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The effects of the blockchain technology and big data analytics on supply chain performance: The mediating effect supply chain risk management

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A B S T R A C T

The purpose of this paper is to investigate potential links between Blockchain technology (BCT) and big data analytics (BDA) with supply chain risk management (SCRM) and supply chain performance (SCP) in the Jordanian Chemical and Cosmetic Industries Sector. Additionally, the paper tests a conceptual model that links SCRM to indirect effects. To test our proposition, data were collected from 364 employees working in Jordanian Chemical and Cosmetic Industries Sector. The data were analyzed using structural equation modeling with aid of the Lavaan R package. The results show that the influences of blockchain technology and big data analytics on supply chain performance do occur directly, and indirectly through the cascading of a supply chain risk management.

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1. Introduction

A significant increase in global e-commerce has occurred as a result of globalization and technological advancement (Duong & Ha, 2021). As a result, traditional supply chains fail to lay the foundation for digital transformation (Durst et al., 2019). A number of current studies have highlighted the difficulty supply chain managers are having in coming up with the digital tools needed to transform their supply chains (de Assis Santos & Marques,2022; Can Saglam et al., 2021; Chiarini et al., 2020). Management of risks is imperative in the modern supply chain because it is complex, unpredictable, and characterized by inherent uncertainty (Ahlqvist et al., 2023). During the past few years, a series of disasters and crises have severely disrupted global supply chains. The onset of the Coronavirus pandemic (COVID-19) illustrates the unstable and unpredictable nature of the global environment (Bechtsis et al., 202). The control and mitigation of risks in global business have been the subject of numerous studies by both academics and practitioners (El Baz & Ruel, 2021; Birkel & Hartmann,2019; Bagal et al., 2018). Furthermore, realizing the expected challenges will be crucial, such as how supply chains will operate post-pandemic, how activities will be carried out within or between countries, and preparations for similar crises in the future (Waqas et al., 2022). Since manufacturing units have been shut down for the last several months and COVID-19 restrictions are continuing across the globe, supply chain managers are looking for virtual solutions (de Assis Santos & Marques, 2022).

With supply chains becoming increasingly risky, businesses have shifted their attention to risk management, as failure to do so can be fatal (Ahlqvist et al., 2022). A supply chain risk management (SCRM, henceforth) provides a set of relevant solutions

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to overcoming supply chain disruptions efficiently and effectively to mitigate the risks of end-to-end supply chains (Bagal et al., 2018). Many giants, including Amazon, Dell, and Benetton, have faced supply chain risks and implemented various supply chain risk management tools (Bandaly et al., 2018). In response to the failure of traditional risk management approaches, companies implement innovative approaches and integrate digital technologies like blockchain and big data analytics into SCRM as a way of adapting to digital transformation and mitigating modern supply chain disruptions in a dynamic business environment (Rauniyar et al., 2022). In supply chain management, digital transformation has eliminated traditional barriers that can stymie innovation, making it easier to manage logistics and supply chains efficiently (El Baz & Ruel, 2021).

The term digital transformation is used to describe the integration of disruptive digital technologies, blockchains, AI, IoT, cloud computing, BDA, and using augmented reality (AR) to update business models, business practices, and service delivery (Rauniyar et al., 2022; Roy et al., 2020). By leveraging digital technologies, an organization can easily diagnose and deal with disruptions and identify opportunities more quickly (Singh & Singh, 2019). With digital transformation integrated into supply chains, risks are mitigated, costs are optimized, and the company can grow. SCRM has become incredibly complex due to supply chains (Yildiz Çankaya et al., 2022). There are many aspects to consider (Waqas et al., 2022), in addition to diversifying product portfolios, outsourcing and lean management, as well as the fact that supply chains are increasingly serving multiple geographies (Zouari et al.,2020; Yu et al.,2018). Digital transformation is thereby essential for modernizing and automating manufacturing operations in supply chains to ensure effective SCRM.

Digital transformation technologies, particularly blockchains (BCT) and big data analytics (BDA), provide many opportunities to grow businesses (Al-Khatib & Ahmed, 2022), and these applications provide accurate standards, which can be implemented through improved monitoring and control processes to increase the ability of firms to improve their performance, which in turn reduces supply chain risks (Anusha et al., 2022). BCT enables the use of information technology to work peer-to-peer to reduce risks associated with third-party interventions, including hacking, compromised privacy, financial institution instability, and conflicts within supply chain partners (Philsoophian et al., 2022). As a result, blockchains are potentially useful tools for SCRM because of their inherent attributes (Ivanov & Dolgui, 2021; Cole et al.,2019;). Considering its inherent capabilities, BCT has been hailed as a cutting-edge technology that promises to transform modern supply chains by ensuring the supply chain is safe, transparent, efficient, and trustworthy (Casado-Vara et al., 2018).

