's learning capabilities integrate and leverage good
25 insights into the best course of action to improve decision-making because a large amount of
26 information is utilized to solve existing problems and generate innovative solutions. However,
27 there is a lack of research that has explored how decision-making is affected by BI&A and its
28 impact on value-added business activities (i.e., CE; Božič & Dimovski, 2019a). Selecting the
29 best course of action involves learning about the optimal courses of action and may require the
30 use of efficient technologies for the reuse and redesign of products and services to improve
31 material recovery (Bocken et al., 2016). By effective decision-making, value is created for the

1 organization by redesigning products, improving material efficiency and effectiveness for end-
2 of-life products.

3 There is limited research on understanding the environmental performance outcomes of
4 decision-making quality (Calza, Parmentola, & Tutore, 2020). The underlying mechanisms
5 through which an organization improves CE initiatives have also received limited scholarly
6 attention.

7 We propose that if CE-related decisions are based on correct and valid data insights, derived
8 by discovering certain relationships, and rigorously implemented, firms will be in a better
9 position to discover new patterns from using visualization tools to adapt to changing
10 environmental challenges, thereby improving productivity and efficiency. Therefore, we
11 propose the following:

12 *H6: Big data decision-making effectiveness positively relates to circular economy*
13 *performance.*

14 3.5. *The mediating role of data-driven insights*

15 An organization's heightened concern to bolster its CE outcomes and, as a result, increase
16 engagement in a decision is anchored in two dimensions: knowledge-based resources and
17 organizational learning. According to learning theory (Puranam & Swamy, 2016), knowledge
18 resources play a critical role in decision-making, as gathering information, processing,
19 interpretation, and synthesis enable organizations to enhance their performance and
20 competitive advantage. The organization's learning, therefore, is closely connected to the
21 generation of data insights (Ghasemaghaei & Calic, 2019). Previous empirical studies have
22 shown that improvisational learning is associated with real-time learning and can serve to solve
23 emergent problems (Miner, Bassof, & Moorman, 2001). Scholars have long been interested in
24 the effects of information processing and interpretation on decision-making (Joseph & Gaba,
25 2020). Firms may lack learning capabilities about information processing and therefore be
26 unable to exploit the resources. Using theoretical reasoning that knowledge resources affect
27 organizational learning, we argue that by using data-driven insights, decision-makers would be
28 able to comply with the KBV to enhance CE performance. Decision-makers would be able to
29 generate knowledge and insights from the computer-supported system to collect, interpret, and
30 disseminate valuable knowledge and insights for better decision-making (Božič & Dimovski,

1 2019b). Following Grant (1996), we examined empirically whether and to what extent data-
2 driven insights mediate the relationship between BDA capability and decision-making.

3 Firms are increasingly challenged by data-driven insights, which lead to effective decision-
4 making (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011). A more recent BI&A
5 research by Božič and Dimovski (2019a) calls for a deep analysis to explore an organization's
6 underlying mechanism that facilitates the knowledge-generation process for effective decision-
7 making. A central issue in this area is whether BI&A and organizational BDA capabilities have
8 a positive impact on firm decision-making. Previous studies have examined a mediating link
9 of innovation between BI&A and firm performance (Božič & Dimovski, 2019b), and
10 Ghasemaghaei (2019) established a mediating link of data analytics competency between data
11 analytics and decision-making quality. Akter et al. (2016) examined a direct link between BDA
12 capabilities and firm performance, and Rialti, Zollo, Ferraris, and Alon (2019) investigated a
13 direct link between BDA capabilities and firm agility. By introducing data-driven insights, an
14 organization can enhance decision-making—which, in turn, strengthens the value-added
15 activities of the business. Recently, Ghasemaghaei and Calic (2019) established a mediating
16 link of data-driven insights between big data characteristics and innovation competency.
17 Acharya et al. (2018) show that BI&A helps to identify knowledge management practices and
18 produce new insights for decision-making. In turn, these insights enable firms to make better
19 decision advantages.

