Big data analytics capabilities and supply chain performance: testing a moderated mediation model using partial least squares approach

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Abstract

Purpose – In this study, the authors investigate the effect of big data analytics capability (BDAC) on supply chain performance (SCP) to assess the mediating effect of supply chain innovation (SCI) and the moderating effect of a data-driven culture (DDC).

Design/methodology/approach – The authors collected the primary data through an online questionnaire survey from the manufacturing sector operating in Jordan. The authors used 420 samples for the final data analysis, which the authors performed via partial least squares structural equation modelling using SmartPLS 3.3.9 software.

Findings – The results indicate that BDAC has a strong relationship with SCI and SCP. SCI shows a positive relationship with SCP as well as a mediating effect on SCI. The authors confirmed that DDC moderated the relationship between SCI and SCP.

Originality/value – The authors developed a conceptual and empirical model to investigate the relationship between BDAC, SCI, DDC and SCP. The authors contributed new theoretical and managerial insights that add value to the supply chain management literature through testing the moderated-mediated model of these constructs in Jordan's manufacturing sector.

Keywords Big data analytics capability, Supply chain performance, Supply chain innovation, Data-driven culture

Paper type Research paper

1. Introduction

The emergence of Industry 4.0 technologies such as artificial intelligence, cloud computing and big data (BD) has changed the current business scene (Tang *et al.*, 2022). These technologies have provided firms with many advantages in their various activities (Al-Khatib, 2022a). In the supply chain management (SCM) setting, these technologies have improved decision-making ability (Mageto, 2021) and information sharing (Jia *et al.*, 2020). This, in turn, has allowed for greater control of the supply chain (SC) while reducing disruptions and potential risks because of significant changes in the external business environment, thus improving the level of supply chain performance (SCP) (Kache and Seuring, 2017).

Despite recent academic interest in the manner in which Industry 4.0 technologies have improved SCP (Koh *et al.*, 2019) and organisational performance (Barata, 2021), emerging challenges have placed unprecedented environmental pressure on firms globally, especially

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industrial firms that rely heavily on the SC (Grida *et al.*, 2020). For instance, the COVID-19 pandemic and related preventive measures played a major role in disrupting global SCs (Hohenstein, 2022), which led to a reduction in the provision of products and services and destabilised the business market.

The COVID-19 pandemic has revealed the importance of using smart technologies, especially big data analytics (BDA), during crises (Al-Okaily *et al.*, 2022; Al-Bashayreh *et al.*, 2022). BDA enable the development of new perceptions about future crises and encourage innovative decisions and solutions to the problems associated with them (Mehta and Shukla, 2022). Because the sectors most affected during the pandemic have been global SCs (Joshi and Sharma, 2022), the pandemic has contributed to an increase in academic and industrial interest in the mechanisms and methods that can maintain global SCs under uncertain environmental conditions (Goel *et al.*, 2021). According to Saabye *et al.* (2022), the applications of Industry 4.0 technologies have opened new horizons in SCM by improving SC responses to emergency changes and introducing innovative processes that improve SCP (Friedman and Ormiston, 2022).

Firms that adopt digital transformation initiatives and Industry 4.0 technologies can innovate faster than ever before (Tuukkanen *et al.*, 2022), which can enhance their ability to face the disruptions caused by emergency events in these firms' external environments. Innovation and continuous improvement in the SC will create added value for customers (Ayoub and Abdallah, 2019) and lead to the improvement of processes, activities and performance within the SC (Ayoub and Abdallah, 2019; Abdallah *et al.*, 2021). Moreover, innovation in the SC contributes to reducing waste in the use of resources (Seo *et al.*, 2014) and facilitates efficient transmission and information sharing among all units in the SC (Abdallah *et al.*, 2021), which contributes to improving the efficiency and performance of the SC.

Firms that continue to use BDA technologies enjoy competitive advantages (Mikalef *et al.*, 2020a, b) by developing innovation, seizing new opportunities and responding to customer preferences by using advanced analysis methods that help provide solutions (Johnson *et al.*, 2017; Ramadan *et al.*, 2020). Despite the importance of digital transformation and the adoption of BDA in promoting innovation in the SC and improving SCP, several antecedents must first exist within these firms, such as top management support (Maroufkhani *et al.*, 2022) and a corporate culture oriented towards BDA initiatives (Al-Khatib, 2022a; Chatterjee *et al.*, 2022a, b). Firms with a data-driven culture (DDC) can build organisational values and a data-oriented vision, leading to improved big data analytics capability (BDAC), innovation programme levels and SCP (Mondal and Samaddar, 2021). Agyei-Owusu *et al.* (2021) argued the importance of building a DDC to improve the information quality in the SC and enhance information exchange, contributing to increased value for customers and thus improving the SCP. The SC's reliance on BDA will depend on having a DDC that makes the ability to analyse data an influential value in SC processes and activities (Bechtsis *et al.*, 2021; Yu *et al.*, 2021).