The BDA application is widely used in supply chain management as one of the most promising applications (AL-Khatib, 2022a) which allow the collection, processing, transmission, and storage of large amounts of information (Bag et al., 2021a) for knowledge creation or generation (Bag et al., 2021b) and to access information rarely available to traditional methods of data analysis (Anusha et al., 2022). With the help of BDA, supply chains can perform better by providing information and new insights into the choice of suppliers. (AL-Khatib, 2022b), an optimum distribution network (Al-Khatib & Ahmed, 2022) and a better supply chain innovation level (Choi et al., 2017). Therefore, BDA is a logical and relevant method for SCRM.

BCT and BDA are examples of digital technologies in Industry 4.0. There has been a qualitative leap in the use of digital technologies in the Jordanian Chemical and Cosmetic Industries Sector over the past few years (Al-Khatib, 2022;). Despite this, its supply chains were exposed to several risks during the Corona pandemic since they were dependent on foreign raw materials. To enhance performance activities and access new market information, managers in this sector are utilizing big data and blockchain technology (Bag et al., 2021a; Cole et al., 2021). Despite this, only a few empirical studies have been conducted on the Jordanian Chemical and Cosmetic Industries Sector (Al-Khatib, 2023).

As a result of this study, a contribution to the literature about SCRM is made in the following areas. Several studies in developed countries have examined the relationship between these aspects (Anusha et al., 2022; Bechtsis et al., 2022). However, the Chemical and Cosmetic Industries Sector in emerging countries such as Jordan, are unique in comparison to developed contexts. When reviewing previous literature (Yildiz Çankaya et al., 2022; Singh & Singh, 2019; Schmidt & Wagner, 2019), it was noted that the blockchain technology and BDA can assist in SCRM and improving firms' performance in supply chins. Industry 4.0 applications are rarely integrated into SCRM, particularly blockchain technology and BDA. Thus, the purpose of this work is to fill a research gap in the integration of BDA and blockchain technology to enhance SCRM, for lead and promote performance in the supply chain.

In addition, the findings of this study will be of value to a variety of stakeholders such as managers of Jordanian Chemical and Cosmetic Industries Sector policymakers and investors Therefore, to reach this goal, the empirical study was designed to answer the following questions:

RQ1. Is blockchain technology and BDA impacting supply chain performance?

RQ2. Has SCRM played a mediating role in the effects of blockchain technology and BDA on supply chain performance?

Throughout the rest of this paper, we will follow the following structure. The literature review is presented in section 2. Section 3 describes the research design, followed by Sections 4 and 5 which describe the results and discuss them. Conclusions and research opportunities are discussed in Section 6.

2. Literature review and hypothesis development

2.1 Blockchain technology, Big data analytical, and supply chain risk management

In his essay entitled "The Theory of Growth of the Firm". Penrose (1995) developed the resource-based view theory (RBV), which says that firms are endowed with resources, some of which lead to competitive advantage, others help to sustain the firm in the long run (Mai et al., 2022). Based on two assumptions, Barney (1991) claims that RBV theory promotes superior performance in a firm by exploiting heterogeneity and immobility of resources. There are tangible resources (e.g., buildings and equipment) in the organization as well as intangibles, such as the competencies of the business owners and managers (Mai et al., 2022). As Al-Khatib(2023) explains, Resource Based View (RBV) has emerged as a key lens for understanding efficient resource use in the digital age. Through RBV, organizations can enhance their competitive advantages by managing knowledge, data, and information effectively (Fan & Stevenson, 2018). This view implies that RBV contributes to organizational success and superiority by leveraging organizational resources (Chiarini et al., 2020). A firm's intangible and tangible resources and assets need to be organized and coordinated to achieve sustainable and long-term competitive advantage (Al-Khatib, 2023).

The implication of the RBV theory for the Chemical and Cosmetic Industries Sector is that, for these firms to enhance business performance and competitive advantage, there is a need to strengthen their competencies and resources. As a result, this study considers Industry 4.0 applications in the supply chain such as blockchain technology, and BDA as internal intangible resources that facilitate food firms to have a sustained business performance and reduce risk management in the supply chain.