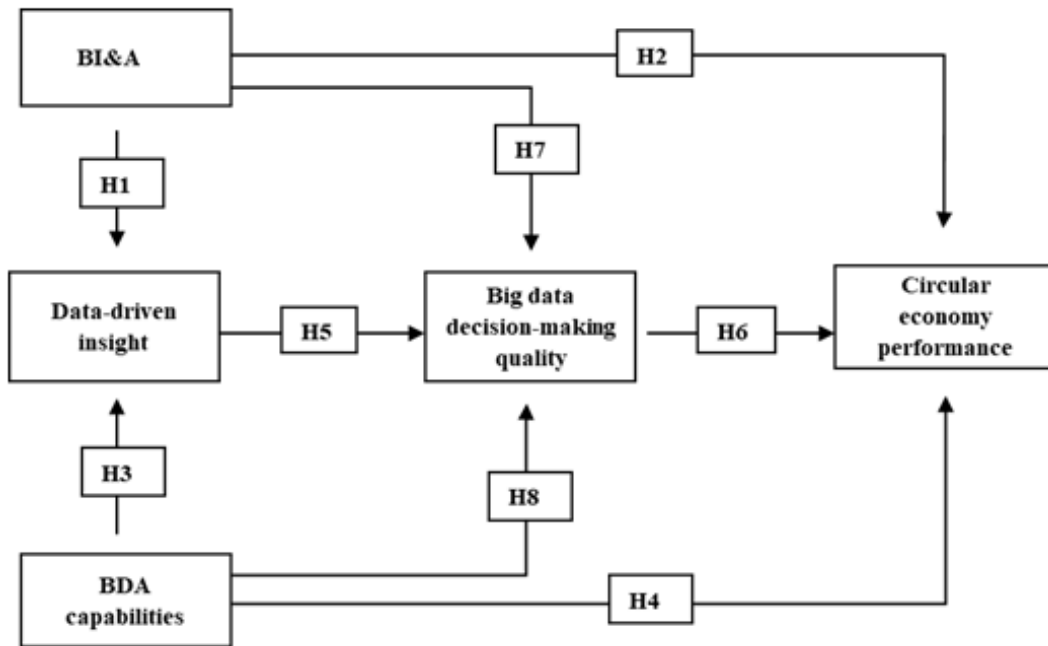
20 BDA capability has become mainstream for organizations to create value (Wixom, Yen, &
21 Relich, 2013); it leverages technology, management, and talent capabilities, which are likely
22 to generate more business value (Akter et al., 2016) for better decision-making (LaValle et al.,
23 2011). Hence, we expect that BI&A is more positively associated with data-driven insights
24 than organizational BDA capabilities. Organizational concerns for the effective utilization of
25 data-driven insights foster a farsighted approach to firm decision-making, with a focus on
26 BI&A (Acharya et al., 2018a; Božič & Dimovski, 2019). The decision-making perspective is
27 founded on the ideas formulated by March (1997). The fundamental assumption of this
28 approach is that decisions are implemented in an organization based on reliable information.
29 The decision-making process in an organization is thus influenced by information processing,
30 gathering, and interpretations (March 1997). However, although the positive effects of data-
31 driven insights on firm decision-making are widely acknowledged (Ghasemaghaei & Calic,
32 2019), there is still a lack of understanding of the process through which effective decision-

1 making is implemented in an organization (Joseph & Gaba, 2020). We propose that BDA
 2 capability would enable a firm to choose the best possible plan of action and execute it through
 3 the utilization of data-driven insights. To summarize, the understanding of the effects of BDA
 4 capability remains mixed. We propose that BDA capability can revolutionize the decision-
 5 making process through data-driven insights. Therefore, we suggest the following:

6 *H7: Data-driven insights mediate the relationship between business intelligence and analytics*
 7 *and decision-making quality.*

8 *H8: Data-driven insights mediate the relationship between big data analytics capabilities and*
 9 *decision-making quality.*

10



11

12

Figure 1. Research Model

13

14 **4. Methodology**

15 *4.1. Sample and data collection*

16 In this study, we used a survey method to collect data through a structured questionnaire. Data-
 17 driven manufacturing firms in the Czech Republic form the population of this study. The
 18 European Commission is introducing new measures regarding the Circular Economy Package,
 19 and the member states must implement its contents into their policies (Vilamová et al., 2019).

1 In response to the adoption of the Circular Economy Package, the Czech government approved
2 the new Waste Management Plan for the period 2015–2024 (Vilamová et al., 2019). Europe is
3 also developing a strategy for a digital economy and planning to shape the digital European
4 society by 2030 (Georgiou, 2018; Misuraca et al., 2012). Being a part of the European Union,
5 the government of the Czech Republic is also strongly working on the concept of a “Digital
6 Czech Republic” by defining 15 major and 115 partial targets to support the digitization process
7 in the country (Digital Czech Republic, 2019). The government is expending its best efforts to
8 make the Digital Czech Republic the main policy concerning digitization, which will gradually
9 replace the existing traditional policies (Digital Czech Republic, 2019). The mission of the
10 Digital Czech Republic is to find out and eradicate all administrative and legislative barriers
11 while aggressively encouraging the best environments for the success of individuals, Czech
12 companies, and the whole country in this digital transformation period (Digital Czech
13 Republic, 2019). This makes the Czech Republic a relevant context for this study.