Current literature indicates few studies that deal with the effects of BDA on supply chain innovation (SCI) that lead to the highest level of SCP; these studies have not demonstrated the importance of DDC in strengthening the relationship between SCI and SCP, especially in developing countries. Therefore, in this study we aim to fill the research gap that previous studies have created in order to enhance the recommendations and theoretical and practical contributions that enable managers to exploit BDA to improve the level of SCP in their manufacturing companies.

Jordan's manufacturing sector is one of the fastest growing and most vital sectors in the country's overall economy (Al-Khatib and Al-Ghanem, 2022; AL-Khatib and Shuhaiber, 2022). Thus, in this study we aim to identify the direct relationship between BDA and SCP, as well as the mediating role of SCI and the moderating role of DDC in this relationship, by providing an empirical contribution through studying the moderated–mediated model.

2. Literature and hypothesis development

In this section we discuss the theoretical framework of the structures we used in the study. We were motivated in building the theoretical framework by the need to know the latest updates in the literature related to these structures and to identify the research gap by using the resource-based view (RBV). To develop a solid theoretical framework, we refer only to articles published in high-quality journals indexed in Scopus and the Web of Science.

In this study we relied on RBV as a basic theory to verify the causal relationships between the constructs. According to Barney (1991), the RBV theory contributes to understanding the relationship between different organisational capabilities and their effects on performance and competitive advantages (Kabadurmu, 2020). Therefore, this study can provide a new understanding of RBV theory at the level of SCs.

2.1 BDAC and SCP

The SC is one of the most important determinants of increasing operational excellence within firms (Queiroz *et al.*, 2022). The SC is the processes and activities that unite organisational efforts within a firm to respond to the needs, desires and information that suppliers and customers provide (Cox and Perkins, 2008). SCM is the management of a wide network of relationships inside and outside the firm to achieve customer satisfaction (Avilés-González *et al.*, 2017). SCM focuses on achieving value for its products by working simultaneously with suppliers, manufacturers, customers and all major stakeholders (Handfield *et al.*, 2020).

The flow of information within the SC plays a key role in maximising profit and value and creating competitive advantages (Partanen *et al.*, 2020). Firms that operate advanced information systems will enable their internal SCM to deal quickly with changes within the SC (Bag *et al.*, 2020). The flow and processing of information lead to the maximum and optimal response to the needs and desires of the market and customers, creating a strong SC network that enables the organisation and its partners to increase profit and create a sustainable competitive advantage (Dehgani and Navimipour, 2019).

Hurwitz *et al.* (2013) defined BDAC as "the capability to manage and analyze petabytes of data that enables companies to deal with clusters of information that could have an impact on the business" (p. 22). BDA tools stimulate corporate activities by highlighting difficult and unstructured data that require special technological capabilities to process it (Gunasekaran *et al.*, 2017). In the SCM setting, BDAC is a firm's ability to collect and organise data related to the SC from heterogeneous systems and to analyse this data to make accurate decisions and build a superior and proactive SCM system (Arunachalam *et al.*, 2018).

Dubey *et al.* (2018), Mandal (2018), Seyedan and Mafakheri (2020) and Xiang *et al.* (2021) have confirmed that BDA provide many unique advantages in the SC by developing predictive models that accurately predict supply and demand, enhance the efficiency of production processes and deliver products to end customers. These in turn create value in the SC and lead to higher performance levels. BDA can also achieve agility in the SC (Lee and Mangalaraj, 2022).

The SC can benefit from BDA by integrating these technologies with managerial and organisational capabilities, which deepens the firms' understanding of events and changes in the SC, leads to accurate real-time decision-making (Tiwari *et al.*, 2018) and thus helps the firm to understand market trends and customer preferences (Janssen *et al.*, 2017). BDA can reduce potential risks by using predictive models to ensure that the most appropriate decisions are used within the SC (Wang *et al.*, 2016).

Chae *et al.* (2014), Kalaitzi and Tsolakis (2022) and Shafiq *et al.* (2020) confirmed that using BDA and applications in SCs, or SC analytics, can improve SCP by improving operational performance, developing innovation in the SC and achieving competitive advantage.

Based on the preceding discussion, we hypothesized the following.

H1. BDAC positively affects SCP.

2.2 BDAC and SCI

In achieving competitive advantages, firms depend on the extent to which they use innovation in developing their products and processes (Al-Khatib and Al-Ghanem, 2022). Innovation plays a critical role in enhancing organisational capabilities and raising the efficiency of processes. In the context of the SC, innovation can be described as organisational efforts and initiatives that firms undertake to improve SCP by relying on new processes and products (Ramakrishna, 2022). These efforts increase innovative activities within the SC and thus help firms achieve competitive advantages (Gong and Møller, 2015). SCI helps increase integration within the SC (Gao *et al.*, 2017). Firms can increase their SCI by improving their SCP and customer service (Espino-Rodríguez and Taha, 2022) and by rapidly increasing information flows within the SC and with suppliers and stakeholders (Hunold and Shekhar, 2022).