Since the pandemic began, academia and practice have become increasingly interested in SCRM (Ahlqvist et al., 2022), In both the short- and long-term, supply chain risks can significantly impact firms' financial, operational, and market success (Yildiz Çankaya et al., 2022). As a result of SCRM, supply chains can improve performance (Prakash et al., 2017) as well as enhancing sustainability (Singh and Singh,2019). Supply chain risk management is the process of identifying, evaluating, and managing supply chain risks (Ahlqvist et al., 2022) SCRM is defined as "identifying potential risks and implementing appropriate strategies to reduce supply chain vulnerabilities by coordinating the efforts of all supply chain members" (Kilubi & Rogers, 2018, Can Saglam et al., 2022). Through collaboration between supply chain members, any SCRM approach should aim to understand, identify, and reduce risks in the supply chain holistically (Duong & Quang, 2021). SCRM is designed to ensure the continuity of business and reduce vulnerability (Fan and Stevenson,2018). If a firm manages risks better than its competitors, its market position can improve. Therefore, improving SCRM not only reduces costs and risks, but also helps to ensure longer-term profitability, continuity, and future growth (Fan & Stevenson, 2018).

To implement SCRM efficiently and effectively, advanced technological requirements are required to acquire and evaluate supply chain information, based on Industry 4.0 applications, such as blockchain technology and BDA (Al-Khatib,2023).

Professionals have noted that BCT is a prominent technology in the era of the digital revolution (Giri & Manohar, 2023), There has been a great deal of literature describing how BCT plays a unique role in supply chain digital transformation in recent years (Giri & Manohar, 2023; Philsoophian et al., 2022; Rogerson & Parry, 2020). BCTs are groups of blocks that can store high-performance encrypted digital data (Saberi et al., 2019). In BCT, records are arranged chronologically (chain of blocks) and all of the network data is stored (Bhandal et al., 2022). The transaction data of each record is also encrypted and includes a timestamp (Akhavan et al., 2018). Users can extend blockchain data through sequential transactions by making public the data. The chain can be checked or copied by any user, but manipulation is difficult if not impossible computationally. (Spieske & Birkel, 2021). Blockchain nodes will ensure data validity and security. Blockchains aim to create a trustworthy environment for businesses (Rogersonand & Parry, 2020). Since this data cannot be accessed by unauthorized individuals, blockchain technology plays a crucial role in improving the supply chain's performance (Rogerson and Parry, 2020). Blockchains offer numerous unique features, including immutability, interoperability, auditability, and decentralized ledgers, making them an ideal technology for managing supply chain risks in the fourth industrial revolution (Dolgui et al., 2020). The management of supply chains has been plagued by many risks, in large SC systems, due to the difficulty of gaining a complete picture of transactions and activities. System entities are only allowed access to specific data and information, which are stored in various places (Gaur et al., 2020). Academics and practitioners are interested in BCT due to its distributed, decentralized nature as a potential solution to these issues (Jang et al., 2023). The decentralized and distributed blocks of information create a reliable and secure platform for recording everyone's transactions. Using blockchain technology, manufacturers and suppliers can detect product failures and unreliable service (Rogerson & Parry, 2020; Dolgui et al.,2020). By implementing BCT, information can be made secure and authentic, reducing the costs of preventing intentional and capricious changes (Spieske & Birkel, 2021).

Rauniyar et al. (2022), described how BCT records transactions and timestamps permanently, making it impossible for attackers to reverse the entire blockchain history, thereby, protecting supply chain information security from asymmetric sharing of information (Dolgui et al., 2020). A key feature of blockchain technology is its ability to track and trace registered information transparently by enabling transparency, validation, automation, and tokenization, thus preventing fraud or manipulation (Casado-Vara et al., 2018). By recording supply chain data in a blockchain, relevant supply chain participants are held accountable and disclosure issues are resolved, thereby reducing conflict and increasing trust (Baryannis et al., 2019). As a result of BCT, visibility in the supply chain can be improved, and forgery protection is assured, which makes it useful for supply chain risk management (Bandaly et al., 2012). Therefore, we suggest the following hypothesis:

