IMPACT OF ADVANCED TECHNOLOGIES ON SUPPLY CHAIN MANAGEMENT: LEGAL CHALLENGES AND INTEGRATION STRATEGIES

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Abstract

The study aims to describe how artificial intelligence (AI), big data analytics (BDA), and business intelligence (BI) are redefining the game of supply chain management (SCM): making it responsive, efficient, and quick to make decisions. It points to the fact that BI can massively improve the quality of decisions and operational efficiency, particularly on scalable cloud frameworks in a sampled survey of 526 supply chain managers across the Middle East and North Africa (MENA) region. On the other hand, it enumerates some challenges like a high cost of implementation and a lack of skilled personnel as major obstacles to the usage of BI by small and medium-sized enterprises (SMEs) (Ramadan et al., 2024) The results thus advise the use of BI in a balanced way: integration of BI findings with human judgment should yield the best decisions without excessive reliance on automated systems. Eventually, this will outline strategic means of balancing the benefits of technology with cost constraints in response to scalability needs. The following insights, within this study, take a pragmatic approach toward guides on how BI, AI, and BDA can effectively support supply chains to be resilient, productive, and agile (Ashal & Morshed, 2024).

Keywords: Big Data, Artificial Intelligence, Business Intelligence, Supply Chain Efficiency, Financial Investment, Scalability, Decision-Making Quality, Hybrid Approach

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1. INTRODUCTION

The technological advancements have bestowed on supply chain management (SCM) the strength to rise in terms of both efficiency and competitive advantage, through tools and technologies such as artificial intelligence (AI), big data analytics (BDA), and business intelligence (BI). The mentioned tools help in strategic decision-making and improvement of logistics management, inventory overview, and customer service. Recent research has shown how BI can optimize SCM operations through the processing

of data for better decision-making and responsiveness (Al-Radaideh et al., 2023; Mohammed et al., 2024; Seddigh et al., 2023). However, very little has been understood about the practical integration of BI, especially for small and medium enterprises (SMEs), which face barriers to high financial investment and a need for technical expertise (Lateef & Keikhosrokiani, 2023). The challenges also pertain to data reliability maintenance to avoid flawed decisions and over-reliance on BI, which may reduce professional judgment (Verma et al., 2023). No comprehensive framework exists in the literature that addresses these issues, especially solutions tailored to the scalability and cost constraints of SMEs.

This research tries to address these gaps by investigating the impact of AI, BDA, and BI on SCM, focusing on advantages, challenges, and integration strategies. It hypothesizes that these technologies enhance the efficiency of SCM and decision-making to a great extent, but are hampered by financial costs, technical complexity, and over-reliance on automated systems. It also extends the discussion to scalable cloud-based solutions and hybrid models, combining human expertise with BI insights, by proposing effective implementation strategies across organizations of different sizes.

Methodologically, the structured quantitative survey on 526 SCM managers in the Middle East and North Africa (MENA) region is designed to analyze inter-relationships among BI adoption, decision quality, scalability, and cost constraints. These findings reveal that the hybrid approaches are significant in improving SCM performance and provide practical strategies to balance technological adoption with organizational cost considerations. This paper contributes to the literature by introducing a scalable hybrid framework that makes advanced technologies accessible and effective for organizations of all sizes.

The structure of this paper is as follows. Section 2 reviews the literature, Section 3 outlines the methodology, Section 4 presents the results, Section 5 discusses the findings, and Section 6 concludes with recommendations and future directions.

2. LITERATURE REVIEW

Recently, AI, BDA, and BI have hugely changed the way SCM is a discipline area toward organizational efficacy and competitive advantage. This helps to come up with strategic decisions and to navigate the current dynamic markets. However, with the speed at which technology has been adopted in the world, this comes with its set of challenges that should be managed best to ensure sustainability.