According to Rajabian Tabesh *et al.* (2016), SCI requires technological and organisational support. Data-driven organisational capabilities can exploit the opportunities to enhance knowledge within the SC, leading to increased innovation in the SC (Hussain *et al.*, 2022). Previous research has emphasised the positive relationship between BDAC and SCI (Bahrami *et al.*, 2022; Lee and Mangalaraj, 2022; Ogbuke *et al.*, 2022; Shamout, 2019; Tan *et al.*, 2015). BDA provide innovative ways of adding value to customers through SCM (Liu *et al.*, 2022). BDAC enables firms to gain new insights that help enhance the dynamic organisational capabilities within the SC (Bahrami *et al.*, 2022). BDA can also assist managers in planning, forecasting and building complex statistical models that provide strategies for identifying and correcting errors, reducing delivery time and improving production capabilities within the SC (Ogbuke *et al.*, 2022; Shamout, 2019). BDA provide opportunities for efficient and rapid analysis of customer and supplier data (Müller and Jensen, 2017), helping generate new insights into delivering innovations within the SC (Chatterjee *et al.*, 2022a, b).

Based on the preceding discussion, we hypothesized the following.

H2. BDAC positively affects SCI.

2.3 SCI and SCP

SCs are an essential source of value creation in firms' and organisations' activities (Hussain *et al.*, 2022). The SC can maintain stability and sustainability in delivering products to the final customer at the right time and place (Queiroz *et al.*, 2022). In a turbulent business environment, firms must use innovative methods to ensure a sustainable SC and improve its performance (Orlando *et al.*, 2022). SCI offers radical and incremental solutions to ensure higher performance within the SC (Kabadurmu, 2020). According to Lii and Kuo (2016), SCI will positively reflect on internal and external integration within the SC, leading to reduced lead time and increased chain agility (Alzoubi *et al.*, 2022).

SCI offers many advantages within the SC by increasing the capabilities of SCM (Sunil, 2019) and enabling the SC to access new sources of knowledge and thus create new value within the SC (Gloet and Samson, 2022). SCI helps firms exchange skills and knowledge among all parties in the SC, which leads to enhanced trust, increased organisational learning (Ojha *et al.*, 2016) and enhanced SCP (Abdallah *et al.*, 2021). According to Wamba and Queiroz (2022), the SC can benefit from innovation initiatives by sharing and exchanging experiences within the SC and by improving production processes.

The RBV is a strategy model that considers an organisation's resources as key to achieving sustainable and superior performance. Integrating tangible and intangible resources within the SC leads to process and logistical innovations that support SCP (Barney, 1991; Grimmer *et al.*, 2017; Kabadurmu, 2020).

Based on the preceding discussion, we hypothesized the following.

H3. SCI positively affects SCP.

2.4 the mediating effect of SCI

Previous research has indicated the importance of innovation as a determinant of organisational success and performance improvement (Al-Khatib *et al.*, 2022b; Al-Khatib and Al-Ghanem, 2022; Anderson *et al.*, 2014). However, a firm's use of BDA applications will greatly help it seize new opportunities and enable innovation (Al-Khatib, 2022c, d; Rialti *et al.*, 2019). BDA help firms make relevant and real-time decisions and provide an innovative work environment (Imran *et al.*, 2021; Wamba *et al.*, 2018). Using BDA within the SC can provide many benefits, such as improving the efficiency of internal processes and improving cooperation with stakeholders (Lai *et al.*, 2018), thus leading to support for open innovation (Shcherbakov and Silkina, 2021) and improvements in SCP.

Habidin *et al.* (2016) found that SCI is one of the main antecedents of increasing excellence and performance in the SC; Bahrami *et al.* (2022) found that SCI positively mediates the relationship between BDA and SCP; and Shamout (2020) found that BDA provide the ability to employ innovation to drive superior performance within the SC.

Although innovation efforts within firms and the SC can create unexpected risks and disruptions in the SC (Eggert *et al.*, 2016), firms can enhance their capabilities at the intersection of BDA and SCI to manage risks more precisely (Kwak *et al.*, 2018) and thus improve SCP.

Based on the previous discussion, we hypothesized the following.

H4. SCI mediates the effect of BDAC on SCP.

2.5 the moderating effect of DDC

Organisational culture plays a fundamental role in promoting innovation (Al-Khatib *et al.*, 2022; Zheng *et al.*, 2019), improving performance (Xie *et al.*, 2016) and creating competitive advantages (Tang *et al.*, 2020). Several studies that investigated the role of organisational culture and its effects on the business environment have confirmed that organisational culture is one of the main determinants of a firm's success (Gamage and Tajeddini, 2022; Scaliza *et al.*, 2022). Organisational culture can be described as the shared beliefs, values, behaviours and goals that exist within organisations (Hartman *et al.*, 2014).