H_1: *The BCT positively affects SCRM.*

Developing big data is a bold attempt by organizations to improve productivity, gain market share, and win new customers. In the field of management and science, big data is called the “fourth paradigm of science” or the “next management revolution” (Wan & Liu,2021). In the context of Industry 4.0, BDA is an important application, a key tool for increasing business efficiency (Maroufkhani et al., 2022). There are several definitions BDA, but one of the most common is Gartner (2012, p. 1), the term refers to the high volume, high velocity, and/or high variety of information assets that require innovative, cost-effective methods of processing information in order to enhance insight, decision-making, and process optimization. A common framework for describing big data and distinguishing it from traditional data is now the classic 3Vs – volume, velocity, and variety (Capurro et al., 2022), The term "volume” indicates the amount of information on a single database or the sheer volume of records on that database (Russom, 2011); “Velocity” describes the rate of data production and/or delivery (Sun and liu,2020),In recent years, numerous scholars and practitioners have added veracity and value to big data(Sun and liu,2020), "Value" emphasizing where big data can be used to generate economic value (Wan & Liu,2021) “Veracity,” indicating how reliable and relevant data are (Lee, 2017).

Researchers have pointed out of how BDA applications can help firms gain a competitive advantage as these applications are increasingly used by companies (Capurro et al., 2022; Waqas et al., 2021; Wang et al., 2016). “Because big data analytics can transform entire business processes, it is very relevant to study it.” As a result, when enterprises are able to utilize these data, particularly within the supply chain, they have the potential to achieve significant savings as well as improvement in performance (Al-Khatib,2023). In an organization, BDA allows data to be collected, mined, analyzed and visualized effectively, enabling leaders to make informed decisions (Schoenherr & Speier-Pero,2015).

Using BDA in the supply chain, inventory analysis and control can be improved (Rauniyar et al.,2022) as well as the potential risks associated with it (Queiroz & Telles, 2018). and improving SCP. Numerous studies have confirmed the ability of big data to improve SCRM (Rauniyar et al., 2022; Spieske & Birkel, 2021; Singh & Singh, 2019; Wang et al., 2016). As part of SCRM, BDA can improve SC visibility and responsiveness, enabling those in charge of decision-making and stabilization to trace disruption roots and observe disruption propagation (Zouari et al., 2020). Singh and Singh (2019) describe tangible, human, and intangible resources as being the components of the BDA capability. Therefore, BDA capabilities for organizations need to be developed simultaneously with IT infrastructure focused on BDA. Nonetheless, firm success can be enhanced by BDA in developing resilience to the business risk associated with supply chain disruption events (Bhandal et al.,2022) Furthermore, scholars argue that BDA in organizations (e.g. de Assis Santos and Marques, 2022), can be used to be nimble in responding to disruptions, mitigate disasters, and improve recovery efforts (Schoenherr & Speier-Pero, 2015). A risk management infrastructure needs to be responsive and effective, and BDA are essential. Therefore, BDA allows firms to develop supply chain risk resilience by enhancing their ability to manage business risk (Queiroz & Telles, 2018). In light of this, it is proposed the subsequent hypothesis:

H_2: *The BDA positively affects SCRM.*

Companies that seek the greatest level of performance succeed in achieving their goals and competing in the market (Mai et al., 2022). An organization's success is determined by its ability to achieve long-term and notable success (El-Baz & Ruel, 2021). There are many centralized and independent systems used in SCP in organizations. An overall view of supply chain activities and transactions has been difficult due to many barriers. Researchers investigating SCP have become interested in BCT (Giri & Manohar, 2023; Rogerson & Parry, 2020), since it is a distributed decentralized technology that has the potential to address these problems (Singh & Singh, 2019). A decentralized and distributed platform for capturing everyone's transactions is created by distributing and decentralizing information blocks. Through these applications, industrial production and logistics activities can be improved and the standard of quality can be raised, which improves SCP (Giri & Manohar, 2023).

A blockchain-based system can detect product failures and unreliable supplier services (Rogerson and Parry,2020). All data chains are instantly shared with this technology. Information can be ensured to be secure and authentic with blockchain, which reduces the cost of preventing unwanted and intentional changes to the data (Hopkins, 2021). Spieske and Birkel (2021)

pointed out that blockchain technology has potential benefits for supply chains by improving trust and transparency when transactions are traceable. Saberi et al. (2019) explored the potential applications of blockchain technology in supply chain management. They explained that blockchain improves SC sustainability because it is a disruptive technology. Schmidt (2019) examined how blockchain technology affects quality, cost, dependability, speed, flexibility, risk reduction, and sustainability metrics in supply chain performance.

H_3: *The BCT positively affects SCP*.

