

Big data analytics capability and supply chain performance: the mediating roles of supply chain resilience and innovation

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Abstract

Purpose – Big data analytics (BDA) capabilities can affect supply chain performance in several ways. The main purpose of this study was to understand how BDA capabilities could affect supply chain performance through supply chain resilience and supply chain innovation.

Design/methodology/approach – The study adopted a cross-sectional approach to collect survey-based responses to examine the hypotheses. Accordingly, 187 responses were collected and analyzed using partial least squares (PLS) in the SmartPLS3.

Findings – The results showed that BDA capabilities improve supply chain performance through resilience and innovation of the supply chain.

Originality/value – The present study also contributed to the existing literature by demonstrating the mediating role of supply chain resilience and supply chain innovation between BDA capabilities and supply chain performance. In this context, some theoretical and managerial implications were proposed and discussed.

Keywords Big data analytics capabilities, Dynamic capability view, Resilience, Innovation, Supply chain performance

Paper type Research paper

1. Introduction

Different organizations are under pressure in today's data-driven world to find innovative ways to create and deliver value to customers through supply chain management (SCM). The ability to extract big data for the purpose of gaining useful business insights is now the most important factor in gaining a competitive advantage in today's rapidly changing business environment. Specifically, developing a better understanding of how big data analytics (BDA) can add value to the organizational supply chain is of interest (Singh, N.P. and Singh, S., 2019). Supply chain (SC) executives are also turning to BDA for big data management, processing and analysis. In this context, BDA has traditionally been introduced as a primary motivator for organizational and supply chain performance (Jha *et al.*, 2020). BDA enables organizations to improve the SC performance components of responsiveness, reliability and



customer service (Fernando *et al.*, 2018). In this regard, Wamba *et al.* (2020) concluded that BDA could undoubtedly help improve SC performance. The concept of BDA capabilities extends the concept of big data to include all associated organizational resources (Mikalef *et al.*, 2019), which may result in value creation and a competitive advantage for organizations. In terms of SCM, BDA capabilities allow businesses to investigate alternative options in the face of supply and demand uncertainty (Wang *et al.*, 2016).

Dubey *et al.* (2021) also attempted to guide managers toward a deeper understanding of the complementary assets and competencies required to fully use the data analytics capability in order to improve supply chain resilience and acquire a competitive advantage in their study. The literature on the potential impact of BDA capabilities on performance appears to have grown in recent years. To extract meaningful theoretical and practical consequences, it is critical to understand whether the central artifacts of big data analytics capabilities result in competitive performance advantages and how these effects occur (Mikalef *et al.*, 2020). According to several researchers, the impacts of BDA capabilities on performance are indirect since they are mediated by other organizational capabilities (Mikalef *et al.*, 2020; Côte-Real *et al.*, 2017; Günther *et al.*, 2017). Additionally, others say that investing in this sector does not always pay off, with only a few businesses benefiting from BDA capabilities (Gupta and George, 2016). Therefore more empirical research about how BDA capabilities contribute to SC performance is required (Gupta and George, 2016; Gunasekaran *et al.*, 2017; Fernando *et al.*, 2018; Choi *et al.*, 2018; Mikalef *et al.*, 2020). As a result, the research question posed here was:

RQ. How and through what mechanisms do BDA capabilities contribute to SC performance?

The dynamic capabilities view (DCV) was chosen as a robust theoretical foundation for addressing this research subject. In today's highly turbulent and unpredictable business climate, firm's resources and other organizational capabilities can only be maximized through dynamic capabilities (Teece *et al.*, 1997). Additionally, BDA capabilities have been recognized as dynamic capabilities (Dubey *et al.*, 2019; Singh, N.P. and Singh, S., 2019; Bahrami and Shokouhyar, 2021) that assist firms in navigating their route to success. Dynamic capabilities do not provide sustainable competitive advantages on their own; rather, they facilitate the creation of sustainable competitive advantages through the use of other organizational capabilities (Eisenhardt and Martin, 2000). Besides, BDA can be employed not only to forecast and prevent risks but also to shape innovative possessions, which can consequently deliver strategic benefits and sustainability to supply chains (Maheshwari *et al.*, 2020). The most significant achievement of BDA is the generation of important insights regarding certain developments in the business and market environments (Wamba *et al.*, 2017). Given the growing and unavoidable disruptions of supply chains (Kumar and Anbanandam, 2020), resilience (viz. the ability to withstand disruptions and to recover operational capability after disruptions occur) significantly contributes to the current philosophy of SCM (Sabahi and Parast, 2020). In this context, Dubey *et al.* (2021) noted that through SC resilience, BDA capabilities may provide organizations with a competitive advantage. On the other hand, innovation could be assumed as the most important tool for enterprises to keep their competitive advantages (Lin, 2008). Innovation also crucially contributes to responding to customers' changing demands and needs through product and service prompt changes (Kwak *et al.*, 2018) along with improvements in organizational processes (Lee *et al.*, 2011). Some scholars have further highlighted that BDA capabilities are the "next big things in innovation" and even frontiers for innovation capabilities (Gobble, 2013). SC innovation also improves the SCM's effectiveness regarding the capability of delivering on promises, meeting standards and dealing with problems (Kwak *et al.*, 2018). In this regard, SCM requires BDA capabilities to demand forecasting and to compartmentalize

market segmentation via SC innovation (Acar and Uzunlar, 2014; Fernando *et al.*, 2018). To answer the research question, this study demonstrated the mediating role of SC resilience and SC innovation between BDA capabilities and SC performance.

Thus, the current study's objective is to ascertain how BDA capabilities affect SC performance via SC resilience and SC innovation. According to the DCV, increased SC resilience and innovation were examined, and as a result, increased SC performance was viewed as an empirical indicator of potential advantage resulting from BDA capabilities. To address the research questions, a total number of 187 Iranian companies representing a range of industries were questioned. Accordingly, the results can insightfully guide managers on the ways of enhancement of SC performance.

