

# The impact of business intelligence and digital supply chain capabilities on sustainable supply chain performance in Jordanian industrial companies: the mediating role of operational efficiency

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## Abstract

The growing pressure of industrial companies to improve their sustainability performance increased the necessity of digital-oriented transformation of the supply chain. The proposed research considers the role of business intelligence and digital supply chain capabilities in sustainable supply chain performance in the presence of operational efficiency as a mediator variable in the framework of Jordanian industrial companies. Based on the resource-based view and the dynamic capabilities theory, the quantitative research design was conducted with the cross-sectional survey. The data of 345 managers and employees with supervisor-levels of work in Jordanian industrial companies were gathered and analyzed with the help of the partial least squares structural equation modeling (PLS-SEM). The empirical findings indicate that the business intelligence and digital supply chain capabilities have positive impacts of significant magnitude on the operational efficiency and sustainable supply chain performance. In turn, the impact of operational efficiency is shown to be the most positive on sustainable supply chain performance as it indicates its key role in fulfilling economic, environmental, and social outcomes. Moreover, the mediation analysis proves that operational efficiency is one of the mediators of the relations between both digital capabilities and sustainable supply chain performance, which means that digital technologies facilitate sustainability in both direct and indirect ways, through the enhancement of internal operations. The results offer a practical demonstration of the fact that digital transformation efforts are beneficial in terms of increasing sustainability when properly combined with effective working procedures. This study explains how digital capabilities improve sustainable supply chain performance and provides practical implications for aligning digitalization with sustainability goals.

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**Keywords:** Business intelligence, Digital supply chain capabilities, Operational efficiency, Sustainable supply chain performance, Jordanian industrial companies



## 1. Introduction

The fast development of digital technologies has deeply changed the supply chain management, especially in the industrial fields which work under the pressure of the growing competition and sustainability [1]. Global supply chains are no longer measured solely by cost efficiency and responsiveness; organizations are now required to achieve sustainable supply chain performance by meeting economic, environmental, and social goals concurrently. [2], [3]. As part of this transforming environment, the concept of digitalization has become an important facilitator that is required to sustain transparency, coordination, and long-term sustainability throughout the supply chain networks [4].

Business intelligence (BI) systems are also among the most influential digital enablers that can reshape the capabilities of organizational decision-making by converting large volumes of data used in operations into actionable information [5]. BI tools are used to conduct real-time monitoring, predictive analytics, and performance evaluation to support the response of companies to disruption and to optimize operational results [6]. According to the existing literature, BI implementation would impact the efficiency of organizations, cost management, and strategic alignment in a positive way, especially in industrial settings relying on large amounts of data [7]. Nevertheless, there is little and fragmented empirical data that can connect BI directly to sustainable supply chain performance (SSCP).

Simultaneously, digital supply chain capabilities (DSCCs), such as data integration, smart systems, digital tracking, and advanced analytics were becoming more prominent as the necessary drivers of the digital transformation of the supply chain [8]. Such features can help to increase end-to-end visibility, supply chain partner coordination, and real-time responsiveness, which increases control over operations and resilience [9]. Digital supply chains allow organizations to minimize waste, manage the resources more efficiently, and increase the environmental performance with a higher level of monitoring and preemptive planning [10]. Although these are the advantages, the literature has not given a complete explanation on how digital supply chain capabilities can be converted into sustainable performance outcomes especially in terms of internal operation [11].

Operational efficiency is a significant internal process through which digital technologies can influence sustainability. [12], [13]. Operational efficiency contributes to the capability of an organization to reduce costs, speed up operations, wastage, and exploit resources to the fullest possible value [14], [15]. BI and DSCCs are digital technologies that facilitate the optimization of the operational processes, allow monitoring performance in real-time, and make informed managerial decisions [16], [17]. Good operational performance benefits economic performance and leads to environmental and social sustainability through decreasing emissions, energy use, and redundancies in the operations [18]. However, operational efficiency as a mediator of the linkage between DSCCs and SSCP is still under-researched in empirical studies.

Despite the increasing interest in digital transformation, limited empirical research has examined how business intelligence (BI) and digital supply chain capabilities (DSCCs) jointly influence sustainable supply chain performance (SSCP) through operational efficiency, particularly in emerging economies. This study addresses this gap by examining how BI and DSCCs affect SSCP, with operational efficiency as a mediating variable. The research is based on Jordanian industrial companies, which is an empirical setting that has had minimal academic coverage despite the severe digital transformation and sustainability issues. Jordanian industrial companies operate under the conditions of the shortage of resources, the high cost of energy, and the growing pressure to implement sustainable practices, which is why the digital-enabled efficiency can be essential to reach the sustainability goals.

Based on the resource-based view (RBV) and dynamic capabilities theory (DCT), the present study represents the BI and DSCCs as strategic organizational resources, which improve the sustainability of the supply chain by providing better operational efficiency [19], [20]. By empirically validating the proposed framework, this study contributes to existing literature in several ways. First, it extends prior research by providing a more

integrated perspective that examines business intelligence (BI) and digital supply chain capabilities (DSCCs) within a single model. Second, it offers a process-based understanding by highlighting the mediating role of operational efficiency in explaining how digital capabilities translate into sustainable supply chain performance (SSCP). Third, the study enriches the literature by providing empirical evidence from an emerging economy context, namely Jordan, where digital transformation and sustainability challenges are becoming more significant.