14 We initially requested 914 firms to participate in the survey and shared the questionnaire with
15 them. Google Forms was used to distribute the questionnaires. Each firm’s contact details were
16 collected using the Bisnode Albertina database. We shared the online questionnaire link with
17 the contact persons in these firms and requested them to share it with employees involved in
18 big-data–related activities and decision-making. We received a response from 109 firms and
19 358 employees, out of which 321 responses were usable. There were multiple respondents from
20 each firm. The whole process of data collection took around 10 months—lasting from January
21 to October 2020. Most of the firms that participated in the survey are 6- to 20-year-old
22 manufacturing firms with approximately 20 to 200 employees. We collected data from key
23 frontline employees and managers involved in big data–related activities, as well as from
24 middle and top managers. In this study, we have controlled firm size, firm age, respondent
25 experience, respondent age, education, and respondent managerial level to eliminate whatever
26 effects these variables might have on decision-making. Several previous studies provide mixed
27 findings on the effects of firm age and size on decision-making, while others provide evidence
28 that firm size has no significant effect on decision-making.

29 *4.2. Common method bias*

30 To mitigate the effect of common method bias, we took several steps. For instance, we collected
31 data in two waves. We ensured the anonymity of respondents. Furthermore, we randomized
32 the items in the questionnaire so the respondents could not easily guess the antecedents and

1 outcome variables. We ran exploratory factor analysis with an unrotated solution to ascertain
2 the absence of common method bias. The statistical check was also satisfactory—that is, the
3 Harman single-factor test suggested that a single factor explained only 32.03%, which provides
4 support for the absence of common method bias. This approach is consistent with the existing
5 literature (Yang et al., 2017).

6 *4.3. Measures*

7 A structured questionnaire was used to measure the variables. The questionnaire is a
8 combination of adopted, adapted, and self-developed items. Decision-making quality was
9 measured using eight items from Shamim et al. (2019a). We developed nine items to measure
10 BI&A, and these items were inspired by Božič and Dimovski (2019) and Gold et al. (2001).
11 BDA was measured by adopting eight items from Akhtar, Khan, Tarba, and Jayawickrama
12 (2018). Data-driven insights were measured by adopting eight items from Ghasemaghaei and
13 Calic (2019). The CE performance measurement scale was developed by authors using insights
14 from the existing literature and adopted in the current study context. We asked respondents to
15 indicate the extent to which they agreed with the following statements on a seven-point Likert
16 scale: “1 – strongly disagree” to “7 – strongly agree.”

18 **5. Results**

19 *5.1. Reliability and validity*

20 All the constructs were tested for reliability and validity. The results indicate that Cronbach’s
21 alpha for all the constructs was more than 0.7, which indicates construct reliability. To examine
22 the discriminant validity, Fornell and Larcker’s (1981) approach was followed. To establish
23 convergent validity, factor loadings of the construct should be greater than 0.65, average
24 variance extracted (AVE) and composite reliability (CR) should be more than 0.5, and AVE
25 should be less than the CR of the construct (Fornell & Larcker, 1981). The results in Table 1
26 indicate that all the constructs meet these requirements. Factor loadings for all the constructs
27 are greater than 0.65. The values in italics are the items that were excluded because the loadings
28 were less than 0.65. Factor loadings for BI&A ranged from 0.74 to 0.81. BDA factor loadings
29 were 0.72 to 0.82. Data-driven insights showed loadings ranging from 0.70 to 0.82. Decision-
30 making quality showed factor loadings from 0.75 to 0.85, and loadings for the CE process
31 ranged from 0.84 to 0.89. The AVE and CR of all the constructs were greater than 0.5, and the

1 AVE of each construct was higher than the CR. These results meet the Fornell and Larcker
 2 (1981) criterion for the evaluation of convergent validity. On the basis of these findings,
 3 convergent validity is established. The results of the convergent validity are summarized in
 4 Table 1.