2. Theoretical background and development of hypotheses

2.1 BDA capabilities as dynamic capabilities

Five 'Vs' distinguishes big data from traditional data. By 'Volume' it means the big data quantities that exponentially increase. 'Velocity' denotes the speed of collecting, processing and analyzing data in real-time. The term 'variety' refers to the range of data kinds collected in big data contexts. 'Veracity' refers to the data sources' reliability. 'Value' refers to the strategic, informational and transactional benefits associated with big data (Akter *et al.*, 2016). Big data has become accessible to virtually all businesses (Jha *et al.*, 2020), but it is difficult or even impossible to analyze and extract valuable insights from this type of data using conventional methods. Thus, while it is critical to understand the 'Vs' of big data, a critical question in contemporary research is how big data generates value (Gupta and George, 2016). Given the explosion in big data's importance in recent years, BDA has taken on a strategic role. BDA is a way to identify key opportunities and to discover and solve business problems. The BDA's critical insights can be invaluable in assisting firms in comprehending the changes occurring in the modern work world. To obtain these essential insights and ensure the success of big data projects, considerations beyond data, tools and analytical approaches must be made. As a result, the notion of BDA capabilities was introduced in order to broaden the scope of big data to encompass all organizational resources (Mikalef *et al.*, 2020). By mobilizing and reorganizing organizational resources, BDA capabilities enable the organization to process, analyze and visualize data, ultimately providing useful insights to enhance decision-making, planning and execution of the organization's missions (Srinivasan and Swink, 2018; Dubey *et al.*, 2019; Mikalef *et al.*, 2020). According to this view of BDA capabilities, they can be viewed as a dynamic capability for the organization, as dynamic capabilities entail finding and shaping opportunities, investing in existing opportunities and sustaining a competitive advantage through promotion and mobilization and reorganize organizational resources (Teece, 2007). It is critical to recognize that, while dynamic capabilities are a necessary condition for obtaining a competitive advantage in today's dynamic and unpredictable circumstances, they are insufficient; success requires additional resources and capabilities developed by dynamic capabilities (Teece *et al.*, 1997; Eisenhardt and Martin, 2000). Thus, insights gained through BDA capabilities alter strategic orientations, business processes and the organizational communication network, thereby assisting other organizational capabilities in strengthening these intermediate capabilities and thereby increasing the organization's value creation (Mikalef *et al.*, 2018; Warner and Wäger, 2019).

2.2 SC resilience

Today's unpredictable situations and settings have exacerbated the issue of supply chain interruption (Christopher and Peck, 2004; Ambulkar *et al.*, 2015). Disruption is defined as any

internal or external threat that disrupts the supply chain's flow of products and services (Jüttner and Maklan, 2011; Craighead *et al.*, 2007). Given the increasing severity and frequency of supply chain interruptions, the issue of resilience has taken on a new prominence in SCM as a critical need (Craighead *et al.*, 2007; Pettit *et al.*, 2013; Sabahi and Parast, 2020). Holling (1973), a pioneer in the field of resilience research, defines resilience as a system's ability to absorb change. According to Brandon-Jones *et al.* (2014) supply chain resilience refers to the supply chain's ability to resume normal operations in a fair amount of time following a disturbance. SC resilience has three main phases as follows: a) anticipation (proactive thinking and planning); b) resistance (maintaining structure and function); c) recovery and response (quick and efficient reactions) (Kamalahmadi and Parast, 2016).

2.3 SC innovation

Supply chain innovation consists of processes and procedures that are improved through technology in the outbound supply chain and changes to products, processes or services that either promote effectiveness or increase ultimate customer satisfaction (Seo *et al.*, 2014). Wong and Ngai (2019) showed that research on SC innovation has mainly used the resource-based view (RBV), because SC innovation is a valuable, inimitable, rare and non-substitutable resource. Therefore, companies that realize SC innovation are usually superior to their competitors. Based on previous studies (Flint *et al.*, 2008; Hazen *et al.*, 2012; Lee *et al.*, 2014; Kwak *et al.*, 2018), the dimensions of SC innovation can be interpreted as process innovation and technology innovation. The aim of technological innovation is strengthening real-time tracking technologies, innovative logistics equipment and integrated information systems throughout the supply chain, which is a key factor in differentiating logistics services (Lin, 2008) and ultimately creating value for end customers (Christopher, 2005). Process innovation refers to re-engineering and re-designing the supply chain with the ultimate goal of improving service quality and reducing costs (Kwak *et al.*, 2018). There are two reasons for the importance of process innovation: first, it results in product innovation (the ability to develop new products and services to meet customer expectations), and second, process innovation is directly related to the level of output produced (Mikalef and Krogstie, 2018).

2.4 SC performance

In the literature, there are two distinct groups of general rationales for the study of SC performance (Sezen, 2008). The first group is concerned with how SC performance is measured. In an influential study, Beamon (1999) used resources (including inventory, cost of using different resources and return on investment), output (including customer satisfaction, sales volume and profit) and flexibility (including new product flexibility, supply flexibility, mix flexibility and volume flexibility) to measure SC performance. Since then, many researchers have used this framework as the basis for their work on measuring SC performance (Chang *et al.*, 2019). Accordingly, SC performance management is central to organizations gaining and maintaining competitive advantage (Ramezankhani *et al.*, 2018). The second group seeks to find ways to improve SC performance (Sezen, 2008). An organization's success depends primarily on its supply chain's performance (Rosenzweig *et al.*, 2003). The present study attempts to investigate how BDA capabilities improve SC performance. For this study's purpose, special focus has been given to end-customer satisfaction in terms of quality and cost (Dwayne Whitten *et al.*, 2012).