## **2. Literature review and hypotheses development**

### **2.1. Business intelligence and operational efficiency**

BI has evolved into fundamental analytical support structure that help organizations to convert scattered operational information into usable knowledge for decision-making, controlling processes, and managing performance [21], [22]. BI and analytics solutions support real-time reporting, descriptive and predictive analytics and performance dashboards to enable managers to identify cases of inefficiencies, enhance resource allocation, and react to the disruption of operations promptly [6], [23]. BI in the operational environment improves monitoring processes and visibility in functions which translate directly to the results of efficiency cycle time, lower cost, and throughput [24].

Under the RBV, BI can be conceptualized as a strategic resource and capability that enhances the competence of an organization in processing information and subsequently allows the organization to achieve better operational results compared to its competitors [19]. It has also been shown that BI-based information quality and analytical decision support enhance managerial performance and operational efficiency due to the opportunity to coordinate and improve processes and make decisions based on evidence [25]. On this basis, in the industrial context, where the routine operations, capacity usage, and cost management play a vital role, BI can have a beneficial impact on operational performance.

*H<sub>1</sub>*: Business intelligence (BI) has a positive effect on operational efficiency.

### **2.2. Digital supply chain capabilities and operational efficiency**

Digital supply chain capabilities (DSCCs) can be defined as the capacity of an organization to implement digital technologies, such as data integration, digital tracking, intelligent systems, and advanced analytics, to allow connectivity, visibility, and coordination between supply chain processes [26]. Digitalization increases the supply chain information flow, cross-functional planning, and operational execution accuracy and speed [27]. It minimizes variability of the processes and gains more efficient inventory management, scheduling, and logistics coordination [11].

The studies on supply chain integration have shown that the closer information and processes are coupled, the better the operational performance due to the enhanced alignment, fewer transaction frictions and responsiveness [28]. Moreover, research on smart and digital supply chains implies that digital technologies allow making decisions and controlling the work of supply chain nodes in real-time, and that these measures can enhance the efficiency of the supply chain by minimizing delays, wastage, and utilizing resources efficiently [29]. Moreover, digital supply chain management has also been linked to enhanced agility and responsiveness in operations, especially when it has analytical capabilities [18]. Thus, DSCCs can have a beneficial effect on efficiency in the operations of industrial companies.

*H<sub>2</sub>*: Digital supply chain capabilities (DSCCs) have a positive effect on operational efficiency.

### **2.3. Operational efficiency and sustainable supply chain performance**

Sustainable supply chain performance (SSCP) embodies the triple bottom line of supply chain performance, including economic, environmental, and social performance [30]. Supply chain sustainability has evolved into a performance-oriented sustainability approach rather than the compliance-based one, where profitability is balanced with environmental stewardship and social responsibility [31]. The literature on sustainable supply

chain management highlights the idea that companies can enhance sustainability performance through process redesign to minimize wastage, emissions, and resource usage without losing competitiveness in the economy [32].

On the other hand, efficient operations minimize redundant activities, energy consumption, and material waste, thereby enhancing cost performance and environmental indicators [33]. Simultaneously, improved efficiency can help in achieving better social-related results in terms of safer working conditions, more robust working operations, and enhanced reliability of the provided services [34]. According to empirical studies of green supply chains, there are improvements in processes and internal operations practices that lead to stronger environmental performance and, in most cases, an extended sustainability performance [35]. As a result, increased operational performance can have a positive effect on SSCP.

*H<sub>3</sub>*: Operational efficiency has a positive effect on sustainable supply chain performance (SSCP).

#### **2.4. The mediating role of operational efficiency**

Although BI and DSCCs are crucial digital assets, they indirectly affect the level of sustainability. The value generated by digital technologies is usually based on the possibility of optimizing the processes, improving coordination and quality of decisions, which must be first reflected in the efficiency of operations and then in the sustainability of the performance [36]. This reasoning is in line with the arguments of DCT, which suggest that organizations achieve better performance when they can sense, seize and reconfigure resources to enhance internal processes in changing environments [20]. In this context, BI and DSCCs contribute to the improvement of operational efficiency through the introduction of data-driven control and digital coordination, which, in turn, can support sustainability results [37].

Additionally, sustainability performance often entails changes at the operational level (e.g., the decrease in waste, the optimization of energy consumption, the enhancement of logistics efficiency) and not just the acquisition of a certain technology [38], [39]. Therefore, operational efficiency may act as an intermediary process between digital capabilities and SSCP [26]. The process-based perspective is supported by the previous studies: analytics and the digital integration process boost the working performance, which, in turn, positively influences the overall performance outcomes [40]. Accordingly, it is theorized that the indirect routes of BI and DSCCs to SSCP are through efficiency in operations.

*H<sub>4</sub>*: Operational efficiency mediates the relationship between business intelligence (BI) and sustainable supply chain performance (SSCP).