5 **Table 1.** Reliability and Convergent Validity

Variable	Items	Factor loadings	AVE	CR	Cronbach's alpha
BI&A	<i>BI&A1</i>	0.65	0.61	0.88	0.84
	<i>BI&A2</i>	0.59			
	<i>BI&A3</i>	0.61			
	<i>BI&A4</i>	0.51			
	<i>BI&A5</i>	0.74			
	<i>BI&A6</i>	0.77			
	<i>BI&A7</i>	0.80			
	<i>BI&A8</i>	0.81			
	<i>BI&A9</i>	0.77			
BDA capabilities	<i>BDA1</i>	0.78	0.61	0.90	0.87
	<i>BDA2</i>	0.76			
	<i>BDA3</i>	0.79			
	<i>BDA4</i>	0.75			
	<i>BDA5</i>	0.82			
	<i>BDA6</i>	0.72			
	<i>BDA7</i>	0.68			
	<i>BDA8</i>	0.61			
Data-driven insights	<i>DDI1</i>	0.70	0.60	0.93	0.91
	<i>DDI2</i>	0.78			
	<i>DDI3</i>	0.76			
	<i>DDI4</i>	0.81			
	<i>DDI5</i>	0.80			
	<i>DDI6</i>	0.82			
	<i>DDI7</i>	0.78			
	<i>DDI8</i>	0.74			
	<i>DDI9</i>	0.71			
Decision-making quality	<i>DDMQ1</i>	0.82	0.65	0.92	0.91
	<i>DDMQ2</i>	0.85			
	<i>DDMQ3</i>	0.82			
	<i>DDMQ4</i>	0.79			
	<i>DDMQ5</i>	0.75			
	<i>DDMQ6</i>	0.78			
	<i>DDMQ7</i>	0.79			
	<i>DDMQ8</i>	0.62			
Circular economy performance	<i>CE1</i>	0.87	0.76	0.94	0.92
	<i>CE2</i>	0.89			
	<i>CE3</i>	0.87			
	<i>CE4</i>	0.87			
	<i>CE5</i>	0.84			

6 To establish discriminant validity, the AVE of each construct should be more than the squared
 7 correlation among the constructs (Fornell & Larcker, 1981). The results in Table 2 show that

1 the AVE of each construct was higher than the squared correlation, which indicates
2 discriminant validity.

3 Another criterion for evaluating discriminant validity is the heterotrait–monotrait (HTMT)
4 ratio, a newly proposed approach based on the multithread–multimethod matrix. This approach
5 is superior to cross-loading and the Fornell and Larcker (1981) approach (Henseler, Ringle, &
6 Sarstedt, 2015). The HTMT criterion involves comparing the ratio to a predefined threshold;
7 this is the first approach. If the level of HTMT exceeds the threshold, then there is a lack of
8 discriminant validity. The criterion suggests that to establish convergent validity, the HTMT
9 ratio for each construct should be less than 0.85. Table 3 shows that all the constructs meet the
10 criterion; therefore, discriminant validity is established. The chi square of the model is 2035.4,
11 the R-square of the dependent variable is 0.57, and the NFI is 0.91, which indicates a good
12 model fit. Table 3 shows the mean, standard deviation, and correlation among the constructs.

Table 2. Mean, Standard Deviation and Correlation

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1 BDA capabilities	4.14	1.44	0.61											
2 CE performance	3.83	1.90	0.73**	0.76										
3 Decision-making quality	4.09	1.47	0.52**	0.54**	0.65									
4 Data-driven insight	4.04	1.71	0.53**	0.46**	0.61**	0.60								
5 BI&A	4.26	1.36	0.68**	0.59**	0.54**	0.67**	0.61							
6 Managerial level	2.72	1.14	0.02	0.10**	0.10*	0.00	0.04	1						
7 Highest education	2.95	0.72	0.00	0.03	0.05	0.03	0.07	0.08	1					
8 Age of respondent	2.3	1.15	0.02	0.11*	0.11**	0.00	0.04	0.98**	0.03	1				
9 Experience	2.32	1.15	0.02	0.12*	0.10*	-0.01	0.02	0.94**	0.02	0.96**	1			
10 Age of firm	3.01	1.25	-0.1*	-0.10*	-0.15*	-0.07	-0.05	-0.21**	-0.04	-0.20**	-0.18**	1		
11 Number of employees	2.11	0.55	-0.09*	-0.04	-0.0	-0.12*	-0.07	0.10**	0.11	0.10*	0.11*	0.37**	1	
12 Annual sales	1.74	0.64	-0.085	-0.09*	-0.07	-0.04	0.08	0.08	0.16	0.04	0.01	0.12**	0.38**	1