BI enables better decision-making in SCM by providing logistics, inventory management, and customer service optimization through the processing of data in huge volumes (Al-Radaideh et al., 2023; Mohammed et al., 2024; Seddigh et al., 2023). This is vital for operational efficiency and quick responsiveness to supply chain disturbances (Aljohani, 2023; Xue et al., 2023). However, the implementation of BI systems can be very costly, and much technical expertise is needed in this context (Lateef & Keikhosrokiani, 2023). The reliability of data used in the BI system is important; an overreliance on potentially non-representative data sets can give rise to strategic decisions that are flawed and can impair business integrity and competitiveness (Verma et al., 2023).

From a financial point of view, BI is majorly related to the potentiality of cost reduction by identifying the inefficiencies in the system or organization (Ali & Morshed, 2024). However, the costs of having the BI might be very high, especially for small-scale enterprises (Lejarza et al., 2021; Patil et al., 2023). Cost-benefit analysis catered to different business scales is essential for the justification of investment in BI. The primary solution to the problem of BI is cloud-based solutions that are more accessible and cost-effective for companies in providing scalability and reducing upfront costs.

Occasionally, integration of the BI system with the existing information technology (IT) infrastructure proved to be a challenging task in itself, which might affect the reliability of the system and increase the operational risks involved at the same time (Tan et al., 2023). Real-time monitoring with BI ensures better operational performance and workflow efficiency through such technologies as barcode scanners and mobile devices (Chauhan et al., 2023; Fernando et al., 2023). While these are advantageous, the current state of affairs has raised concerns regarding decision fatigue, information overload, and system errors, among others (Singh et al., 2022). BI tools have improved resource allocation and budgeting techniques in human resource and financial management (Haase et al., 2023). On the other hand, such great reliance on BI in those areas reduces the role of professional judgment and intuition; hence, hybrid models that incorporate both BI and human supervision need to be established (Hussain et al., 2023).

In customer relations, BI augments the competitiveness of SCM through improved customer satisfaction and loyalty (Al-Okaily et al., 2023). However, the paper further argues that there may be one-size-fits-all strategies in standardized data-based strategies that fail since they may not satisfactorily meet diversified customer needs (Zambetti et al., 2023). In addressing those concerns further, advanced customer analytics and personalization strategies of BI systems ideally intend to develop more tailored customer experiences (Ashal & Morshed, 2024).

The above area of study reflects that in the field of SCM, advanced analytics and AI with human judgment are critical by integration, reflecting the transformative potential of these technologies to optimize operations. Advanced analytics and AI have a vast number of opportunities for enhancing the decision process within the realm of SCM. However, it takes all this promise into reality when it is complemented with human judgment (Morshed et al., 2024). However, the human role should always be one of oversight, making that strategic decision and interpreting the data within context (Narwane et al., 2021; Shah et al., 2023). The literature underscores the limitations of the prescriptive power of technology on its own; it is human expertise bringing the contextualized knowledge and more nuanced understanding so critical for balancing data-driven insight with practical know-how (Horani et al., 2023; Jreissat et al., 2024). This balance will be essential in making the decisions at hand effective in SCM, and there will not be huge risks associated with over-relying on technology.

In particular, incorporating BI, BDA, and AI in the current SCM has critical challenges, such as a lack of skilled personnel and organizational

resistance. Because the technologies come with strategic mixes of technical skills and contextual understanding during implementation, it is hard for organizations to maximize integrated systems fully (Shao et al., 2022). Overcoming these challenges requires a holistic approach in which training and skill development are streamlined according to the new technologies. Placing the human face to organizational change would make sure that the workforce becomes well-equipped to use such tools, further strengthening SCM efficiency and effectiveness overall (Althabatah et al., 2023; Tan & Sidhu, 2022).