In the context of BDA, the main role of organisational culture is to support the application of BDA (Mikalef *et al.*, 2020a, b). In supporting organisational capabilities oriented towards BD (Sultana *et al.*, 2022), firms seek to build a DDC to increase their organisational and technological capabilities of extracting the most information possible through data analysis to gain business value (Chaudhuri *et al.*, 2021).

Kiron *et al.* (2013, p. 1) described DDC as "a pattern of behaviors and practices by a group of people who share a belief that having, understanding and using certain kinds of data and information plays a crucial role in the success of their organization". Akhtar *et al.* (2016) and Rodrigues *et al.* (2021) explained that in order for firms to adopt BDA, they must have an organisational culture that supports efforts to improve performance. Mondal and Samaddar (2021) indicated that having a DDC can improve firms' innovation levels because such a culture seeks to enhance the effective organisational values oriented towards BD and thus the better use of data to achieve innovative results that contribute to improving business value (Chatterjee *et al.*, 2021). Having a DDC can also help in the adoption of programmes and initiatives related to BDA (Belhadi *et al.*, 2020), which leads to the promotion of innovation (Fernando *et al.*, 2018).

In the context of SC analytics, DDC contributes to enhancing the information exchange in the SC and raises the importance and quality of data in the SC, leading to enhanced SCP (Agyei-Owusu *et al.*, 2021; Yu *et al.*, 2021). BDA help in promoting effective SCM (Li and Liu, 2019). Thus, SCI needs a lot of support from the firm, especially from its organisational culture (Brownlow *et al.*, 2015). Therefore, DDC helps to support innovation initiatives in the SC (Akhtar *et al.*, 2016; Fernando *et al.*, 2018; Karaboğa *et al.*, 2019; Mondal and Samaddar, 2021).

Based on the preceding discussion, we hypothesized the following.

H5. DDC moderates the effect of SCI on SCP.

Figure 1 shows the conceptual model that investigates the effect of exogenous constructs on endogenous constructs.

3. Methodology

3.1 Measurements and instruments

We selected our constructs based on recommendations of previous research on data collection. Good constructs are fundamental to achieving reliable and valid measurements (Duan *et al.*, 2020). We developed the questionnaire items by making minor changes to the constructs to conform to the context of Arab and Jordanian culture. We then translated the questions into Arabic to achieve the largest percentage of non-English-speaking participants. We used a 5-point Likert scale to measure the participants' responses to the questions. This scale is the most commonly used in social and administrative studies (Wilson, 2014). Table 1 shows the questionnaire items distributed to the study participants.

3.2 Sampling approach

We used a survey-based approach to collect data from firms operating in Jordan's manufacturing sector. According to AL-Khatib and Shuhaiber (2022), there are 1,784 small, medium and large manufacturing companies operating in the country. We targeted a purposive sample of the population from this sector by distributing the questionnaire to as many participants as possible (Sekaran and Bougie, 2016).

3.2.1 Response rate. We conducted the survey in the last quarter of 2021 after having distributed the questionnaire between September and late November. Owing to the difficulty of obtaining a sampling frame for all employees in manufacturing companies in Jordan, we used a purposive sample that included employees most useful to our research purposes (Wilson, 2014).

COVID-19 social distancing measures compelled us to distribute the questionnaires through social networks, websites and e-mail: 450 to the study sample of employees in manufacturing firms operating in Jordan and 420 that we used for the hypothetical study model test. The response rate of the questionnaire was 93.3%. To ensure the questionnaire