2.5 BDA capabilities and SC performance

The big data revolution is in full swing and has had a major impact on SCM. The advent of big data allows for the consideration of complicated factors in designing a supply chain, thus enabling the advancement of a powerful supply chain network (Wang *et al.*, 2018a). Waller and Fawcett (2013) urged scholars to explore the application of Big Data in the supply chain

and emphasized the importance of BDA technology in SCM. Based on their discussion, Big Data is employed in SCM to enhance competencies and provide novel capabilities. [Li et al. \(2018\)](#) showed that demand chain management has a significantly better performance when paired with e-commerce and big data benefits compared to traditional SCM practices. [Wang et al. \(2018b\)](#) conducted an assessment of supply chain analytics' contribution to logistics and SCM by applying big data strategies. [Mishra et al. \(2018\)](#) believe that to improve the SCM efficiency of e-commerce, big data can be used as a robust tool. The information gained through Big Data is capable of maximizing productivity, collaboration, as well as speed, along with visibility while improving interactions with supply chain actors. Integrating BDA into operations and supply chains helps companies better realize their customers, minimize service costs, manage risks efficiently and generate new and unforeseen revenue streams ([Mishra et al., 2018](#)). Because of its significant operational and strategic potentials, BDA can be considered a game-changer that increases corporate efficiency and success ([Wamba et al., 2017](#); [Maheshwari et al., 2020](#)). [Jha et al. \(2020\)](#) explain that big data and BDA are typically viewed as core drivers of supply chain and organizational performance. [Kache and Seuring \(2017\)](#) showed that BDA capabilities could contribute to supply chain visibility and transparency, a better understanding of customer behavior and operational efficiency. [Wamba et al. \(2020\)](#) concluded that BDA could certainly help improve supply chain function and performance. BDA capabilities enhance supply chain efficiency by increasing operational efficiency, reducing costs and increasing profitability ([Fernando et al., 2018](#); [Côte-Real et al., 2020](#)). Given the above, despite the high potential of BDA capabilities to improve firm-level and SC performance and researchers' considerable attention to this issue, it appears that their impact is not well understood and the extent to which BDA capabilities affects SC performance is still unknown, and more empirical evidence is needed in this regard, according to the researchers ([Dubey et al., 2021](#); [Mikalef et al., 2020](#)). Since this study is concerned with the generative mechanism by which BDA capabilities improve SC performance, the first hypothesis is considered for test the direct relationship between BDA capabilities and SC performance.

H1. BDA capabilities have a direct positive effect on SC performance.

2.6 BDA capabilities, SC resilience and SC performance

The concept of resilience is an unavoidable necessity in the supply chain to survive in a highly competitive environment. It also plays an inevitable role in SC performance ([Ramezankhani et al., 2018](#)). Achieving SC resilience requires long-term strategic investment ([Papadopoulos et al., 2017](#)). According to [Dubey et al. \(2019\)](#), visibility and analytical capabilities complement and support one another. To summarize, investing in the development of organizational analytical capabilities results in an improvement in visibility, which results in increased supply chain resilience ([Brandon-Jones et al., 2014](#); [Sabahi and Parast, 2020](#)). Using BDA technology, a novel feature of proactive planning is enabled for risk management infrastructure and enhances the ability for resource reconfiguration in the recovery phase ([Ivanov et al., 2019](#)). BDA capabilities help identify and manage supply chain risks through its tangible resources ([Singh, N.P. and Singh, S., 2019](#)). Human capabilities (from BDA capabilities) can also improve the ability to respond to disruptions ([Mandal, 2018](#)). Additionally, evidence from previous research supports the hypothesis of a positive relationship between BDA capabilities and SC resilience. [Dubey et al. \(2021\)](#) explained how the ability to analyze data improves SC resilience through moderating effects of organizational flexibility. Moreover, [Papadopoulos et al. \(2017\)](#) developed a theoretical framework for supply chain network resilience using BDA. According to [Mandal \(2018\)](#), the key factors enabling supply chain agility include BDA business knowledge, BDA technology management knowledge and BDA relationship knowledge.

Singh, N.P. and Singh, S. (2019) showed that with the adoption of BDA capabilities by organizations, they would be enabled to efficiently leverage resident knowledge and improve SC resilience capability. Mandal (2019) pointed out the BDA management capabilities as important enabling factors of supply chain preparedness, supply chain alertness and supply chain agility. However, he believes that the important role of BDA in the development of SC resilience is not clearly understood. Therefore, we propose:

H2. BDA capabilities positively impact SC resilience.

Supply chain disruptions have a serious impact on any supply chain as they disrupt the flow of information, materials and money and prevent the regular activities of supply chains, resulting in nothing but reduced efficiency and competitiveness (Ramezankhani *et al.*, 2018). In such situations, quick and effective supply chain response to disruptions is critical (Ponomarov and Holcomb, 2009). The negative impact of supply chain disruptions can be prevented through resilience, while it also helps in recovering to a favorable level of performance in a desirable time after the impact of an incident (Wieland and Wallenburg, 2013).

In today's volatile climate, SC resilience is a must (Gölgeci and Kuivalainen, 2020). A number of previous research have found a favorable association between resilience and various dimensions of performance (Hohenstein *et al.*, 2015; Ramezankhani *et al.*, 2018; Liu and Lee, 2018; Gölgeci and Kuivalainen, 2020). Chowdhury and Quaddus (2017) showed that the SC resilience scale potentially predicts supply chain operational vulnerability and SC performance better. Altay *et al.* (2018) believed that SC resilience is a dynamic capability that significantly impacts SC performance. The result of SC resilience is that even in disruptions, business processes are implemented in the shortest possible time, and services are provided that ultimately meet customer needs (Liu and Lee, 2018). Not only is the customer satisfied (Govindan *et al.*, 2015), but profitability does not stand still; this means better customer service and higher financial performance (Wieland and Wallenburg, 2013). Therefore, we propose:

H3. SC resilience positively impacts SC performance.