*H<sub>5</sub>*: Operational efficiency mediates the relationship between digital supply chain capabilities (DSCCs) and sustainable supply chain performance (SSCP).

#### **2.5 Conceptual framework**

This study develops a theoretical framework that explains the impact of digital-based innovative organizational capabilities on supply chain sustainability and their application in internal operations. The framework is based on the RBV and DCT, which illustrate BI and DSCCs as strategic assets that help organizations to process information, organize activities, and redesign supply chain processes according to the environmental and market positions. These digital abilities are anticipated to enhance operational efficiency through real-time visibility, making decisions based on data, integrating processes, and optimizing resources in all supply chain operations.

Operational efficiency is placed as a mediating factor that conveys digital abilities in the form of better SSCP. Effective operations enable the realization of low costs, less wastage, enhanced speed and reliability of processes, which pave way to economic performance, environmental sustainability, and social responsibility in the supply chains. Based on this, the framework hypothesizes that BI and DSCCs have indirect influences on SSCP through enhancing operational efficiency. The proposed framework explains how digital transformation enhances sustainability performance in Jordanian industrial companies by integrating digital capability theory with sustainable supply chain performance.

By explicitly linking digital capabilities to sustainability outcomes through an internal process-based pathway, the research model in Figure 1 provides a theoretically grounded and empirically testable approach. This framework builds upon already available literature on digital supply chain and sustainability by explaining how digital transformation efforts can lead to a sustainable supply chain performance of industrial companies in an emerging economy setting like Jordan.

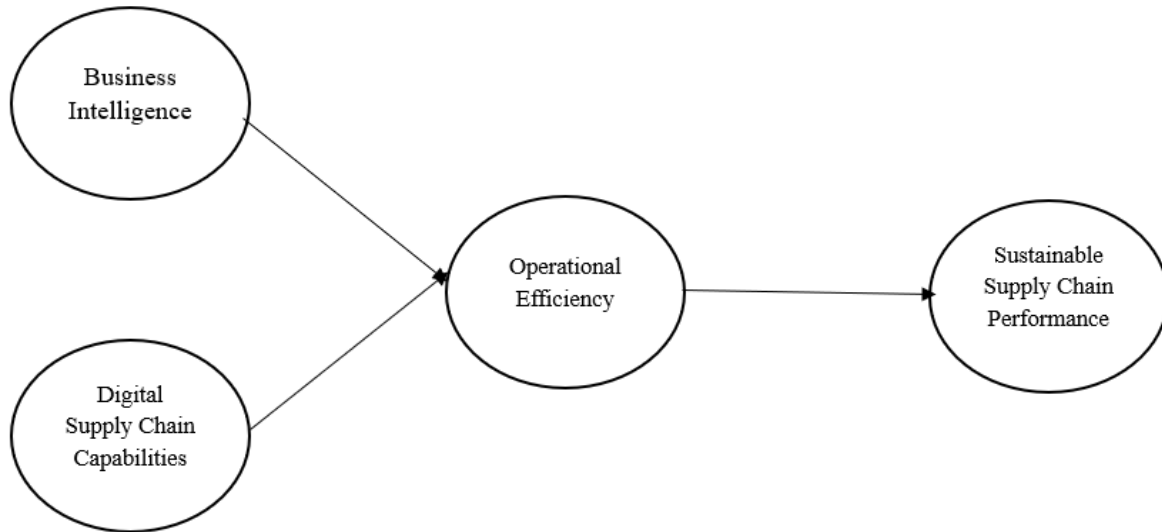


Figure 1. The conceptual model

### 3. Methodology

This study adopts a quantitative research design using a cross-sectional survey approach to examine the impact of BI and DSCCs on SSCP, with operational efficiency acting as a mediating variable, within Jordanian industrial companies. A quantitative approach is appropriate for this research as it enables the empirical testing of theoretically derived relationships among latent constructs and allows for the examination of direct and indirect effects using structural equation modeling (SEM) techniques [41].

The target group of the study consists of industrial companies operating in Jordan across different manufacturing sectors, including food processing, pharmaceuticals, chemicals, construction materials, and consumer goods. These companies were selected due to their increasing reliance on digital technologies and their growing need to improve operational and sustainability performance under competitive and regulatory pressures. The unit of analysis comprises managers and supervisory-level employees who are directly involved in supply chain activities, digital systems, and operational decision-making, as they are considered the most relevant respondents regarding the practices examined in this study.

A purposive sampling technique was employed to ensure that data was collected from respondents with relevant experience and sufficient knowledge of supply chain operations and digital practices. A total of 345 valid questionnaires were obtained and used for data analysis. This sample size is adequate for the application of partial least squares structural equation modeling (PLS-SEM), as it exceeds the minimum requirements for models that include multiple constructs and mediation relationships [42]. The sample size achieved provides sufficient statistical power to estimate model parameters and to test the proposed hypotheses.