SCP is positively correlated with BDA (Kilubi & Rogers, 2018). The use of BDA can enhance the response of a company's internal and external processes by creating new knowledge within the organization (Han et al., 2019) Moreover, the use of BDA can assist in the formulation of strategic decisions (Dubey et al., 2018), Enough information can be obtained from these analytics to improve performance.

Analytics of big data contribute to SCP, by integrating different systems, linking them, and analyzing them to obtain clean data, and by using it to infer new knowledge and draw new conclusions (Anusha et al., 2022). and Making processes and activities more efficient (Bag et al., 2021a). As a result of big data analytics, a large collection of data is processed using a variety of technologies, human capabilities, and organizational support, providing previously unattainable insights (Al-Khatib and Ahmed,2022) thereby increasing benefits both at the scale of the supply chain and at the company level (Bag et al., 2021b).

H_4: *The BDA positively affects SCP.*

SCP is defined as "the activities of an extended supply chain that meet the needs of customers, such as product availability, delivery on time, as well as the inventory and capacity necessary to provide that performance efficiently" (Grimm, 2004). To thrive in a dynamic market environment, businesses must maximize their supply chain performance continuously and intensively to gain a competitive advantage (Duong & Quang,2021). The researchers argue that by enhancing SCRM visibility, companies can anticipate, prepare for, and mitigate risks more effectively (Roy et al., 2020). Studies have shown that SCRM reduces operational losses, increases responsiveness, and prevents interruptions of supply chains (Fan & Stevenson, 2018). As part of an SCRM, the risk of the supply chain is identified, evaluated, and mitigated, along with the cost reduction of the supply chain (Yu et al., 2018). By SCRM, companies can identify potential risks (Prakash et al., 2017) and act accordingly to increase efficiency and responsiveness in fulfilling orders on time, making deliveries on time, and meeting deadlines. Supply chain risk management can be used from upstream to downstream for a firm to be more flexible (Zouari et al.,2020). With SCRM, substandard products are prevented from being manufactured (Waqas et al., 2022). Therefore, improving supply chain performance by reducing disruptions in the supply chain reduces risk through SCRM. Considering this, it was hypothesized that:

H_5: *The SCRM positively affects SCP.*

Technology enabled by Industry 4.0 offers a promising opportunity to enhance SCRM. Through these technologies, stock levels, demand, supply, and market fluctuations can be identified in real-time, improving SCP (Al-Khatib, 2022). In previous studies, the BTC was demonstrated to positively impact SCRM by improving control and monitoring, improving demand and supply matching, as well as facilitating supply-demand management (Hopkins, 2021). Similarly, recent studies have demonstrated that BDA improves SCRM by reducing demand volatility and increasing agility, which results in increased innovation for the supply chain (Schoenherr & Speier-Pero, 2015).

Using SCRM, you can improve supply chain performance by sharing information within the supply chain in real time. According to Bhandal et al., (2022), SCRM plays a powerful role in improving SCP, including plan performance, performance at sources, performance at production facilities, and performance at distribution points. These measures can be used to determine how effective SCRM is in SC.

When BCT applications are combined with BDA applications, the level of SCRM can be improved and analyzed the information analyzed through BDA applications can be improved as well. SCRM can also be made more responsive using BDA (Anusha et al.,2022), which ultimately allows the supply chain to perform at its best by utilizing resources effectively, reducing operational costs, encouraging innovation, and improving services, thereby contributing to better SCP (Bag et al., 2021a).

Al-Khatib and Ahmed (2022) pointed out from a RBV viewpoint, SCRM could make supply chain activities more effective and efficient with the help of BDA and BCT applications; hence, it might play a role in improving the performance of supply chains. As a result of the use of blockchain applications in SCRM, supply chain performance can be enhanced through increased trust, reliability, and data confidentiality (Bag et al., 2020).

H6: *The SCRM mediates the effects of the BCT on supply chain performance.*

H7: *The SCRM mediates the effects of the BDA on supply chain performance.*

We developed our theory model on the basis of the literature review, which, as shown in Fig 1 as follows,