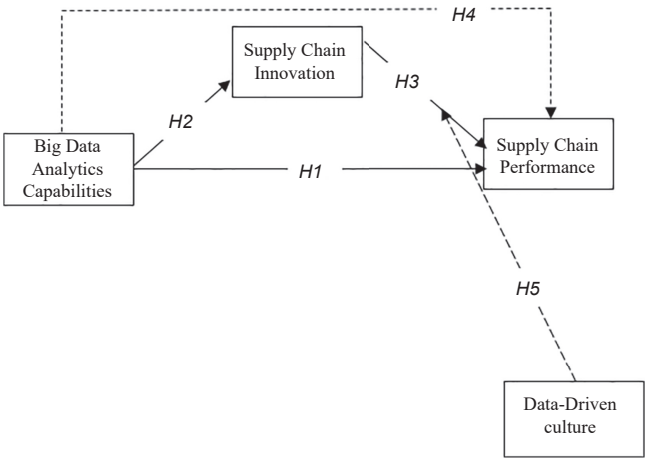

Figure 1.
Research model

Construct	Item code	Item	Reference
BDAC	BDAC1	The firm invests in BDA applications	Shamim *et al.* (2020), Singh and Singh (2019)
	BDAC2	The infrastructure in the firm helps to use and process BD	
	BDAC3	The firm is constantly implementing initiatives related to BD to ensure the provision of high-quality BD	
	BDAC4	The firm's human resources department has a strategic plan to attract BDA to benefit from their expertise in this field	
	BDAC5	The firm helps people to spread knowledge about BD	
	BDAC6	The firm maintains its organisational resources that enhance its ability to benefit from BD in its various activities	
SCI	SCI1	The firm uses real-time tracking technology	Bahrami *et al.* (2022), Kwak *et al.* (2018), Yoon *et al.* (2016)
	SCI2	The firm works to introduce agile processes and rapid response into the SC	
	SCI3	The firm encourages new and creative ways within the SC	
	SCI4	The firm focuses on innovation to reduce costs in the SC	
	SCI5	The firm focuses on using advanced vehicles in the SC	
DDC	DDC1	The firm has a clear vision of the use of BD in various activities	Chatterjee *et al.* (2021), Duan *et al.* (2020), Gupta and George (2016)
	DDC2	The firm embraces and supports all new and constructive suggestions and ideas related to BD	
	DDC3	The firm provides all available resources to enhance management decisions based on BD	
	DDC4	BD is one of the firm's main assets	
	DDC5	The firm is implementing initiatives to enable employees to use BD to make data-driven decisions	
SCP	SCP1	The firm provides on-time delivery	Bahrami *et al.* (2022), Kwak *et al.* (2018), Yoon *et al.* (2016)
	SCP2	The firm focuses on reducing waste in operational processes within the SC	
	SCP3	The firm makes efforts to reduce transportation costs	
	SCP4	The firm's SC can deliver flawless products to end customers	
	SCP5	The firm can reduce inventory throughout the SC	

Table 1. Construct measurements

reached current employees, we recorded their access to it by entering their email address and excluded those respondents who did not meet this criterion. Table 2 shows the distribution of participants by demographic and personal characteristics.

Most of the respondents (272) were male, representing 67.8%; most of the respondents held a bachelor's degree or had completed graduate studies; and most of the respondents held administrative or managerial positions in their companies.

3.2.2 Representativeness. We tested non-response bias by conducting an independent sample *t*-test, which compares statistically significant differences in the constructs of the study through the responses we collected (Armstrong and Overton, 1977; Liu *et al.*, 2021). We divided the data into two equal groups of 210 responses each. We compared the mean of the

constructs according to these two groups, disregarding all differences that were not statistically significant.

3.2.3 Common method bias. Because of the use of a survey-based approach, and because this study includes cross-sectional correlational variables, the probability of common method bias (CMB) is high (Podsakoff and Organ, 1986). We used Harman's one-factor test (Siemsen *et al.*, 2010) to detect CMB and conducted exploratory factor analysis of all items in the questionnaire. The number of factors was 17 and the variance of the first factor was 47.04%, i.e. less than 50%. There were therefore no concerns regarding CMB in this study.

4. Results of data analysis

We tested the hypotheses between the exogenous constructs and endogenous constructs by using data collected from the manufacturing firms to reveal the causal effects of BDAC on SCP and to test the hypothesis of the mediating role of SCI and the moderating hypothesis of DDC.

To study the interrelationships between observed and latent variables, we performed exploratory partial least squares structural equation modelling (PLS-SEM) using SmartPLS 3.3.9 software (Ringle *et al.*, 2015). Because the constructs used are new in the context of this study, PLS-SEM is more useful than covariance-based structural equation modelling (CB-SEM). Although the sample size was suitable for conducting CB-SEM, we used PLS-SEM because of the lack of normal distribution of data (Hair *et al.*, 2019). PLS-SEM is non-parametric and therefore can be used when multicollinearity exists (Hair *et al.*, 2014). According to Hubona and Belkhamza (2021), it may be more appropriate to use PLS-SEM than CB-SEM with conceptual models that contain mediating or moderating effects.

We used a two-step PLS-SEM approach: we first measured validity and reliability and then tested the structural model and related it to hypothesis testing.

4.1 Validity and reliability

PLS-SEM tests the measurement model by testing convergent validity and discriminant validity. To verify convergent validity, we extracted the average variance extracted (AVE) values to show the quality of convergent validity in the constructs. The AVE values must be equal to or greater than 0.50, and factor loadings (FL) must have reached values greater than or equal to 0.70 (Hair *et al.*, 2014, 2019).

We also verified the reliability of our constructs through composite reliability (CR) where all values were greater than 0.70, which is greater than the statistically acceptable threshold (Hair *et al.*, 2014). Table 3 summarizes the validity and reliability of the first-order constructs.

We assessed discriminant validity using the heterotrait-monotrait ratio (HTMT) of correlations (Henseler *et al.*, 2015). Based on this criterion and as summarized in Table 4, we achieved discriminant validity on all constructs, with values less than 0.85.