However, overreliance on the data-driven approach without much-needed human insight poses several risks, including oversimplifying complex operational problems. The trouble lies in exaggerating the use of data to such an extent that standardized processes are developed that do not address the complexity of SCM (Ranjan & Foropon, 2021; Zhang et al., 2022). A balanced approach should therefore be advocated with both human insights and a data-driven analysis. Human judgment is important in placing data within a larger context of interpretation, where it gives the critical analysis that shields against over-simplification of the issues at hand and ensures the strategies are strong and effective (Cambra-Fierro et al., 2022; Thekkoote, 2022).

It is only by aligning data-driven technologies with a customer-centric strategy that SCM will result in increased operational efficiency yet satisfy customers. AI can guide organizations through data-driven insights while at the same time keeping a focus on customer satisfaction (Ahmad et al., 2023). Human judgment remains critical in deriving and operationalizing these insights for meeting customer needs effectively. The literature also advises that one size does not fit all, where a coherent narrative needs to be developed between data-driven insights and organizational value (Ranjan & Foropon, 2021; Zhang et al., 2022). The narrative ensures that technological advancements are embedded within the overall objectives and values of the organization toward developing a customer-centric culture, one that is more concerned with customers' satisfaction than just data-driven efficiency.

For the future, looking forward to SCM with AI, BDA, and BI is in a position to bring even more incredible advancements. Some of the possible innovations will include predictive analytics for demand forecasting, autonomous decision systems, and integration with the Internet of Things (IoT) for real-time monitoring, among others (Abdelmaboud et al., 2022). Also, it is worth mentioning that all these aspects must cover ethical and security-related issues, including data privacy and cyber security (Alajlan et al., 2023). Making BI solutions scalable and accessible to SMEs will be critical to democratizing these technologies (Morshed, 2024). Augmented analytics combines BI with AI to deliver automatically generated prepared data and insights, moving a step forward in making analytics available and actionable (Himeur et al., 2023).

In conclusion, the enormous benefits of integrating AI, BDA, and BI into SCM are there, but significant challenges have to be tackled. Proper balancing of technological developments with human expertise while making sure that the implementation is both ethical and scalable will allow the organizations to derive full benefits out of these technologies for SCM.

The legal challenges brought about by new technologies in supply chain management are regulated mainly by civil law. Contractual disputes, privacy violations, and liability issues — especially those pesky doctrines of negligence and strict liability — keep our leading civil litigation firms busy as AI, BI, and BDA transform not only supply chains, but also the entire global economy. Since Civil Code obligations always have the potential to overlap with laws of torts and contracts, intelligent companies do whatever it takes to establish clear compliance frameworks, legitimate assembly (BDA) and disassembly (reverse engineering), and enforceable non-compete agreements while operating their pretty smart supply chains.

The aim of this research is to study the impact of AI, BDA, and BI on SCM based on challenges and benefits that are shown during their implementation and suggest ways for effective integration of such solutions.

H1: The integration of artificial intelligence, big data analytics, and business intelligence positively influences the efficiency of supply chain management operations.

H2: The high initial and maintenance costs of business intelligence systems have a negative influence on their adoption by small and medium enterprises.

H3: The over-reliance on business intelligence systems negatively influences decision-making as they tend to disregard some very important qualitative factors.

H4: Cloud-based business intelligence solutions are positive influencers in the scalability and accessibility of advanced analytics tools for small and medium enterprises.

H5: A hybrid approach involving combined data-driven insights with human expertise positively influences decision-making in supply chain management and performance.

3. METHODOLOGY

This study is quantitative and seeks to find out how BI can impact SCM. This approach helps the results be more accurate and more profound.

The research has been structured based on a quantitative framework, which is very helpful for the survey-based design to collect the empirical data of the respondents. This design is perfect in terms of providing a proper analysis of the relationships between variables.

The participants in the study were 526 supply chain managers drawn from the MENA region with substantial experience in SCM and BI tools. Participants reported on their experiences and perceptions of using BI in SCM. Therefore, a sample size of 526 is large enough to ensure that the analysis performed is robust sufficient to provide high statistical significance, as required in structural equation modeling (SEM).