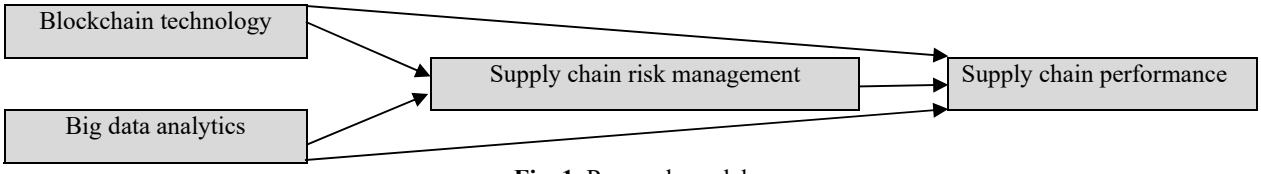

Fig. 1. Research model

3. Methodology

3.1 Sample and data collection

A questionnaire survey is used to collect data for assessing the validity of the model and research hypotheses. From Sep to Dec 2022, in-depth surveys were conducted with 60 companies in the Jordanian Chemical and Cosmetics Sector. We selected these companies at random from among 232 in Jordan. A representative from each of these firms was contacted, mostly in the HR departments, either over the phone or in person. As part of our communication with respondents, we explain the purpose of the study, guarantee information security, and request their help with data collection. In the beginning, we used literature-based scales to develop our initial list of items. As a way of confirming the consistency between the English and Arabic questionnaires, backward translation was used. In all, this study has issued 550 questionnaires and received 391 to collect data, of which 364 are valid, representing 66.1% validity rate (Sekaran & Bougie, 2016; Kara et al., 2020). In Table 1, you will find a distribution of the respondents to the study sample.

Table 1
Demographics and personal characteristics

Category	category	Frequency	%
Gender	Male	285	0.783
	female	79	0.217
	Total	364	100
Level of education	Bachelor's degree or less	278	0.763
	A postgraduate degree	86	0.236
	Total	364	100
Years of experience	Five years or less	72	0.197
	5 - 10 years or less	161	0.442
	Ten to less than fifteen years	85	0.233
	More than 15 years	46	0.126
	Total	364	100

3.2 Measurement

A five-point Likert-scale ranging from “1” for “strongly disagree” to “5” for "strongly agree" was used in measuring the variables in the study.

Big data analytical*:** A total of six items were used in this study, adapted from the study carried out by Al-Khatib (2022a) and Al-Khatib (2023), to assess the use of BCT in their organization. ***Blockchain technology: An adaptation of 6 items was used in this study by Philsoophian et al. (2022) to assess the use of BCT in their organization. ***Supply chain risk management*:** This study used 4 items adapted from the study of de Assis Santos and Marques, (2022). ***Supply chain performance***. This study used 4 items adapted from the study of de Assis Santos and Marques, (2022).

Measurement model assessment

Several analyses were used to assess the suggested model, including a confirmatory factor analysis (CFA) and structural equation modeling. The analysis was performed using the Lavaan R package (Rosseel, 2012). The measurement model was assessed using a number of measures. According to the CFA, the measurement model was mis specified by three items. The measurement model is made more tenable by removing them. Due to this action, the structures of the variables did not change; the remaining items remain representative of their concepts. Based on Cronbach's alpha coefficients (Ca), we found, in table

1, (Cr) values between 0.82 and 0.85, higher than recommended (Nunnally, 1978), suggesting that the measurement model is reliable. To determine whether the measurement model was convergent, the composite reliability (Cr) and average variance extracted (AVE) were used. In general, Cr values ranged between 0.87 and 0.92 for all constructs; AVEs were above 0.5 for all. Our measurement model demonstrates acceptable convergent validity since the AVE measure is strict and the Cr values are higher than the traditional cutoff point of 0.7.

Table 1
Reliability and Validity

Construct	Ca	Cr	AVE	Items	label
Blockchain technology (BCT)	0.852	0.921	0.532	BDA1	0.698
				BDA2	0.776
				BDA3	0.776
				BDA4	0768
				BDA5	0.726
				BDA6	0.758
Big data analytics(BDA)	0.843	0.871	0.562	BCT1	0.764
				BCT2	0.687
				BCT3	0.697
				BCT4	0.658
				BCT5	0.694
				BCT6	0.725
Supply chain risk management(SCRM)	0.821	0.882	0.542	SCRM1	0.728
				SCRM2	0.763
				SCRM3	0.698
				SCRM4	0.721
Supply chain performance(SCP)	0.841	0.905	0.63	SCP1	0.685
				SCP2	0.695
				SCP3	0.720
				SCP4	0.711

The Heterotrait-Monotrait ratio of correlations (HTMT) was used to determine discriminant validity. There should be a minimum HTMT ratio of 0.85 between the two constructs (Voorhees, Brady, Calantone, & Ramirez, 2016). There was no ratio greater than 0.85 in Table 2, indicating that each construct is distinct. Finally, the model fit indices were acceptable (Chi-square = 223.251; d.f. = 106; Chi-square/d.f. =2.096; TLI = 0.941; CFI= 0.943; NFI = 0.911; NNFI= 0.924; RMR= 0.043 and RMSEA= 0.65. According to Bollen (1989), 2.097 is less than the maximum 3.0 chi-squared calculation. There is no disagreement between the goodness-of-fit indices and the suggested cutoffs (Hu & Bentler, 1999). Therefore, this model provides a good fit for the data. Moreover, the scales have solid evidence of reliability, convergent validity, and discriminant validity.