Table 2.
Respondents' profile

Demographic variables	Categories	No.	%
Gender	Male	272	64.8
	Female	148	35.2
Academic qualification	Diploma or less	95	22.6
	Bachelor's degree	251	59.8
	Postgraduate degree	74	17.6
Job in company	Manager/Department head	106	25.2
	Administrative employee	140	33.3
	Non-administrative employee	174	41.4

First-order constructs	Code	FL	AVE	CR
BDAC	BDAC1	0.767	0.583	0.848
	BDAC2	0.776		
	BDAC3*	–		
	BDAC4*	–		
	BDAC5	0.772		
	BDAC6	0.740		
DDC	DDC1	0.758	0.632	0.896
	DDC2	0.797		
	DDC3	0.819		
	DDC4	0.818		
	DDC5	0.782		
SCI	SCI1	0.760	0.593	0.854
	SCI2	0.762		
	SCI3	0.788		
	SCI4	0.770		
	SCI5*	–		
SCP	SCP1	0.697	0.543	0.826
	SCP2*	–		
	SCP3	0.754		
	SCP4	0.768		
	SCP5	0.726		

Note(s): * Items removed due to low loadings

Table 3.
Validity and reliability

Variables	1	2	3	4
1. BDAC				
2. DDC	0.747			
3. SCI	0.684	0.678		
4. SCP	0.780	0.778	0.689	

Table 4.
Discriminant validity (HTMT ratio)

4.2 Structural model

In this study we tested five hypotheses using bootstrapping, a non-parametric statistical procedure (Streukens and Leroi-Werelds, 2016). Table 5 shows the results of our testing of direct hypotheses, moderating hypotheses and mediating hypotheses. We found that the results supported all the direct hypotheses (H1, H2 and H3). The result of the H1 test, which explains the direct relationship between BDAC and SCP, was ($\beta = 0.378, t = 7.101, p < 0.001$); the result of the H2 test, which examines the causal relationship between BDAC and SCI, was ($\beta = 0.684$, $t = 19.908$, $p < 0.001$); and the result of the H3 test was ($\beta = 0.198$, $t = 4.054, p < 0.001$).

Hypothesis	Relationship	Std. beta	Std. dev	*t*-value	*p*-value	BCI LL	BCI UL	f^2
H1	BDAC → SCP	0.378	0.053	7.101	$p < 0.001$	0.283	0.458	0.19
H2	BDAC → SCI	0.684	0.034	19.908	$p < 0.001$	0.619	0.734	0.88
H3	SCI → SCP	0.198	0.049	4.054	$p < 0.001$	0.120	0.283	0.06
H4	BDAC→ SCI → SCP	0.136	0.034	3.931	$p < 0.001$	0.082	0.193	
H5	SCI*DDC → SCP	0.045	0.017	2.721	0.003	0.021	0.075	0.02

Table 5.
Hypotheses testing

To test the moderated–mediated model, we calculated the indirect effect of the mediator construct, which represents SCI in the relationship between BDAC and SCP. The result of the H4 test was ($\beta = 0.136$, $t = 3.931$, $p < 0.001$). Preacher and Hayes (2008) suggested using the mediation test through the confidence interval at a confidence level of 95% and showed that mediation is achieved if the confidence interval is positive or negative (i.e. zero does not enter between the two intervals). Table 5 shows all confidence intervals that did not contain zero. Therefore, SCI can be said to mediate the positive relationship between BDAC and SCP. H5 was supported because DDC moderates the relationship between SCI and SCP, with a moderating effect of ($\beta = 0.045$, $t = 2.721$, $p < 0.01$).

Figure 2 shows that at the higher levels of DDC, the relationship between SCI and SCP is stronger compared to the lower levels. We calculated the value of R^2 (the goodness-of-fit measure for linear regression models) as 0.468 for the relationship between BDAC and SCI and 0.714 for all exogenous constructs. These values indicated the model's medium and high predictive power (Hair *et al.*, 2019), so the values of the corresponding variance in endogenous constructs were 46.8 and 71.4%, respectively. We evaluated the fit of the model by calculating the standardized root mean square residual values, which were less than 0.08, indicating that we achieved the fit of the model in our test (Hair *et al.*, 2019).

We assessed the out-of-sample prediction with the PLSpredict algorithm (Shmueli *et al.*, 2019) using a 10-fold and 10-repetition cross-validation procedure. Table 6 presents the results. The PLS-LM values and root mean square error (RMSE) values were negative, so we concluded that the model has high predictive power.