The measurement instruments used in this study were adapted from established and validated scales in prior research to ensure content validity. BI was measured using items that capture the organization's ability to collect, analyze, and utilize data to support operational and strategic decision-making, drawing on Chen et al. [43] and Popovič et al. [44]. DSCCs were measured through indicators reflecting data integration, digital tracking, intelligent systems, and advanced analytics within supply chain processes, based on Wu et al. [45] and Ivanov et al. [46]. Operational efficiency was assessed using items related to cost reduction, process speed, waste minimization, and efficient resource utilization, consistent with Flynn et al. [47] and Dubey et al. [48].

SSCP was operationalized using measures that capture economic, environmental, and social performance dimensions, adapted from Carter & Rogers [49] and Zhu et al. [50]. All constructs were measured using a Likert-type scale to capture respondents' perceptions of organizational practices and performance.

Data were collected through a structured questionnaire distributed to respondents in Jordanian industrial companies over a specified data collection period. Prior to the main survey, the questionnaire was reviewed by academic experts and industry practitioners to ensure clarity, relevance, and contextual suitability. Respondents were informed about the purpose of the study and assured of confidentiality and anonymity to encourage honest and unbiased responses. Participation was voluntary, and no identifying information was collected.

The data collected were analyzed using PLS-SEM with Smart-PLS software. This technique was selected due to its suitability for examining complex research models that include mediating relationships and its robustness in handling non-normal data distributions [51]. The analysis followed a two-stage procedure. First, the measurement model was assessed to evaluate indicator reliability, internal consistency reliability, convergent validity, and discriminant validity [52]. Second, the structural model was examined to test the hypothesized relationships by analyzing path coefficients, coefficients of determination ( $R^2$ ), and the significance of direct and indirect effects [53]. The mediating role of operational efficiency was assessed using a bootstrapping procedure with 5,000 resamples to determine the significance of indirect effects. To assess the potential for common method bias (CMB), Harman's single-factor test was conducted. The results indicated that a single factor did not account for the majority of the variance. Additionally, full collinearity VIF values were below the threshold of 3.3, suggesting that CMB is not a serious concern.

#### 4. Data analysis and results

To evaluate the measurement and structural models, the analysis of data was done using PLS-SEM with Smart-PLS package. This method was used to assess reliability and validity of the measurement scales and test the hypothesized relationships between the study variables. The analysis was done in a two-stage process. Firstly, the measurement model was tested to test the indicator reliability, internal consistency reliability, convergent validity, and the discriminant validation. Second, structural model was tested to examine path coefficients, coefficient of determination ( $R^2$ ), and significance of both direct and indirect effects off a bootstrapping test with 5,000 resamples.

##### 4.1. Business intelligence and operational efficiency

The measurement model was tested to verify the reliability and validity of the constructs that are contained in the study. This evaluation was aimed at looking at the reliability of indicators, internal consistency reliability as well as convergent validity. The factor loadings were used to assess indicator reliability, and it was concluded that all the measurement items were loaded well on their respective constructs and beyond acceptable threshold. The Cronbach alpha and composite reliability indices ( $\rho$  and  $\rho_c$ ) were used to determine the internal consistency reliability, and all of them revealed good levels of reliability. Convergent validity was evaluated based on the average variance extracted (AVE) with all the constructs having scores of over the recommended minimum indicating that a large percentage of the variance in the indicators is attributed to the underlying constructs. Overall, the findings indicate that measurement models have sufficient reliability and convergent validity, which proves its appropriateness in the future, structural model analysis. Accordingly, Table 1 presents the measurement model results.

Table 1. Measurement model results

Construct	Item	Loading	Cronbach's alpha	CR ( $\rho_a$ )	CR ( $\rho_c$ )	AVE
Business intelligence (BI)	BI_1	0.827	0.894	0.898	0.922	0.703
	BI_2	0.826				
	BI_3	0.847				

Construct	Item	Loading	Cronbach's alpha	CR ( $\rho_a$ )	CR ( $\rho_c$ )	AVE
Digital supply chain capabilities (DSCC)	BI_4	0.875	0.804	0.814	0.872	0.630
	BI_5	0.816				
	DSCC_1	0.847				
	DSCC_2	0.767				
	DSCC_3	0.730				
Operational efficiency	DSCC_4	0.826	0.855	0.874	0.896	0.636
	OE_1	0.837				
	OE_2	0.613				
	OE_3	0.840				
	OE_4	0.834				
Sustainable supply chain performance (SSCP)	OE_5	0.839	0.880	0.884	0.912	0.676
	SSCP_1	0.810				
	SSCP_2	0.822				
	SSCP_3	0.795				
	SSCP_4	0.840				
	SSCP_5	0.841				

As seen in the results in Table 1, all items used to measure their constructs have satisfactory factor loading. Reliability analysis indicates that the Cronbach alpha and the composite reliability values of all the constructs are above the recommended value, and this indicates sufficient internal consistency. Besides, the values of the average variance extracted (AVE) are above the recommended threshold, which demonstrates a high level of convergent validity. Such results confirm that measurement model is reliable and valid and thus it can be further analyzed to the structural model.

Figure 2 shows the measurement model of the results. Although one indicator (OE\_2 = 0.613) is slightly below the preferred threshold of 0.70, it was retained as it exceeds the minimum acceptable level of 0.60 and does not adversely affect the reliability and validity of the construct.