Recent research indicates that IT in general (DeGroote and Marx, 2013) and BDA capabilities in particular, such as technological advancements, improve company performance through enhancing supply chain agility (Dubey *et al.*, 2019). In this context, Dubey *et al.* (2021) stated that data analytics capabilities enable firms to gain competitive advantage through SC resilience. Bahrami and Shokouhyar (2021) demonstrated that BDA capabilities boost the firm's performance by enhancing SC resilience. Business analytics capabilities assist management in making decisions and improve supply chain visibility and innovation, hence enhancing business performance and reducing environmental variability (Singh, N.P. and Singh, S., 2019). BDA capabilities have a vital role in mitigation of disaster and enables organizations to react to disruptive events (Redman, 2014). BDA enables enterprises to strengthen their resilience skills for risk management in the supply chain (Singh, N.P. and Singh, S., 2019). Therefore, we propose:

H4. SC resilience mediates the link between BDA capabilities and SC performance.

2.7 BDA capabilities, SC innovation and SC performance

BDA capabilities that are able to extract environmental information to identify and exploit new business opportunities can consistently lead to innovation in organizations (Bose, 2009; Chae, 2014; Wang and Dass, 2017; Rialti *et al.*, 2018). Functions enabled by strong BDA capabilities can facilitate the ability to change technology (Mikalef *et al.*, 2020). The importance of BDA resources varies depending on contextual factors, and specific combinations lead to high capabilities in incremental and radical process innovation

(Mikalef and Krogstie, 2018). BDA capabilities enable organizations to gain insights that help them strengthen their dynamic capabilities, with successive positive effects on incremental and radical innovation capabilities (Mikalef *et al.*, 2019). Lozada *et al.* (2019) analyzed the present relationship between BDA capabilities and co-innovation and showed that BDA capabilities directly and positively affect co-innovation. Moreover, BDA has a positive and significant impact on the innovation capabilities of the service supply chain (Fernando *et al.*, 2018). Despite the growing interest in understanding the big data phenomenon and its impact on various business contexts, little experimental research has analyzed BDA potentials in relation to innovation (Mikalef and Krogstie, 2018; Lozada *et al.*, 2019). We therefore propose:

H5. BDA capabilities positively impact SC innovation.

Innovation plays a critical role in responding to the changing demands and needs of customers through timely product and service modifications (Kwak *et al.*, 2018) and organizational process improvement (Lee *et al.*, 2011). Although scattered in the literature due to the multifaceted nature of innovation, previous studies support a positive relationship between SC innovation and various dimensions of SC performance (Lin, 2008; Seo *et al.*, 2014; Lee *et al.*, 2014; Panayides and Lun, 2009; Fernando *et al.*, 2018). Research indicates that the focus of SC innovation is on operational issues and processes, which cover networking, management practices, procurement and distribution (Chapman *et al.*, 2002). The result can be a competitive advantage and sustainable development in services (Isaksson *et al.*, 2010). According to Lii and Kuo (2016), an innovation-based supply chain has positive effects on SC performance. Al-Sa'di *et al.* (2017) investigated business processes and indicated that process innovation results in sustainable organizational competitive advantage. Product innovation leads to more productive work, higher annual sales and better organizational performance (Wadho and Chaudhry, 2018). In general, SC innovation can be said to improve supply chain effectiveness in terms of delivering on promises, meeting standards and solving problems (Kwak *et al.*, 2018). Therefore, we propose:

H6. SC innovation positively impacts SC performance.

Previous studies have widely noted the importance of innovation as one of the remarkable strategic advantages achieved through the use of information systems (Wang *et al.*, 2018b). BDA helps organizations change to gain a competitive advantage (Mikalef and Krogstie, 2018). BDA capabilities can bring about fundamental changes in processes through process reconfiguration and adjustment of operational inefficiencies (Wang *et al.*, 2016); it can also significantly impact technological capabilities. Nowadays, the use of innovative technologies has not only improved operational efficiency and increased mutual benefits as a facilitator of logistics and marketing activities (Bello *et al.*, 2004), but also helps to improve inventory management effectively (Christopher, 2005). BDA capabilities improve the visibility of organizations to understand better the internal and external environment (Chung and Tseng, 2012); so that they could affect the innovation capabilities of supply chain members. Business analytics in enterprise processes provides critical information to organizations and enables them to play a more innovative role in the supply chain (Laursen and Thorlund, 2016). Therefore, we propose:

H7. SC innovation mediates the link between BDA capabilities and SC performance.

3. Research design

3.1 Sample and data collection

Notwithstanding that most research on information technology (IT) has been thus far carried out in developed countries, some studies have successfully included Iranian data into their

overall findings (Ashrafi *et al.*, 2019). The results from a study in the supply chain context of Iranian automotive manufacturers had confirmed that conceptualizing supply-chain business intelligence competencies could be an important enabler for supply chain agility regarding agile capabilities as well as performance (Sangari and Razmi, 2015). In the context of SCM in developing countries, Queiroz and Telles (2018) had further analyzed the BDA conditions at various levels of SCM in several companies in Brazil. Concerning the impact of big data on supply chain management, they stated that finding critical success elements in other growing economies could be beneficial. Motivated by the above-noted evidence and with the assistance of the database received from the Ministry of Industry, a total number of 367 companies were selected. Different industries were selected to obtain the highest insights on the development of BDA capabilities in different contexts (see Figure 1).

The survey approach was used to evaluate the research hypotheses because it enables the correct documenting of norms, identification of extreme information and the delineation of correlations between various variables in a sample (Gable, 1994). Moreover, it facilitated conceptual models' examination according to real-world data (Flynn *et al.*, 1990). Before the principal survey, the reliability and validity of the measures were tested by using a pilot study. For this purpose, all survey questions were precisely translated into Persian. Then, in-depth interviews were conducted with ten senior managers working in SCM, and the opinions of four assistant professors were obtained to ensure content validity and translation accuracy. With reference to the given pre-test, good reliability and validity for the measures were concluded. The inquiry began with definitions and examples of big data, BDA and BDA capabilities, to help respondents comprehend big data in SCM and get more accurate replies. Because survey-based research is always prone to bias, Armstrong and Overton's (1977) recommendations for evaluating non-response bias were followed. The *t*-test found no significant difference between early and late respondents in this investigation. In the instance of this study, the survey was developed with a single respondent in mind. The targeted respondents were senior managers holding relevant academic degrees and having practical backgrounds in business analytics. They were typically holding positions such as supply chain manager, marketing and purchasing director, as they possessed fundamental experiences regarding SCM, as well as operations managers who were knowledgeable about information systems, risk management programs and effects of innovation on supply chain processes. Moreover, IT managers were recruited since they had more BDA knowledge regarding supply chain processes and performance outcomes (Queiroz and Telles, 2018).