Note. Bold values are AVE; * Correlation significant at 0.05; ** Correlation significant at 0.01

Table 3. Heterotrait–Monotrait Ratio, Skewness, and Kurtosis

	Factors	Skewness	Kurtosis	1	2	3	4
1	BDA capabilities	-0.25	-1.23				
2	BI&A	-0.24	-0.81	0.74			
3	Circular economy process	-0.24	-1.46	0.78	0.61		
4	Data-driven decision-making quality	-0.08	-1.52	0.50	0.60	0.60	
5	Data-driven insights	-0.43	-1.16	0.53	0.77	0.50	0.65

5.2. Hypotheses testing

We used partial least squares (PLS) structural equation modelling to test the hypotheses. There are several reasons to use PLS: (1) PLS is a structural equation modelling method designed to estimate composite factor models, and its construct scores are more reliable than sum scores. (2) PLS has sufficient information to estimate different weights, and it can also help to detect a wide spectrum of measurement model misspecifications. (3) PLS can be applied in many instances of small samples when other models fail (Henseler et al., 2014). (4) PLS can be a valuable tool for exploratory research (Henseler et al., 2014). Moreover, it simultaneously considers the measurement model and the theoretical structural model (Chin, Marcolin, & Newsted, 2003).

First, we tested direct associations. The results revealed that BI&A is positively and significantly associated with data-driven insight ($\beta = 0.65$, $p < 0.001$) and CE performance ($\beta = 0.15$, $p < 0.01$). These findings support H1 and H2. A direct association of BDA with data-driven insights ($\beta = 0.60$, $p < 0.001$) and CE performance ($\beta = 0.54$, $p < 0.001$) is also supported by the results, so H3 and H4 are also accepted. Data-driven insights are positively related to decision-making quality ($\beta = 0.45$, $p < 0.001$), and decision-making quality is positively related to CE performance ($\beta = 0.28$, $p < 0.001$). These findings support H5 and H6.

Second, we tested the mediation effect using SmartPLS (Ringle, Wende, & Becker, 2015) with a bootstrapping procedure, setting the bootstrap at 5,000 runs. To assess the mediation effect, we used a bootstrap confidence interval for the indirect effect. An SRMR value less than 0.08 in the PLS path model provides support for the model fit of the empirical data. Our results show that the SRMR value was less than the desired value, excluding the direct effect. We then identified partial mediation to assess the variance accounted for (VAF) value in explaining the extent to which mediation variables account for the variance of the dependent variable. A VAF value between 20 percent and 80 percent indicates that a partial mediation exists. A VAF value greater than or equal to 1 is described as a full mediation (Hair & Hult, 2016).

We followed the Baron and Kenny (1986) and MacKinnon, Fairchild, and Fritz (2007) approach to examine whether the mediation had occurred or not since it is widely employed in examining the role of mediating variables. The mediation is said to occur if the indirect effect is significant. We further tested whether there was a full mediation relationship or a partial mediation relationship, following the guidelines of MacKinnon et al. (2007). Significance level

1 was measured by bootstrapping. Then we examined the mediating role of data-driven insights
2 in the association of decision-making quality with BI&A and BDA. The results suggest full
3 mediation of data-driven insights in the relationship of BI&A and decision-making quality;
4 after entering data-driven insights as a mediator in this relationship, the direct association of
5 BI&A and decision-making quality became insignificant ($\beta = 0.11$, $p > 0.1$). The indirect
6 relationship between BI&A and decision-making quality was positive and significant ($\beta = 0.30$,
7 $p < 0.001$). These findings support H7. However, the results do not suggest that data-driven
8 insights mediate the relationship between BDA and decision-making quality ($\beta = 0.03$, $p >$
9 0.1).