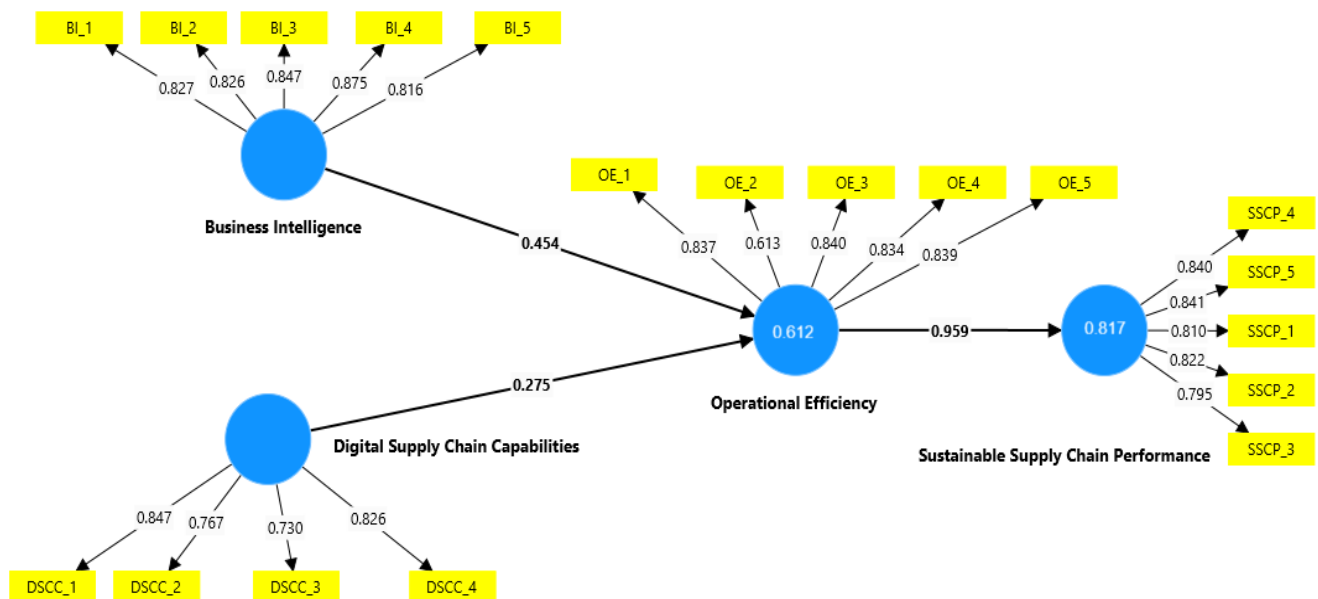


Figure 2. Measurement model

#### 4.2. Discriminant validity (HTMT)

Heterotrait-monomethod ratio (HTMT) was used in testing the discriminant validity. As Table 2 indicates, all the HTMT values among the constructs are less than the recommended value of 0.85 [54], which implies that each construct is empirically different among the others. These results prove that the measurement model has sufficient discriminant validity and that the constructs have a unique feature of the underlying theoretical notions.

Table 2. Discriminant validity (HTMT)

	BI	DSCCs	Operational efficiency	SSCP
BI				
DSCCs	0.833			
Operational efficiency	0.784	0.807		
SSCP	0.792	0.825	0.782	

These findings of the HTMT also confirm the discriminant validity of the constructs since all the values do not surpass the critical value so that the measurement model does not have any multicollinearity issues at the construct level.

#### 4.3. Discriminant validity (Fornell–Larcker criterion)

Fornell-Larcker criterion was also used to assess discriminant validity [55]. It is in line with this approach that the square root of the average variance extracted (AVE) of a single construct should be higher than the correlations of that specific construct with other constructs. As is stated in Table 3, the diagonal values, which are the square roots of AVE, are large than the inter-construct correlation in each case. The above results imply that each construct has more variance with the indicators it has as compared to other constructs within the model. In this connection, the Fornell Larcker criterion proves the sufficient discriminant validity and promotes the uniqueness of study constructs.

Table 3. Discriminant validity results (Fornell–Larcker criterion)

	BI	DSCCs	Operational efficiency	SSCP
BI	0.889			
DSCCs	0.783	0.794		
Operational efficiency	0.697	0.676	0.798	
SSCP	0.710	0.696	0.659	0.722

The Fornell-Larcker findings are also in line with the HTMT analysis and are used to further confirm that discriminant validity is achieved in all the constructs incorporated into the model [55].

#### 4.4. Structural model assessment and hypotheses testing

The structural model was evaluated to test the proposed relationships between BI, DSCCs, operational efficiency, and SSCP. The analysis was aimed at estimating the importance and robustness of the path coefficients based on bootstrapping procedure. All the suggested relationships are statistically significant (i.e., Table 4), which provides strong empirical support of the structural model. Collinearity diagnostics were assessed using variance inflation factor (VIF) values. The results indicate that all VIF values were below the recommended threshold of 5, suggesting that multicollinearity is not a serious concern in this study.