Table 2
Heterotrait-Monotrait ratio of correlations

Constructs	BCT	BDA	SCRM	SCP
Blockchain technology (BCT)				
big data analytics(BDA)	0.811			
Supply chain risk management(SCRM)	0.723	0.751		
Supply chain performance(SCP)	0.544	0.638	0.554	

Hypothesis testing

As shown in table 3 and figure 2, the proposed model is estimated. As a result of direct effects estimation, Blockchain technology is directly associated with Supply chain risk management ($\beta = 0.513$, $P>0.05$), and a direct association has been found between big data analytics and supply chain risk management based on direct effects estimation ($\beta = 0.314$, $P>0.05$), so the hypothesis H1 and H2 can be accepted as true. Yet, supply chain risk management has a significant and positive relationship with supply chain performance ($\beta = 0.723$, $P> 0.05$), confirming hypothesis H5. These findings signify that there is a high possibility that Supply chain risk management mediates the impact of Blockchain technology and big data analytics as stated in Hypotheses H6 and H7, which will be tested later. In addition, the results indicate that blockchain technology has a positive and significant impact on supply chain performance ($\beta = 0.611$, $P<0.05$) and There is also a significant and positive relationship between big data analytics and supply chain performance (($\beta = 0.628$, $P<0.05$), providing support for hypotheses H3 and H4.

Table 2
Estimation of the direct effects

Direct Relationships	Standardized Coefficient	Standard Error	z-value	p-value
Blockchain technology → Supply chain risk management	0.513	0.159	4.123	0.000
Big data analytical→ Supply chain risk management	0.314	0.161	4.258	0.000
Blockchain technology → Supply chain performance	0. 611	0.154	4.536	0.000
Big data analytical → Supply chain performance	0. 628	0.157	3.958	0.000
Supply chain risk management → Supply chain performance	0. 723	0.138	25.862	0.000

To examine hypotheses H6 and H7, the indirect effects between BCT and BDA on SCP through SCRM were estimated using bootstrapping strategy (Hayes, 2009). Table 3 shows that through SSCRM the impact of Blockchain technology on SCP (β = 0.615, P<0.05, CI= 0.213, 1.002) and through SCRM impact of BDA on SCP (β = 0.518, P<0.05, CI= 0.178; 0.893) were significant. These results indicate that SCRM does mediate the impact of BCT and BDA on SCP . Therefore, hypotheses H6 and H7 are accepted.

Table 3
Estimation of indirect effects

Relationships	**Estimate**	**Standard Error**	**z-value**	**p-value**	**CI 2.5%**	**CI 97.5%**
Blockchain technology → Supply chain risk management → Supply chain performance	0.615	0.197	3.254	0.002	0.213	1.002
big data analytics → Supply chain risk management → Supply chain performance	0.518	0.184	3.129	0.004	0.178	0.893

4. Discussion

In this study, we sought to identify if the BCT and BDA impact SCRM and SCP causally, as well as verify that SCRM mediates this impact based on data compiled from a sample of Jordan's Chemical and Cosmetic Industries Sector.

A set of empirical findings was reached because of the study. According to the conceptual model, all hypotheses were supported. This study's results support the RBV theory, which emphasizes the importance of leveraging an organization's unique assets to improve performance and compete more effectively (Al-Khatib, 2022). In many works of literature (Ahlqvist et al., 2022, Anusha et al., 2022; Bechtsis et al., 2022; Rogerson & Parry,2020), assert that BCTs and BDAs enhance SCRM, enhancing supply chain decision-making accuracy by improving access to high-quality information. In addition, Industry 4.0 will provide a better understanding of inventory and demand using applications that increase visibility throughout the supply chain (Waqas et al., 2021).