1 **Table 4.** Path Analysis and Hypothesis Testing

Path	Direct effects β/t-value	Indirect effects β/t-value	Total effects β/t-value	Hypothesis	Result
BI&A → Data-driven insights	0.65***/10.55			H1	Accepted
BI&A → CE performance	0.15**/2.72			H2	Accepted
BDA capability → Data-driven insights	0.60***/12.10			H3	Accepted
BDA capability → CE performance	0.54***/10.47			H4	Accepted
Data-driven insights → Decision-making quality	0.45***/7.09			H5	Accepted
Decision-making quality → CE performance	0.28***/4.68			H6	Accepted
BI&A → Data-driven insights → Decision-making quality	0.11/1.61	0.30***/5.61	0.41***/6.59	H7	Accepted
BDA → Data-driven insights → Decision-making quality	0.18**/3.01	0.03/1.08	0.21**/3.23	H8	Rejected

2

6. Discussion

This study examined how BI&A and BDA influence CE performance by enhancing data-driven insights and decision-making quality by drawing data from 109 Czech manufacturing firms. The findings suggest that both BI&A and BDA capabilities are positively related to CE performance. These findings are consistent with those of Kristoffersen et al. (2020). Furthermore, BDA capabilities constitute a stronger predictor of CE performance. BI&A fully relies on data-driven insights to enhance CE performance; however, BDA capabilities are directly related to CE performance. Our results are also consistent with suggestions made by Ghasemaghaei and Calic (2019)—that is, BI&A and BDA capabilities are positively associated with data-driven insights, which enhances decision-making quality. Our findings suggest that BI&A influences decision-making quality through the mediating role of data-driven insights, which means it relies on data-driven insights to connect with decision-making quality. In the absence of data-driven insights, the relationship between BI&A and decision-making quality is insignificant. However, BDA does not rely on data-driven insights to influence decision-making quality, as the results show that there is no indirect relationship between BDA capability and decision-making quality. However, the direct relationship between BDA capability and decision-making quality is significant, which is consistent with Shamim et al. (2020). This may be because companies are now moving towards autonomous decision-making, and BDA capability is a broader construct that involves human talent, technological infrastructure, and management capability (Wamba et al., 2017). The multidimensional nature of the BDA construct does not depend on mediators such as data-driven insights to influence decision-making quality. However, this issue needs further investigation. Finally, the results suggest that decision-making quality achieved using BI&A, BDA capabilities, and data-driven insights enhances CE performance of firms and that BI&A can have a stronger impact on data-driven insights than BDA capability can. We also found that BDA is more strongly related to decision-making quality than BI&A is. Previous studies have highlighted the importance of LSDM using adequate preference representations for the implementation of a data-driven large-group decision-support system (Ding et al., 2020). Thus, in this study, LSDM captures the extent to which participants from the same industrial cluster are involved in solving complex problems of resource scarcity with the help of BDA. Our findings reveal that data-driven insights act as a mediating factor between BI&A and big data decision-making quality. Given the importance of BDA capability, there remains a paucity of evidence of BDA capability on CE performance—although there are a few exceptions to this, such as Gupta et

1 al. (2019) and Popovič, Hackney, Tassabehji, and Castelli (2018). We conclude that CE
2 performance can be improved through robust BI and the use of BDA, as well as through
3 recognizing the value of good decision-making in organizations. Our results suggest that an
4 organization's BDA capabilities are an important resource to realize the value of knowledge
5 and information and that data-driven insights need to encompass the importance of BI&A for
6 effective big data decision-making for CE performance. These findings are particularly useful
7 because the emergence of a digital economy and new forms of digital business models for firms
8 and markets has raised the demand for strategic decision-making processes to an unprecedented
9 scale. Decision-making in this situation relies heavily on artificial intelligence and data-driven
10 technologies such as big data (Ding et al., 2020). Our proposed framework can enable better
11 decision-making in this context.

12 *6.1. Theoretical contributions*

13 Our research contributes to the literature in several ways. The main contribution of our study
14 is proposing and testing a conceptual model that identifies the mechanism that enables a firm
15 to enhance the CE. First, this study seeks to advance the current decision-making literature by
16 explicitly exploring if and how BDA capabilities affect data generation and CE performance
17 in manufacturing firms. Prior research has suggested that the dynamic capabilities perspective
18 matters for performance outcomes (Dubey, Gunasekaran, Childe, Blome, & Papadopoulos,
19 2019; Mikalef et al., 2019). Our study contributes to the literature by demonstrating that the
20 KBV also plays a key role in enhancing decision-making quality. This study contributes to the
21 decision-making literature by linking it to the KBV to show that data generation insights affect
22 decision-making quality. Our conceptual model can be interpreted through the KBV lens. We
23 build on the KBV to suggest that learning is a key characteristic that provides a new source of
24 information and generates new knowledge that enables organizations to capture value from key
25 knowledge sources. Our results suggest that to enhance decision-making quality and gain CE
26 outcomes, decision-makers need to rely on data analytics to keep pace with the dynamic needs
27 of knowledge creation (Alavi & Leidner, 2001).