Taking into consideration the aforementioned cases and contacting the human resources management in each company, the suitable respondents were identified and the necessary data was collected within three weeks via an email questionnaire. One week after the first

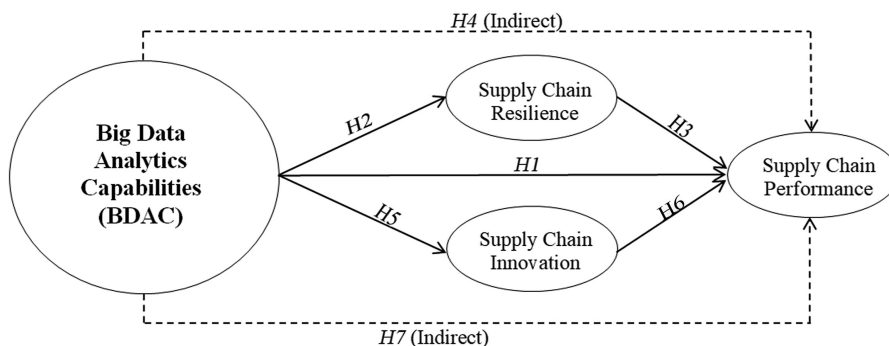


Figure 1.
Research model

round, reminder emails were sent, and the second round was sent in the third week. Finally, a total of 202 questionnaires were collected. After eliminating a number of partial received responses, a total of 187 useable responses were recovered, indicating a response rate of 38.96% (see Table 1).

3.2 Measurement items

The survey instrument scales were taken from prior scientific research to make sure that they had the required face and content validity. The entire survey contained 31 items. BDA capabilities were measured on the 10-item scale adapted from Côte-Real et al. (2020). SC performance was also measured via an 11-item scale adapted from Gunasekaran et al. (2017). Of note, such items had been developed by Dwayne Whitten et al. (2012) to examine SC performance in a comprehensive study. The SC resilience was also assessed based on 4-items developed by Dubey et al. (2021), who examined the effect of BDA capabilities on SC resilience and competitive advantage in firms. The items were originally developed by Brandon-Jones et al. (2014) following an analysis of the speed with which businesses respond to disruptions and recover from them. For supply chain innovation, The Kwak et al., 2018 scales (6 items) were applied, which were used in a study on the relationship between risk management capabilities, supply chain innovation and competitive advantage in global supply chains. All constructs were considered reflectively. The whole scales were provided in a 7-point Likert-type format (from strongly disagree to agree strongly) (see Table A1).

4. Data analysis and results

We used Smart PLS 3.0 in order to test the research models. This software uses partial least squares structural equation modeling (PLS-SEM). PLS may analyze complex models with

Table 1.
Respondent
characteristics

Respondents (N = 187)	Frequency (%)
<i>Job title type</i>	
Supply chain manager	45.5
Marketing manager	14.2
Operations manager	7.1
IT manager	33.2
<i>Industry type</i>	
Oil & Gas	11.4
Automotive	13.2
Textiles	4.1
Pharmaceuticals	5.9
Manufacturing	13.4
Electrical equipment	8.2
Transport services	10.6
ICT	11.1
Electrical equipment	8.9
Construction	7.4
Other	5.8
<i>Number of employees</i>	
0–50	22.0
51–100	17.1
101–500	16.4
501–1,000	19.3
1,001–10,000	25.2

fewer sample sizes and assess exogenous variables' predictive potential (Peng and Lai, 2012; Dijkstra and Henseler, 2015). Variance-based PLS-SEM can manage both measurement and structural models (Hair *et al.*, 2013). According to Hair *et al.* (2011) proposed model, an adequate sample size is "ten times the largest number of formative indicators used for measuring one construct" and "ten times the largest number of structural paths directed at a specific latent construct in the structural model." Thus, 187 replies appear to be a sufficient sample size based on the proposed model.

4.1 Measurement model

The measurement model quality was also assessed using the analysis of reliability and validity. The construct and item levels of reliability were assessed, with composite reliability (CR) and Cronbach's alpha (CA) values calculated at the construct level. To maintain construct internal consistency, CA and CR indices have to be between 0.7 and 0.9 (Hair *et al.*, 2016). Such values were above 0.7 in this study. So the measuring model showed strong internal consistency. Except for SCP5 and SCI3, all measurement item loadings surpassed 0.7, proving the indicators' reliability. The SCP5 and SCI3 were not excluded because the obtained CR and convergent validity were above their minimum value (Hair *et al.*, 2016) (see Table 2).

Validity was then determined using convergent and discriminant validity tests (Hair *et al.*, 2014). For convergent validity, all values for average variance extracted (AVE) were over the threshold of 0.5, meaning each construct explained more than 50% of the variation of its indicators (Hair *et al.*, 2016). Discriminant validity refers to the ability to measure several constructs independently. Three tests were done on discriminant validity. To begin, each construct's AVE square root was checked against its highest association with other constructs (Fornell and Larcker, 1981). Then, in the manner described by Farrell (2010), each indicator's outer loading was examined to determine if it was greater than its cross-loadings with other constructs. Finally, the heterotrait-monotrait (HTMT) ratio of the correlations was calculated according to Henseler *et al.* (2015). The HTMT has to be less than one (preferably <0.85) to clearly distinguish two components (Henseler *et al.*, 2016). The values obtained in this study (less than 0.85) accordingly indicated enough discriminant validity and the results generally confirmed it (see Tables 2 and 3).