The development of highly accurate predictive models and improvement of supply chain risk management can be achieved using BDA in the supply chain (Dubey et al., 2018). With BDA, a large set of data sources can be analyzed and new information can be obtained so that SCRM can be improved (Duong et al.,2018). BDA and BCT may be useful in supporting SCRM. Through BDA , firms can manage large amounts of data that would otherwise be unmanageable; second, by tracking suppliers in real time, firms can increase supply chain visibility, which reduces risks, and third, compared to traditional business process solutions, firms can obtain quick and reliable responses in time .Through BCT, inventory can be constantly updated and future needs can be predicted, increasing the efficiency of end-to-end supply chain processes. By using BCT, it is possible to plan and meet customer demands in real-time (Giri & Manohar,2023). Providing a better and more effective way to manage supply chains and storing data and information can allow for back-end recording (Philsoophian et al., 2022).

5. Implications

Theoretical implication

This study makes an important contribution by systematically reviewing the current literature and emphasizing the crucial role of strengthening SCRM as an effective strategy for companies to succeed in the supply chain. Several contributions were found to support the hypothesis because Blockchain technology and BDA have demonstrated an impact directly on SCRM and supply chain performance. It further enhanced our understanding of Industry 4.0's capabilities for enhancing supply chain performance by revealing the direct relationship between SCRM and supply chain performance. Furthermore, the study contributed new theoretical insights into the mediating role played by SCRM, demonstrating how Blockchain technology and

BDA are crucial to SCRM's success. Based on the results of this study, SCRM was understood to be an important consequence of antecedents related to Blockchain technology and Big Data.

The paper addresses some gaps in research regarding the direct impact of big data analytics and Blockchain technology capabilities on SCRM and supply chain performance. Among the contexts that have received little attention from researchers in the field of digital technologies in Industry 4.0 is the Jordanian Chemical and Cosmetic Industries Sector. Consequently, by emphasizing the importance of big data analytics and Blockchain technology for SCRM and supply chain performance, this paper provided interesting results. These organizational, administrative, and human capabilities can therefore be leveraged to improve the level of environmental readiness of these firms by enhancing the value of digital technologies in Industry 4.0.

Practical implication

firms in emerging and developing markets will find this paper to be of importance for two reasons. Despite the growing use of blockchain technology and BDA in SCRM, there has been little empirical research and comparison, mainly focusing on Western economies and ignoring developing economies. This study has demonstrated that blockchain technology and BDA have a significant impact on SCRM, particularly in emerging and developing countries like Jordan. The second reason is that these findings provide deeper insights into the relationships among Blockchain technology, BDA, SCRM, and supply chain performance, It implies that to foster SCRM, managers should focus on applying blockchain technology and BDA together with other appropriate supports to foster SCRM. Consequently, management needs to recognize the importance of deploying blockchain and BDA applications that are simple to operate and offer great value to interfirm supply chains**.**

Despite the potential applications of blockchain technology and BDA, both technologies are still in their infancy; Especially in the Jordanian context, as a result, organizations can leverage this technology and change their market position to gain a competitive advantage (Giri and Manohar, 2023). With the use of blockchain technology and BDA, particularly within the supply chain, producers can gain confidence in the origin of products they distribute to consumers and users, while it will also help to perform operations effectively at the intra-firm level. Similarly, blockchain could greatly improve the management of a globalized supply chain with many echelons, complex product flows, and different suppliers (Giri and Manohar, 2023).

limitation and future research

Future studies may be able to address some of the limitations of our research. First, Due to the fact that data for this study were gathered from Jordan's Chemical and Cosmetic Industries Sector, there may be some variability in the results of the research model when it comes to the relationships between latent constructs. In order to extend and consolidate this paper's findings, other studies in different contexts will be necessary. A future study may collect data from companies that have implemented Blockchain technology and BDA in the supply chain for at least a few years. By collecting data in this manner, we may be able to learn new things about blockchain technology and BDA, and about the mediating role played by SCRM. Additionally, data collection and analysis can be done using other methods, such as case studies, that provide greater depth. Blockchain technology, which is a new potential disruptive technology, is also at its very early stages, which limits the available study.

The deployment of blockchain throughout supply chains may be the focus of future research. Furthermore, some technical issues related to blockchains, such as scalability, security, and decentralization, must be addressed in future research. It is also necessary to conduct more research studies on blockchain diffusion and adoption, as well as social effects and their management implications. Because blockchain technology is still in its infancy. There should be more empirical evidence added to future studies to improve supply chain risk management. Research in the future should also examine the amount of value created by blockchains.

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