28 Second, this study proposes that enhanced CE performance requires a specific set of internal
29 organization processes (data-driven insights and decision-making) and BDA (Ghasemaghahi
30 & Calic, 2019) and responds to the call for a better understanding of the relationship between
31 BDA and CE (Gupta et al., 2019b). However, our results suggest that an organization's ability
32 to shift data-driven insights to decision-making is based on organizational learning capabilities.

1 Third, we maintain that decision-making can be realized by generating data-driven insights,
2 which are accumulated within an organization through BDA. There is a growing recognition
3 of the importance of BDA capability for effective decision-making; however, scant attention
4 has been focused on how BDA capability shapes firm decision-making (Janssen et al., 2017).
5 There remains a limited understanding in the existing literature on how decision quality can be
6 improved (Janssen et al., 2017). We suggest that firms with better decision-making qualities
7 can transfer and internalize knowledge for the creation of recycling products.

8 Fourth, most previous studies have analyzed the impact of BDA in combination with the
9 dynamic capability perspective on firm performance and innovation performance (Lehrer et
10 al., 2018; Wamba et al., 2017), but comparatively, few empirical studies have examined the
11 influence of BDA capability on decision-making outcomes (Ghasemaghaei, 2019; Shamim et
12 al., 2020). The qualitative study of Gupta et al. (2019) highlights the need to establish the
13 relationship between BDA and CE outcomes. Mikalef et al. (2019) and Zhang and Xiao (2020)
14 show that from the capabilities perspective, firms with strong BDA may enhance innovation.
15 Our results suggest that big data decision-making embedded in data-driven insights is
16 important for enhanced CE performance. These findings provide a deeper understanding of the
17 importance of data-driven insights and their vital role in big data decision-making.

18 Furthermore, the literature suggests that for large-group decision-making, groups should not
19 overrely on experts (Emmerling & Rooder, 2020). This study suggests an important mechanism
20 to reduce dependency on experts for LSDM—that is, with the help of BI&A, BDA, and data-
21 driven insights. Ding et al. (2020) argue that large-scale group decision-making requires the
22 application of artificial intelligence for quality decisions. This study offers a mechanism of
23 incorporating artificial intelligence into the decision-making process through BDA, BI&A, and
24 data-driven insights leading to CE performance.

25 *6.2. Managerial relevance*

26 This research attempts to provide important managerial guidelines to managers and firms on
27 managing data-driven insights for effective decision-making. Our study investigated the impact
28 of BI&A and organizational BDA capability on data-driven insights and big data decision-
29 making and, consequently, on enhancing CE performance. Gupta et al. (2019) highlight the
30 need to establish a relationship between BDA and CE outcomes. There is a growing recognition
31 of the need for BDA in effective decision-making; however, scant attention has been focused
32 on how BDA capability shapes firm decision-making (Janssen et al., 2017). First, managers in

1 the manufacturing industry can develop a set of viable data-driven strategies in order to
2 transform linear production activities into a closed-loop production system; having strong BDA
3 capabilities appears to be critical to making better decisions to use efficient technologies for
4 the reuse and recovery of material from end-of-life products. In contrast, an organization with
5 strong BI&A is required to focus on the effective utilization of data-driven insights for
6 decision-making. Our results suggest that the insights delivered through the application of
7 predictive, perspective, and descriptive analytics illuminate the gaps in CE performance.

8 Second, although previous research has established a positive association between BDA and
9 data-driven culture (Duan, Cao, & Edwards, 2020), there have been few or no previous research
10 attempts to theorize and empirically investigate the link between BI&A and data-driven
11 insights. The findings of this study offer important insights into big data decision-making
12 enhanced through data-driven insights. Our results suggest that top management may follow
13 data-driven-based insights more than simply relying on BDA capabilities. The overreliance on
14 BDA capabilities may lead to less effective decision-making, and this may have strong
15 implications for the firms, as well as for the impact of decision-making on CE performance.
16 One important implication for managers is that decision-making entails an increasing level of
17 dependence on data-driven insights affected by BI&A.