4.2 Common method bias (CMB)

The relationship between independent and dependent variables can be influenced by CMB due to relying on only one respondent (Podsakoff and Organ, 1986). CMB can be derived from societal desirability or the consistency concept (Podsakoff *et al.*, 2003). Therefore, our model incorporates a number of methods for reducing the likelihood of negative outcomes. The Harman one-factor test was used to respond to Podsakoff and Organ (1986). The complete variance was explained by the first extracted factor, which accounted for around 27.37% (<50%) of the variance, demonstrating that CMB is not a concern. Our model was found to be free of CMB after performing a complete collinearity test, which revealed a value of less than 3.3 for each VIF (Kock, 2015). CMB, based on these findings, does not appear to be a substantial concern.

4.3 Structural model

Following Hair *et al.* (2019), after the collinearity test established that there was no collinearity in our study, we used the R^2 value to estimate the effect of exogenous constructs. The variance is measured by the R^2 that is described in each of the endogenous constructs. So it measures the model's explanatory power (Hair *et al.*, 2019). Significant, moderate or weak

Constructs	ID	Factor loading	Mean	SD	CA	CR	AVE
BDA capabilities	BDAC1	0.78***	5.10	1.07	0.736	0.845	0.647
	BDAC2	0.81***					
	BDAC3	0.73***					
	BDAC4	0.79***					
	BDAC5	0.84***					
	BDAC6	0.81***					
	BDAC7	0.89***					
	BDAC8	0.86***					
	BDAC9	0.79***					
	BDAC10	0.94***					
SC resilience	SCR1	0.73***	4.15	0.94	0.858	0.778	0.603
	SCR2	0.78***					
	SCR3	0.80***					
	SCR4	0.77***					
SC innovation	SCI1	0.73***	3.66	0.73	0.836	0.880	0.552
	SCI2	0.79***					
	SCI3	0.62***					
	SCI4	0.71***					
	SCI5	0.82***					
	SCI6	0.76***					
	SCP1	0.75***					
SC performance	SCP2	0.83***	4.86	1.01	0.887	0.913	0.601
	SCP3	0.77***					
	SCP4	0.76***					
	SCP5	0.66***					
	SCP6	0.71***					
	SCP7	0.82***					
	SCP8	0.75***					
	SCP9	0.79***					
	SCP10	0.81***					
	SCP11	0.74***					

Table 2.
Descriptive and
psychometric table of
measurements

Note(s): BDA= Big Data Analytics; SC= Supply Chain; SD=Standard Deviation; CA= Cronbach Alpha; CR= Composite Reliability; AVE = Average Variance Extracted, *** $p < 0.001$

Table 3.
Inter-correlations of the
first-order latent
constructs

	(1)	(2)	(3)	(4)
(1) BDA capabilities	0.87			
(2) SC resilience	0.59	0.83		
(3) SC innovation	0.43	0.38	0.79	
(4) SC performance	0.58	0.33	0.46	0.81

endogenous latent variable R^2 values are 0.75, 0.50 or 0.25 (Henseler *et al.*, 2012; Hair *et al.*, 2011). Table 4 shows appropriate R^2 values for all dependent variables in the structural model. The R^2 score for the SC performance was 0.51, demonstrating good support for the research model. Following that, the Stone–Geisser Q^2 value estimate procedure is used to determine the predictive relevance of the inner model (Hair *et al.*, 2016). As shown in Table 4, Q^2 for all dependent variables is greater than zero, indicating appropriate predictive relevance (Hair *et al.*, 2016). Then, the Cohen (1988) f^2 formula was used to determine the f^2 value of the BDA capabilities, which was found to be more than the cut-off value of 0.0. To assess model fitness, we evaluated The Goodness-of-Fit (GoF by using PLS-SEM

(Henseler *et al.*, 2016). The model's overall GoF was 0.50, as determined using the following equation (Alolah *et al.*, 2014): $GoF = \sqrt{AVE \times R^2}$. Table 4 also gives the overall model fit (GoF) values for each dependent variable.

4.4 Hypotheses testing

We used bootstrapping with 5,000 samples to determine the relevance of path coefficients. Based on the obtained statistical results, except for the H1 (BDA capabilities → SC performance) hypothesis, H2 (BDA capabilities → SC resilience), H3 (SC resilience → SC performance), H5 (BDA capabilities → SC innovation) and H6 (SC innovation → SC performance) hypotheses were supported. Path coefficients were showed in Figure 2.

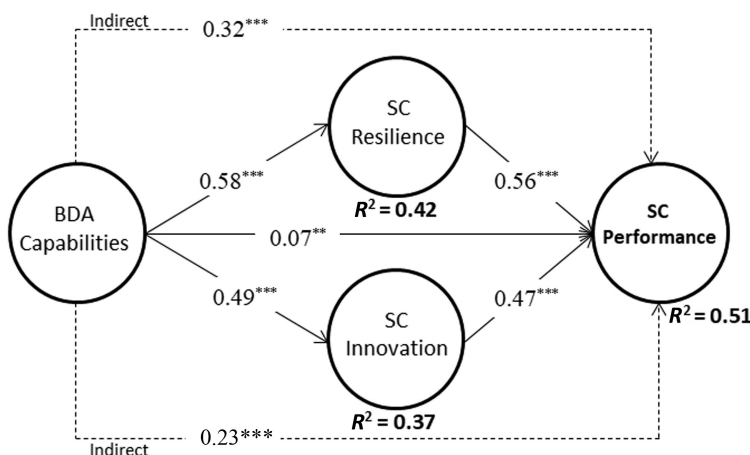
4.5 Mediation test

We utilized the PLS-SEM mediation test to assess the magnitude of mediating effects of supply chain resilience and supply chain innovation on the connection between BDAC and supply chain performance (Hair *et al.*, 2016; Preacher and Hayes, 2008). This study used PLS-SEM for the mediation test, which has more statistical power than earlier testing methodologies, such as the parametric Sobel (1982) test (Matthews *et al.*, 2018). We began by assessing the relevance of indirect impacts, followed by the direct influence of BDA capabilities on SC performance. Table 5 summarizes the findings of the mediation test using a