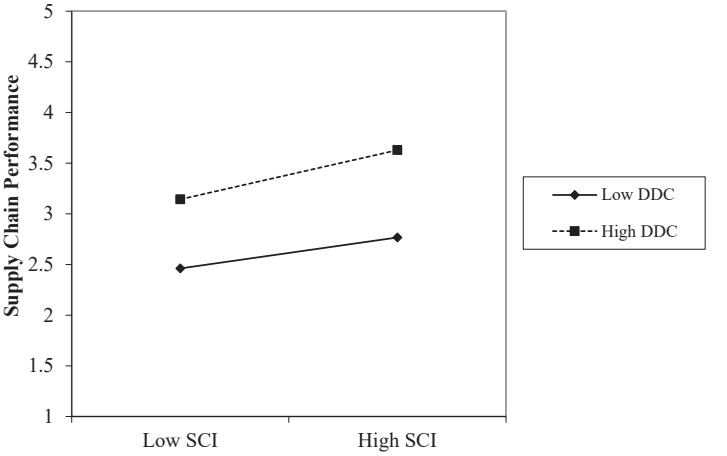

Figure 2.
Moderating effect of data-driven culture on the SCI and SCP relationship

	PLS		LM		PLS-LM	
MV	RMSE	MAE	RMSE	MAE	RMSE	MAE
SCP1	0.694	0.486	0.700	0.476	−0.006	0.010
SCP3	0.711	0.502	0.730	0.510	−0.019	−0.008
SCP4	0.717	0.521	0.721	0.527	−0.004	−0.006
SCP5	0.800	0.593	0.804	0.594	−0.004	−0.001

Table 6.
PLS-predict

5. Discussion

In this study we aimed to identify the impact of BDAC on the SCP in the Jordanian manufacturing sector and the mediating role of SCI and moderating role of DDC. The COVID-19 pandemic acutely disrupted the Jordanian economy's SCs and the country's organisational ability to respond to it (Al-Omoush *et al.*, 2022) and affected sustainable green SCP in the country's manufacturing sector (AL-Khatib and Shuhaiber, 2022).

In the empirical results of our study, all direct hypotheses (H1, H2 and H3) were accepted, which confirmed the positive role of all exogenous constructs. We found that BDAC positively affected SCP in the Jordanian manufacturing sector, a result consistent with several studies in the SCM literature (Dubey *et al.*, 2018; Kalaitzi and Tsolakis, 2022; Mandal, 2018; Seyedan and Mafakheri, 2020; Xiang *et al.*, 2021). These studies emphasized that BDA enhance operational excellence through using processed BD in decision-making (Chae *et al.*, 2014). BDA play an effective role in improving SCP by providing new predictive models and new information that can be used to enhance the efficiency of operations within the SC. BDA can also be used to reduce potential risks (Wang *et al.*, 2016). BDA can provide a new understanding of environmental changes and analysis of supply and demand, leading to positive effects on SCP (Bahrami *et al.*, 2022).

Our study revealed that BDAC enhances SCP in the manufacturing sector. Our results agreed with several studies in the literature (Bahrami *et al.*, 2022; Lee and Mangalaraj, 2022; Ogbuke *et al.*, 2022; Shamout, 2019; Tan *et al.*, 2015), indicating that BDA can introduce new models of innovation by increasing integration within the SC and improving the flow of information, which leads to increased innovative capabilities in the SC (Hunold and Shekhar, 2022) and value creation for end customers (Liu *et al.*, 2022). Firms can benefit from BDA in generating new business strategies that allow for identifying and correcting errors and reducing waste in manufacturing and transportation processes (Ogbuke *et al.*, 2022; Shamout, 2019). BDA also analyse stakeholder data to increase homogeneity within the SC (Müller and Jensen, 2017), leading to innovations within the SC.

The results indicated that SCI enhances SCP because SCI enables an increase in SC capabilities (Sunil, 2019; Wamba and Queiroz, 2022), leading to assistance in the exchange of experiences, skills and knowledge in the SC and improvement of SCP (Abdallah *et al.*, 2021; Gloet and Samson, 2022). The SC can benefit from SCI by integrating tangible and intangible resources within the SC, which leads to process and logistics innovation that supports SCP (Kabadurmu, 2020).

In addition, SCI plays a mediating role in the relationship between BDAC and SCP through data analysis. Our study results are consistent with those of Abdallah *et al.* (2021), Ayoub and Abdallah (2019) and Bahrami *et al.* (2022), which showed the positive role of SCI mediation. BDA provide a rich knowledge base through BD, which may lead to increased levels of innovation (Lai *et al.*, 2018) and firms to thus employ these innovations within the SC, leading to improved SCP (Shamout, 2020).

Finally, our results confirmed the acceptance of the moderated–mediated model; all relationships were statistically significant. The moderating hypothesis related to DDC's role in the relationship between SCI and SCP was accepted, thus supporting the literature that examined the role of organisational culture as a soft force to improve performance and organisational excellence (Al-Khatib *et al.*, 2022). DDC helps firms disseminate data-oriented organisational values to support top management initiatives towards BDA and thus derive benefit from these initiatives in promoting SCI (Rodrigues *et al.*, 2021; Yu *et al.*, 2021). DDC can help firms achieve business value by properly exploiting information extracted through BD (Chaudhuri *et al.*, 2021) and can support management in improving SCP (Li and Liu, 2019) by supporting the promotion of innovative values in the SC (Fernando *et al.*, 2018; Karaboğa *et al.*, 2019; Mondal and Samaddar, 2021), which leads to improved performance.