18 Third, data-driven insights have attracted attention from researchers and practitioners in recent
19 years due to the increasing awareness and importance of BDA and business analytics
20 capabilities. Previous research has emphasized the importance of big data to make better and
21 high-quality decisions (Tang & Liao, 2019). However, there have been no research attempts to
22 empirically test if organizational BDA capability enhances data-driven insights and determine
23 what role data-driven insights play in effective big data decision-making. As McAfee et al.
24 (2012) observe, leading organizations can typically accept big-data-driven decision-making.
25 CE performance can be well implemented and sustained with the effective utilization of BI&A.
26 Our results also identify that BI&A helps in aligning CE performance goals through data-driven
27 insights to support decision-making as an organization transitions towards more circularity-
28 oriented business practices. Thus, we inform managers that a digital-enabled CE resides in the
29 firm's ability to effectively utilize data-driven insights to arrive at decisions. Thus, it is
30 important to select the best data-driven insights to design strategies that enable firms to enhance
31 their CE performance. The implications for the top management of firms are that BI&A and
32 data-driven insights may be useful when they have a greater chance of implementing CE
33 performance. Firms that wish to improve their social impact may consider the data-driven

1 insights in analyzing and understanding the different views of the CE implementation–related
2 problems.

3 The literature suggests that for large-group decision-making, groups should not overrely on
4 experts (Emmerling & Rooders, 2020). This study suggests a mechanism to reduce dependency
5 on experts for large-group decision-making—that is, with the help of BI&A, BDA capability,
6 and data-driven insights. Ding et al. (2020) argue that large-scale group decision-making
7 requires the application of artificial intelligence for quality decisions. Although previous
8 studies have highlighted the importance of LSDM using adequate preference representations
9 for the implementation of a data-driven large-group decision-support system (Ding et al.,
10 2020), little or no research has directly examined the influence of big data tools on decision-
11 making quality (Tang & Liao, 2019). We suggest that superior CE performance is more likely
12 when BDA capabilities are aligned and nurtured in a way that fits the nature of the firm’s data-
13 driven insights. Because effective decision-making is complex, firms with greater data-driven
14 insights may expand the base of knowledge, expertise, and resources, and this enhances CE
15 performance.

16

17 **7. Conclusion**

18 This study focused on the impact of BDA capability on CE performance and examined the
19 decision-making quality of manufacturing firms in the Czech Republic, a country where firms
20 are very active in using big data. Our findings highlight the positive influence of BDA and
21 BI&A on data-driven insights and decision-making, which leads to enhanced CE performance.
22 BI&A is a stronger predictor of data-driven insights, and BDA is a stronger predictor of
23 decision-making quality. Our findings on the mediating relationship of data-driven insights
24 show a more direct and indirect relationship between BDA capabilities and decision-making
25 than BI&A. BI&A fully relies on data-driven insights to connect with decision-making quality,
26 and BDA has a direct relationship with decision-making quality. Overall, we conclude that the
27 important and effective use of BDA capabilities in the generation of data-driven insights may
28 shape the relationship between decision-making and CE. In summary, this line of research
29 suggests that CE performance can often be understood from an organizational learning
30 perspective. This study contributes to the extant literature on decision-making as an important
31 source of CE performance. Our findings provide a better understanding of how BI&A
32 applications may enhance data-driven insights focused on big data decision-making for CE

1 performance. The study also lends support to the notion that a firm's CE performance stems
2 from its data-driven insights and decision-making quality.

3 7.1. Limitations and future research

4 This study has a few limitations, which provides important avenues for future research. The
5 first limitation is that the data collection was limited to the Czech Republic, which provides the
6 context of an emerging economy. Value creation through big data in an emerging economy
7 context can be different from that of developed and less developed countries. However, being
8 in a single economic zone, these findings can be generalized for other similar European
9 countries, but future research is needed to enhance the generalizability of the findings in other
10 regions, including Asia, Latin America, and Africa. Another limitation is the cross-sectional
11 design of this study; however, we responded appropriately by reducing the common method
12 bias: the data were collected in two waves, we randomized the items, and we ensured the
13 anonymity of respondents. Future studies may examine the relationship between CE and
14 environmental performance and could use a longitudinal experimental design. Furthermore,
15 future studies may investigate the mediating effect of CE performance in the relationship
16 between BDA capability and environmental and innovation performance.

17 In addition, we suggest that scholars should test data integration management capability as a
18 mediating variable between BDA capabilities and decision-making and investigate how such
19 capabilities enhance CE performance across different types of firms. Such studies could also
20 examine sustainable digital business models and the role of supply chain firms in enhancing
21 end-of-life product performance and sustainability. Lastly, the role of diverse stakeholders is
22 important in a CE; thus, future studies need to pay greater attention to the role of stakeholders
23 in enhancing CE performance.

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