No.	Path	Path coefficient	Supported	R^2	Q^2	GoF
H1	BDA capabilities → SC performance	0.07**	NO			
H3	SC resilience → SC performance	0.56***	YES	0.51	0.37	0.55
H6	SC innovation → SC performance	0.47***	YES			
H2	BDA capabilities → SC resilience	0.58***	YES	0.42	0.28	0.48
H5	BDA capabilities → SC innovation	0.49***	YES	0.37	0.25	0.47

Note(s): *** $p < 0.001$; ** $p < 0.01$

Table 4.
Summary of the PLS results



Note(s): **Significant at $P < 0.01$
***Significant at $P < 0.001$

Figure 2.
Structural model results

bootstrapping approach in SmartPLS3 (Matthews *et al.*, 2018). The indirect effect's significance, as demonstrated in Table 5, qualifies for mediation analysis. Additionally, we estimated variance accounted for ($VAF = \text{indirect effect} / \text{direct effect} + \text{indirect effect}$) to ascertain the strength of the SC resilience and SC innovation mediating effects. As mentioned by Hair *et al.* (2013), partial mediation is shown when (VAF) surpasses the 0.2 threshold level, and when it exceeds 0.8, full mediation is offered. The findings indicate that SC resilience entirely mediates the association between BDA capabilities and SC performance, while SC innovations partially mediate the relationship. This prompted us to accept hypotheses H4 and H7.

5. Discussion

The purpose of this study was to determine how BDA capabilities could impact SC performance via SC resilience and innovation. To achieve this goal, the concept of BDA capabilities was introduced as a vital capacity that companies should cultivate to reach optimal performance results in the big data age. Statistical results also showed that almost all dimensions (viz. management, infrastructure and personnel expertise capabilities) were equally important in building BDA capabilities. Although no direct association was established between BDA capabilities and SC performance, the empirical findings indicated that BDA capabilities could contribute to SC performance improvement by boosting SC resilience and innovation. In addition, SC resilience as a full mediator and SC innovation as a significant partial mediator seemed to strengthen the association between BDA capabilities and SC performance. The results associated with the effects of BDA capabilities, SC resilience and SC innovation correspondingly showed an agreement with previous literature and provided new insights into the contribution of all the dimensions to SC performance enhancement.

5.1 Implications for research

This study tried to answer how BDAC increases supply chain performance by acknowledging BDAC's favorable impact on several aspects of corporate and supply chain performance in previous research. In addition to boosting supply chain resilience and innovation, BDAC as a dynamic capability based on DCV, has been found to assist improve overall performance. This is one of the first studies to examine the role of SC resilience and innovation in mediating the relationship between BDA capabilities and SC performance. By providing insights and strategic orientations, the results contribute to the literature on improving supply chain performance.

5.2 Implications for practice

We can safely say that BDAC is improving supply chain performance (Wamba *et al.*, 2020), but its operation is opaque, and it may impact supply chain performance in multiple ways.

No.	Mediated path	Support	Indirect effect	VAF	Conclusion
H4	BDA capabilities → SC resilience→ SC performance	YES	0.32***	0.82	Full mediation
H7	BDA capabilities → SC innovation→ SC performance	YES	0.23***	0.76	Partial mediation
Note(s). *** $p < 0.001$					

Table 5.
Mediation analysis

This study's findings demonstrated that BDA capabilities indirectly improve supply chain performance. Accordingly, this study looked at big data from a managerial viewpoint, concentrating on organizational capabilities, rather than a technical or engineering one. The findings indicated that SC resilience and innovation could act as a mediator between BDA capabilities and SC performance, which could serve as a valuable framework for corporate investment allocation. These findings also corroborated the widespread belief that IT may enable businesses to produce value through intermediary organizational capabilities (Benítez *et al.*, 2018). Like the findings of this study, Wamba *et al.* (2017) argue that BDA capabilities can provide a competitive advantage in uncertain circumstances. The use of big data analytics to sustain and increase performance through enhancing supply chain resilience and innovation might be the key to success in unexpected environments and supply chain disruption circumstances.

Organizations aimed to increase supply chain visibility can accordingly invest in the adoption and development of BDA capabilities. Given that, the understanding of environmental changes as well as those in supply and demand has augmented in organizations, which has ultimately led to positive performance effects (Srinivasan and Swink, 2018; Dubey *et al.*, 2019). BDA also allows companies to use not only data from downstream and upstream elements of their supply chain but also information from social media and distributed sensors to understand changes in the environment and markets.

The study results accordingly confirmed the positive relationship between BDA capabilities and SC resilience, and that between SC resilience and SC performance, which was in consonance with prior research arguing that SC resilience could play a key role in the success and effectiveness of BDA projects (Dubey *et al.*, 2021; Singh, N.P. and Singh, S., 2019; Mandal, 2019). These results emphasize the vital role of SC resilience against supply chain disruptions in maintaining its high performance (Christopher and Peck, 2004). Given the functional effects of SC resilience, managers have to figure out its critical role, as a prerequisite for success in unpredictable environments (Gölgeci and Kuivalainen, 2020). Investing in vertical information systems can increase information-processing capacity (Gupta and George, 2016). In this regard, investing in BDA capabilities can be an effective method that improves SC performance in organizations by escalating coordination between the supply chain members. Organizations that make good use of the quality of information obtained from BDA-based systems can also provide alternative procedures, options and pathways for managing unavoidable supply chain disruptions. These conditions can help organizations continue to provide services, the result of which is customer satisfaction and continued profitability. According to Singh, N.P. and Singh, S. (2019), the study findings also showed that today's organizations cannot only utilize organizational memory to manage the risk of supply chain disruptions, and it is necessary to enter the world of BDA to achieve this goal.