6. Implications and conclusion

6.1 Implications for theory

Our study has numerous theoretical implications. Our main contribution to the literature was our study of moderated–mediated models for both SCI and DDC in the relationship between BDAC and SCP in the setting of the Jordanian manufacturing sector. Thus, we provided three new theoretical insights through the moderated–mediated model.

First, we provided a greater understanding of how firms can exploit BDA in the SC. They can use their organisational data-oriented capabilities to improve SCP by improving their operational efficiency, reducing potential risks (Seyedan and Mafakheri, 2020; Xiang *et al.*, 2021) and adding new value to increase customer satisfaction with products (Kalaitzi and Tsolakis, 2022).

Second, we provided a greater understanding of the contribution of SCI to improving SCP. Using BDA will contribute to raising SCI levels and improving performance (Bahrami *et al.*, 2022; Ogbuke *et al.*, 2022; Shamout, 2019).

Third, we provided a new understanding of the organisational culture in the SC and of how to exploit DDC to improve SCP by improving innovation in the SC (Li and Liu, 2019). In realizing data analysis results that support the moderated–mediated model, our study has provided a new understanding of the technological, organisational, innovative and cultural factors that improve the SCP in the Jordanian manufacturing sector.

In our study we have contributed new theoretical and managerial insights that add value to the SCM literature by testing the moderated–mediated model of constructs in the Jordanian manufacturing sector in the light of RBV theory.

6.2 Implications for practice

Our study has several implications for SC managers. First, our results support the causal effects in the relationship between BDAC on SCP. We therefore recommend that SC managers in manufacturing firms invest in BDA technology and applications and keep up with the latest developments in this technology. Moreover, we recommend that managers concentrate on developing SC capabilities to deal routinely with BD and build organisational capabilities capable of exchanging information extracted from BD with all parties within the SC. We also recommend they use BDA in collaborative planning, open innovation initiatives and inventory management. SC managers can also work on using data collected through Internet of things applications and radio-frequency identification systems to improve SCP and use this data to provide new logistics operations.

Second, our results revealed that BDAC enhances SCI, so managers in manufacturing firms can enhance innovation by using new insights extracted from BDA to generate new ideas and innovations in manufacturing processes and transferring products. Moreover, SC managers should use BDA to increase the experience, knowledge and skills of individuals working within SC units, which increases their exchange of new knowledge and thus raises innovation capabilities in the SC.

Third, our results confirmed that SCI enhances SCP and mediates the positive relationship between BDAC and SCP. Therefore, SC managers in manufacturing firms should invest in BDA initiatives and focus on innovation within the SC as one of the most important outputs of BDA in improving SCP. We recommend that SC managers develop logistics operations in the SC by using BD to enhance SC agility, which may reduce the negative effects of any uncertain environments the SC may face.

Finally, our results showed that DDC moderates the positive relationship between SCI and SCP. Therefore, managers in manufacturing firms should promote data-oriented organizational values and build an organizational culture that focuses on exploiting organizational capabilities directed toward BD. Such a culture enables the SC to exploit and

exchange information with the SC parties and use it to increase innovation, leading to improved and increased SCP.

6.3 Limitations and future directions

Despite arriving at a set of interesting results, our study has the following limitations that must be taken into consideration when making generalisations about the results: First: conducted our study in the context of the Jordanian manufacturing sector without taking into account the homogeneity in the industrial, pharmaceutical and food sectors. Thus, it would be useful to conduct a study that defines the manufacturing sector more specifically. Second, we used a self-administered questionnaire to collect our data, which included cross-sectional correlational variables. Therefore, the results of the data analysis and relationships between constructs are not conclusive. Thus, it would be useful to conduct future studies that collect other types of data, such as longitudinal or panel data. Third, we used the deductive–quantitative approach in conducting hypotheses testing but ignored qualitative approaches. Therefore, future scholars should use interviews or mixed methods in collecting their data. Fourth, we conducted our study in one sector and one country. Therefore, we recommend that further studies cover wider contexts, countries and cultures to enable scholars and SC managers to understand the causal relationships between constructs more comprehensively. Although we conducted our study in the manufacturing sector of a developing country, we recommend that our conceptual model be used in other contexts, such as in developed countries, to come up with new insights related to the applications of Industry 4.0 that may enrich the literature related to BDA, SCs and innovation. Finally, we suggest using other constructs in future studies on green SC innovation, intellectual capital and sustainable SCP, for example.

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