In this paper, the relationships between advanced technologies and SCM performance were analyzed by using SEM, since it had several advantages over other statistical methods. SEM suits complex and usually multivariate relationships, thus allowing both observed and latent variable modeling at the same time, given an important feature of the constructs on efficiency, scalability, and decision quality in SCM. The SEM also enables an overall model fit assessment using various fit indices, allowing in a stronger way than simpler regression or path analysis to validate the hypothesized

relationships. This approach allows for gaining a more nuanced understanding of how BI, AI, and BDA collectively drive SCM, providing deeper insights than other analytical methods would allow.

The quantitative data were collected between April 2023 and June 2023 using a more sophisticated questionnaire design from an advanced survey tool. In this study, the respondents are supply chain managers who gave empirical data based on experiences and their judgments. To analyze the data, the relationships between the variables established by conceptual/theoretical definitions will be tested with the software program AMOS, which is SEM software.

Quantitative data were collected using an advanced survey platform chosen for its range of design features and the ability to make contact with a large number of participants within the time frame available. The tool ensures quality data collection by improving respondent engagement and data integrity through its functionality. In line with this, the study integrated several measures to reduce potential biases in the survey responses. Among others, the survey design allowed respondents to make unbiased and honest responses by ensuring respondent anonymity. The survey used validated scales for measurements to enhance the reliability and validity of the data obtained. These were selected based on their use within similar research contexts.

The research identifies and operationalizes several critical variables in measuring how BI positively influences SCM:

- BI systems (*BI_Sys*): The use of BI tools and technologies is measured on a Likert scale, which evaluates the frequency and proportion of usage. For instance, 1 = never, 5 = always;
- Efficiency in SCM (*SCM_Eff*): Increased efficiency in logistics, inventory management, and customer service. This shall be gauged on a Likert scale questionnaire capturing perceived improvement in the levels of efficiency as a result of the BI implementation (e.g., 1 = strongly disagree, 5 = strongly agree);
- Financial investment (*Fin_Inv*): It is in monetary terms relating to BI systems implementation and maintenance. A Likert scale will be used to gauge the level of financial burden (e.g., 1 = very low, 5 = very high);
- Scalability and accessibility (*Scal_Acc*): Measuring the extent to which BI solutions are scalable and accessible, particularly about SMEs, as measured by a Likert scale, level of scalability and accessibility perceptions (e.g., 1 = strongly disagree; 5 = strongly agree);
- Decision-making quality (*Dec_Qual*): The impact of BI on decision quality in SCM, as measured by a Likert scale on decision-making quality (e.g., 1 = very poor; 5 = excellent);
- Hybrid approach (*Hybrid_App*): Integrating the data-driven insight with human expertise — effectiveness of the hybrid approach measured using a Likert scale that rates strongly disagree to agree strongly.

This should be compared with January 2023 through March 2023, followed up with planned April 2024 through June 2024. It will, therefore, be possible to have a dynamic view of the effects on SCM within one year concerning BI up to 2024. An approach capturing trends and patterns over time and furnishing insight into how the influence of BI on SCM evolves, hence capturing trends and patterns over time (Becker, 2024).

The research was quantitative, and the use of AMOS as a tool for SEM is seen to support hypothesis testing regarding the relationships between observed and latent variables. The application of this model in the present study is emphasized by validating the structural model using survey data. Unlike previous studies, this quantitative approach paves the way for applying a variety of analytical techniques that will offer the proper framework for understanding the effects of BI on SCM, ensuring a clear and correct interpretation and application of the said findings.

The primary data for the study were provided by the 526 supply chain managers from MENA through direct responses to the survey questions. The measured quantitative data include the use of BI tools, efficiency in SCM, return on investment (ROI), scalability, and accessibility, the quality of decision-making, and the effectiveness of the hybrid approach combining data-driven insights with human expertise. A survey instrument and validated scales were used in this study, building on the existing research in BI and SCM, as described above.