The findings indicate that BI has a positive and significant influence on operational efficiency ( $\beta = 0.454$ ,  $p < 0.001$ ) which means that data-driven analytical processes have a large impact on enhancing the operational performance. BI also exhibits a positive impact on SSCP that is direct ( $\beta = 0.435$ ,  $p < 0.001$ ), indicating that the practical utilization of organizational data leads to improved sustainability outcomes compared to operational

outcomes. Equally, DSCCs potentials have a positive impact on operational efficiency ( $\beta = 0.275$ ,  $p < 0.001$ ), which shows the importance of digital integration, tracking, and analytics in enhancing coordination of processes and use of resources. The direct influence of DSCCs on SSCP is also high ( $\beta = 0.263$ ,  $p < 0.001$ ) and validates its role in driving economic, environmental, and social performance outcomes.

Moreover, there is a strong and significant impact of operational efficiency on sustainable supply chain performance ( $\beta = 0.959$ ,  $p < 0.001$ ). This finding highlights the importance of effective operations to attain sustainability goals, and it implies that cost efficiency improvement, speed of processes, reduction in wastage, and optimization of resources are the primary forces of SSCP.

Altogether, the structural model findings are solid empirical evidence in supporting the suggested hypotheses and proving the value of BI, DSCCs, and operational effectiveness to SSCP. The exceptionally high path coefficient between operational efficiency and SSCP ( $\beta = 0.959$ ) should be interpreted with caution. This strong relationship may indicate conceptual proximity between the constructs, as operational efficiency directly contributes to economic, environmental, and social performance outcomes. It may also reflect the nature of industrial firms, where efficiency improvements are closely tied to sustainability performance.

Table 4. Structural model results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics ( O/STDEV )	P values	Decision
BI → Operational efficiency	0.454	0.450	0.072	6.352	0.000	Supported
BI → SSCP	0.435	0.431	0.069	6.329	0.000	Supported
DSCCs → Operational efficiency	0.275	0.281	0.065	4.228	0.000	Supported
DSCCs → SSCP	0.263	0.269	0.062	4.228	0.000	Supported
Operational efficiency → SSCP	0.959	0.959	0.004	3.007	0.000	Supported

As the results show, all the hypothesis paths are positive and significant, yielding empirical evidence about the structure of relationships.

#### 4.5. Mediation analysis (indirect effects and VAF)

The indirect influences of BI and DSCCs on SSCP through the operational efficiency were evaluated as the mediating role of operational efficiency. In PLS-SEM, it is considered that mediation has been made when the indirect effect (i.e., the multiplication of the effect between the independent variable and mediator as well as the multiplication of the effect between the mediator and the dependent variable) is significant and important. Secondly, VAF was also calculated to establish the strength of mediation effect by comparing the indirect factor to the overall effect [56].

Its findings show that BI has a positive indirect influence on SSCP through operational efficiency. In particular, the indirect effect of BI has been calculated as the product of the path coefficient between BI and operational efficiency and the path coefficient between operational efficiency and SSCP, which returned the indirect effect of 0.435 ( $0.454 \times 0.959$ ). Given that the direct impact of business intelligence on sustainable supply chain performance is positive and significant ( $\beta = 0.435$ ,  $p < 0.001$ ), it can be concluded to this mediation that operational efficiency directs a significant part of the effects, even though the impact is still present. The VAF of this relationship is 0.50 ( $0.435/0.870$ ) which means that operational efficiency accounts for about half of the overall influence of BI on SSCP.

In the same vein, DSCCs exhibit a positive indirect effect on SSCP through operational efficiency. The estimate of the indirect effect was 0.264 ( $0.275 \times 0.959$ ). Since the direct correlation between DSCCs and SSCP value is

also positive and significant ( $\beta = 0.263$ ,  $p < 0.001$ ), the mediation is considered partial mediation. The value of VAF of this relationship is 0.50 (0.264/0.527), which implies that the contribution of operational efficiency to the overall effect of DSCCs on SSCP is approximately half. In general, the results obtained can be summarized by stating that operational efficiency is one of the mechanisms in which DSCCs can be converted into SSCP.

Table 5. Mediation results (indirect effects, total effects, and VAF)

Relationship	Direct effect	Indirect effect (a×b)	Total effect	VAF	Mediation type
BI → Operational efficiency → SSCP	0.435	0.435 (0.454×0.959)	0.870	0.50	Partial mediation
DSCC → Operational efficiency → SSCP	0.263	0.264 (0.275×0.959)	0.527	0.50	Partial mediation

The results of the VAF reveal that the total effects can be attributed to operational efficiency by a significant percentage whereas the rest is held by significant direct paths, which substantiates some aspects of mediation in both the relationships.

## 5. Discussion

The results of the current research provide high empirical evidence regarding the importance of digital-driven capabilities in the improvement of SSCP at the Jordanian industrial companies. The findings indicate that BI and DSCCs play an important role in SSCP in both a direct and indirect way through operational efficiency. These results support the opinion that digital transformation initiatives create value not only due to the adoption of technology [57], but also because they can enhance internal processes of operation leading to the ultimate sustainability results.