Similarly, BDA capabilities improve SC performance through SC innovation, which was in coherence with prior studies reflecting on the key role of SC innovation in the success and effectiveness of BDA projects (Tan *et al.*, 2015; Fernando *et al.*, 2018; Mikalef *et al.*, 2019; Lozada *et al.*, 2019). The study results also provided empirical evidence for managers with regard to the importance of SC innovation in supporting business value. Managers should thus consider big data as a potential for new knowledge and data analysis as a practical way to attain this new knowledge, which helps managers become aware of decision-making processes and has good potential for innovation in new products and services, marketing methods and new business models. Innovation in products or services also allows companies to quickly adapt to changing market conditions and keep pace with competitors (Corte-Real *et al.*, 2017).

BDA system reports provide managers with insights that enable them to better comprehend market and industry changes, make more informed and timely decisions during

times of disruption, and respond more effectively. Additionally, the study's findings support the notion that when managers employ innovative technologies to enhance supply chain capabilities, their businesses are likely to acquire a competitive advantage (Akter *et al.*, 2016; Srinivasan and Swink, 2018; Dubey *et al.*, 2019). Notably, retaining a competitive advantage requires continued client service, which leads in enhanced customer happiness and revenue.

BDA capabilities require significant resource and effort inputs. Given that many organizations are only now implementing BDA, it is vital to broaden relevant knowledge and expertise prior to making a successful investment in this area. Furthermore, the findings of the study can be incorporated into a strategic roadmap for managers who are still uncertain or cautious about investing in BDA capabilities. They can effectively manage information assets within firms by implementing this strategic approach (Grover *et al.*, 2018).

In today's data-driven world and markets, investing in big data technology to increase resilience and innovation may be a prudent choice. In this regard, Rogers (2016) reaffirmed that "digital transformation is fundamentally about strategy, not technology." Therefore, managers must regard BDA capabilities as a source of strategic advantage. The current study emphasized managers' critical role in developing various strategies and methods for delivering the expected benefits of BDA capabilities in businesses. Barratt and Oke (2007) argued that competitive advantage was determined by how technology was employed, rather than by the technology itself. So even when BDA capabilities are present, the required economic value may not be realized directly in companies. Finally, while implementing and developing BDA capabilities is a necessary condition for business success, it is insufficient. Managers must first consider all of BDA's dimensions, including management, infrastructure and personnel expertise capabilities (Wamba *et al.*, 2017; Akter *et al.*, 2016), and then manage and steer these capabilities effectively (Mikalef *et al.*, 2020; Côte-Real *et al.*, 2017; Günther *et al.*, 2017).

5.3 Limitations and future directions

Like prior research, this study had several limitations, probably affecting the results. First, this study was conducted in Iran and the generalizability of the results to other countries in the world needed to be done slightly with care due to the specific conditions of this country. Therefore, future studies are suggested to examine the model through the data collected from different nations. Second, given the study's cross-sectional character, future researchers are encouraged to focus on longitudinal datasets (i.e. investigating the same subject matter over time) in order to assess the study's findings' credibility. Additionally, the fact that data were acquired by a single respondent from each organization raises the possibility of CMB. To lessen this risk, more research is needed to involve more participants as well as more than one respondent from each organization. Thirdly, future research should consider additional sociocultural antecedents, such as management style and environmental uncertainty, as well as moderating variables such as information quality. Finally, the DCV perspectives were merely employed in this study. Other theories, on the other hand, may be used in future research to support the model and its outcomes.

6. Conclusion

In this study, the impact of BDA capabilities on SC performance was examined. Despite increased interest in understanding the phenomenon of big data and emphasizing the positive effect of BDA-derived insights on performance, there is still no proper understanding of how BDA capabilities contribute to improving SC performance. Therefore, this study attempted to answer the question as to how and in what ways BDA capabilities develop SC performance. To address this question, a conceptual model was proposed based on the DCV and the evidence in the relevant literature to explore the impact of BDA capabilities on SC

performance by examining SC resilience and SC innovation. Overall, the findings demonstrated that BDA capabilities had a significant positive effect on SC resilience, SC innovation and SC performance, with SC resilience and SC innovation identified as the significant mediators. The main findings of this study are presented in detail as follows:

First, BDA capability can be a strategic investment in improving SC performance.

Second, companies should invest in SC resilience and SC innovation development supported by BDA capabilities, since they are strong mediators between BDA capabilities and SC performance.

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Table A1.
Construct and
survey items

Big data analytics capabilities	To what extent has your organization implemented Big Data Analytics in each area? (1 = little or no usage . . . 7 = heavy usage)
	• Sourcing analysis
	• Purchasing analytics
	• CRM or customer analysis
	• Network design/optimization
	• Warehouse operations improvements
	• Process/equipment monitoring
	• Production run optimization
	• Logistics improvements
	• Forecasting/demand management – S&OP
Supply chain resilience	• Inventory optimization
	• Our organization can easily restore material flow
	• Our organization would not take long to recover normal operating performance
	• The supply chain would quickly recover to its original state
Supply chain innovation	• Our organization can quickly deal with disruptions
	• A cutting-edge system that can integrate information
	• Technology for the real-time tracking
	• Innovative vehicles, packages or other physical assets
	• Continuous innovation in core global supply chain processes
	• Agile and responsive processes against changes
	• Creative methods and/or service
	• This organization has full visibility of our supply chain
Supply chain performance	• This organization appropriately manages supply chain risk
	• This organization's primary supply chain has the ability to minimize total product cost to final customers
	• This organization's primary supply chain has the ability to deliver product precisely on-time
	• This organization's primary supply chain has the ability to deliver zero-defect products to final customers
	• This organization's primary supply chain has the ability to minimize all types of waste throughout the supply chain
	• This organization's primary supply chain has the ability to deliver right-sized lot sizes and shipping case sizes to final customers
	• This organization's primary supply chain has the ability to eliminate late, damaged and incomplete orders to final customers
	• This organization has the ability to minimize channel safety stock throughout the supply chain
	• This organization's primary supply chain has the ability to deliver value-added services to final customers
	• This organizations supply chain has the ability to respond faster than competitors to changing environments