The strong positive impact which BI has on operational efficiency supports the fact that the power of data-driven decisions is the key factor contributing to the enhancement of operational processes. BI systems allow real-time access to precise and combined information, which facilitate the processes monitoring, lower the uncertainty in operations and facilitates the allocation of resources more efficiently. The outcome concurs with the previous studies that emphasize the role of analytical capabilities in enhancing organizational efficiency through better coordination and managerial responsiveness [58]. BI seems to be a major facilitator of efficient operations especially in the context of Jordanian industrial companies where cost-control and optimization of operations are of utmost importance considering the constraints on resource.

Moreover, the remarkable direct impact of BI on SSCP implies that analytical findings are not the only thing that leads to sustainability performance. This implies that BI helps in sustainability-oriented decision-making processes, including assessing the environmental footprint, social adherence, and economic and sustainability targets. The relevance of this finding to the strategic contribution of BI to the triple bottom line of sustainability, as well as its implications, expands the scope of previous research studies as it shows that the subject is also applicable in the context of emerging economic industry [59].

It is also notable that DSCCs have a positive impact on operational efficiency, which supports the significance of digital integration, tracking systems, and advanced analytics in streamlining supply chain operations. DSCCs create better visibility in the activities of the supply chain, decrease information silos, and enhance coordination among the internal operations and external partners. Such enhancements help in accelerated operations, less waste and better utilization of resources which are highly applicable to industrial companies in the dynamic and complex environments [14].

Moreover, the positive direct correlation between DSCCs and SSCP means that the concept of digitalization is directly related to sustainability. This result indicates that DSCCs help companies to track the environmental and social performance in a more efficient way, lessen emissions and material waste, and enhance the

transparency of the supply chain operations. These abilities are becoming more significant in the case of industrial companies under pressure in terms of regulation and stakeholder demands in terms of sustainability performance [60].

The most important discovery of this research is the high positive impact of operational efficiency on SSCP. These findings underline operational efficiency as a key factor in sustainability performance, which proves that cost-saving, faster operations of the process, reduction of waste, and use of resources are the focus of the implementation of economic, environmental, and social performance goals. This observation is in line with the argument that sustainability in supply chains is largely operational-based and relies extensively on the efficiency with which organizations manage internal processes [61].

The mediation analysis also proves that, in terms of relationships between BI and SSCP, along with the relationships between DSCCs and SSCP, operational efficiency is partially a mediating factor. These findings suggest that digital capabilities have both direct and indirect effects on sustainability by enhancing operations. The partial mediation indicates that the process of efficiency is one of the main transmission processes, but at the same time digital technologies bear an alternative impact on sustainability outcomes, including increased transparency and monitoring and strategic alignment of sustainability goals.

Overall, the results are a good indication of the theory underlying the research. According to the RBV, BI and DSCCs are valuable resources of the organization that has a positive performance. In DCT terms, these digital capabilities allow companies to detect signs of operational inefficiencies, exploit opportunities to improve the situation and adjust processes to have SSCP. The findings are relevant to the current body of literature as they provide a process-oriented description of how digital transformation initiatives may translate into sustainability results, especially in the case of industrial companies in emerging economies like Jordan.

### **5.1. Theoretical implications**

The research provides some significant theoretical implications that can contribute to the research on digital transformation, supply chain management, and sustainability. First, the findings can contribute to the accumulating literature that incorporates BI and DSCCs into SSCP. Although these digital capabilities have been commonly studied in isolation in the past, this research is novel in that it theoretically models their effects together and empirically demonstrates their interactions with the operational mechanism within the organization to determine sustainability outcomes.

Second, the study has good theoretical justification of the use of positioning operational efficiency as a central mediating variable between DSCCs and SSCP. Empirically validating this mediation, the findings go beyond simple direct-effect explanations and draw a process-based understanding of the way of how the digital resources are converted into sustainability outcomes. This adds to the literature on supply chain and information systems by explaining the internal routes on how digital technologies produce value, and hence the demand to have more explanatory processes as opposed to outcome-based models.

Third, findings can be generalized to the RBV because the findings prove that BI and DSCCs are strategic organizational resources that contribute to sustainable performance when they are used to their full potential via operational efficiency. Meanwhile, the results confirm the DCT by revealing that digital capabilities allow companies to identify areas of inefficiencies, use opportunities to enhance operational processes, and reform the process to attain SSCP. Regarding that, the research can connect the RBV and DCT by means of how fixed digital resources develop into dynamic performance outputs.

Lastly, this study contributes to sustainability and supply chain theory by providing empirical evidence in an emerging economy setting. Most previous research has focused on developed economies, but this study highlights theoretical links between digital capabilities, efficiency, and sustainability that are also relevant for industrial companies operating under resource limitations and institutional pressures. This enhances the contextual relevance of existing theories and the applicability of digital-driven sustainability models in developing and emerging markets.

## 5.2. Managerial implications

From a managerial perspective, the findings are easy to comprehend and act on by the decision-makers of industrial companies that are interested in improving SSCP. To start with, the managers must note that investments in BI systems are not IT projects but strategic implementation that will directly and indirectly influence the sustainability goals. Through the application of BI as a tool of real-time monitoring, predictive analytics and performance appraisal, managers will enhance operational decisions to be made and assist in economic, environmental, and social performances.

Second, the findings also emphasize the need to create DSCCs as a system, opposed to the individual adoption of digital tools. Managers are advancing towards integrating data and digital tracking and using advanced analytics throughout the supply chain as such features promote visibility, coordination, and responsiveness. The result of such integration is that companies can minimize waste, enhance inventory and logistics operation and enhance adherence to sustainability standards.

Third, the presence of a close link between operational efficiency and SSCP implies that sustainability strategies are supposed to be either cohesive or consistent with operational excellence programs. Process optimization, minimizing waste, and effective use of resources should be among the priorities of managers in terms of the sustainability programs. Instead of considering sustainability as a distinct or compliance-related operation, companies can attain greater results by integrating sustainability goals within the operation.

In addition, the partial mediating impact of operational efficiency implies that sustainability benefits can be achieved by managers through improvements in processes and strategic decision-making based on digital data. It also suggests that leadership must encourage the culture of data improvement that will contribute to the continuous enhancement of the processes, the cross-functional cooperation, and sustainability planning based on evidence. The crucial step in achieving the full potential of digital transformation is to train employees to utilize digital tools properly and analyze the insights they generate.

Lastly, to policymakers and industrial leaders, the results imply that the promotion of digital uptake and efficiency of the industrial sector can be significant in promoting national sustainability agendas. Certain incentives, supportive policies, and investments in digital infrastructure can assist industrial companies to take the opportunity offered by digital technologies to improve competitiveness and establish sustainable performance of supply chain in the long term.

## 6. Conclusion

This study focused on the research topic on the effect of BI and DSCCs on SSCP within the Jordanian industrial corporations using operational efficiency as an intermediate of operation. Using empirical evidence collected with the help of PLS-SEM, the results confirm that digital-driven capabilities are determinants in maximizing the sustainability outcomes both directly and indirectly by increasing the operational efficiency.

The findings can be used to prove that BI and DSCCs are highly effective in enhancing the efficiency of operations, which, in turn, has remarkable influence on SSCP. In addition, the mediation analysis illustrates that the effect of operational efficiency intervenes in the relationships between digital capabilities and sustainability performance, which implies that the value of digital technologies is not only to enhance internal processes but also to support sustainability-oriented decision-making and performance improvement. The results highlight that the effective combination of digital technologies and operational excellence is one of the main factors of SSCP.

Overall, the study offers empirical evidence that the initiatives of digital transformation can become a strategic tool on the way towards economic, environmental, and social sustainability of industrial supply chains. The study focuses on the Jordanian industry and identifies the applicability of the digital-enabled efficiency and sustainability models to emerging markets with limited resources and a growing competition.

## **6.1. Limitations**

Although this work is considered a contribution, it also highlights several limitations that should be acknowledged. To begin with, the study was cross-sectional in nature, thus hindering causal conclusions or identifying how digital capabilities, operational efficiency, and sustainability performance may evolve over time. Longitudinal data would help gain more understanding of the way these relationships change as companies continue in their digital transformation processes.

Second, the paper was based on self-reported information that was gathered via a questionnaire, and it is prone to common method bias or subjectivity of respondents. As much as measurement scales were applied and statistical processes performed to maintain reliability and validity of the study, future researchers can strengthen the study by using objective performance measures or secondary sources of data.

Third, the empirical research narrowed down on the industrial companies in Jordan only. Although this background is very informative, the results might not be completely applicable to other industries or nations with different institutional, technological, or regulatory frameworks. Extending the results to other contexts of study should therefore be done carefully.

## **6.2. Future research directions**

Continuing from the limitations of this research, several directions for further research are proposed. Research studies that may be conducted in the future use longitudinal research designs to understand the interaction between DSCCs and operational efficiency through time to impact SSCP. These methods give a further dynamic insight into the outcomes of digital transformation and sustainability.

Also, future studies may consider other or additional mediating and moderating factors, including organizational culture, digital skills, supply chain resilience, or pressure of environmental regulation, to help in further clarification of how digital technologies affect sustainability performance. The analysis of these factors can make theoretical models more profound and provide a more detailed explanation of sustainability-driven digital transformation.

Lastly, it would be preferable to extend the study to other areas of research or cross-country comparative research to better ascertain the external validity of the results, as well as to get a better insight into the contextual differences. Comparison of the state of emerging and developed economies or manufacturing and service industries might yield valuable information on how the effectiveness of digital supply chain capabilities can be realized in terms of sustainable performance based on the institutional and technological environment.

## **Declaration of competing interest**

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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## **Author contribution**

The contribution to the paper is as follows: Areej Hijazin: data curation, investigation, review and editing; Tamara Adel Al-maaitah: conceptualization, methodology, formal analysis; Ahmad Khraiwish: methodology, software, validation; Saham Salman Alismail: original draft, supervision; Khaled Aldarabah: study review and

editing; Atef B. Al-Qur'an: resources, visualization, project administration. All authors approved the final version of the manuscript.

### Ethical approval statement

Our institutions do not require research ethics approval for reporting survey-based HR research.

### Informed consent

Informed consent was obtained from all individual participants involved in the study prior to data collection.

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