This detailed procedure ensures the validity and reliability of the study by guaranteeing the findings with robust methods for both data collection and analysis. Therefore, through this, the study ensures the validity and reliability of findings, offering a comprehensive understanding of BI has influence on SCM.

4. RESULTS

The paper explores how BI influences SCM, focusing on efficiency, decision-making, scaling, and costs. The relevant respondents are primarily male and generally between 26–45 years old. BI indeed enhances SCM efficiency. However, the amount of money invested is also varied and is sometimes costly. Scalability and quality of decision matter so does the hybrid approach. Reliability scores are high, and robust measures have been established. Positive associations are found between BI systems and SCM effectiveness, whereas the cost implications of financial investment are challenging. It is already indicated that model fit indices are pretty supportive of the data presentation. The overall conclusion is that BI can revolutionize SCM, with effective implementation being cost-effective.

Table 1. Demographic information

Demographic	*Percentage*
Age 18–25 years old	9%
Age 26–35 years old	50%
Age 36–45 years old	31%
Age 46 years old and above	10%
Male	72%
Female	28%

The table above shows the general demographic information of the respondents concerning the research study on BI in SCM. Most of them are in the ages 26–35 years old (50%), followed by 36–45 years old (31%) and a small percentage of 18–25 years old (9%) and 46 years old and above (10%). Most of the males constitute respondents, being 72%, while the females consist of 28%. This is such a diverse sample, indicating the prevalence of mainly mid-career and senior professionals — a fact that concurs very well with the focus of the study on BI's role in SCM optimization. The literature speaks of the usefulness of BI towards improvement in

efficiency and decision-making, but also points out its financial and technical challenges. Rich and varied experiences of the surveyed demographic bestow a holistic view regarding the practical application and strategic value of BI towards SCM (Bennett & Chatterji, 2023).

Figure 1. Demographic information

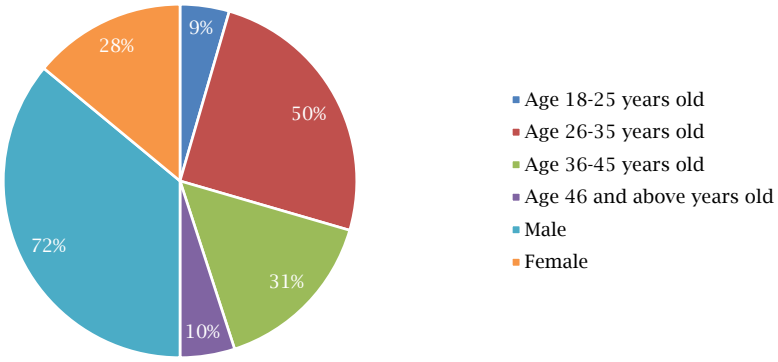


Table 2. Descriptive statistics

Variable	*Mean*	*SD*
BI_Sys	3.8	0.6
SCM_Eff	4.0	0.5
Fin_Inv	3.2	0.9
Scal_Acc	3.9	0.7
Dec_Qual	3.5	0.8
Hybrid_App	3.7	0.7

Table 2 shows the mean and the standard deviation (SD) of the six most essential variables in the study on the impact of BI on SCM. The *BI_Sys* (mean = 3.8, SD = 0.6) tend to be used most of the time for making data-driven decisions in increasing efficiency in logistics, inventory, and customer service. In this manner, data analysis will improve *SCM_Eff* (mean = 4.0, SD = 0.5) and lead to substantial improvements across these organizations. Financial investment would reflect that the costs are moderate and highly variable; there seems to be a problem for smaller enterprises. When adopted to enjoy the benefits for a bigger audience, scalability, and accessibility are paramount in cloud-based solutions. *Dec_Qual* does suggest an improvement, though over-reliance on (mean = 3.5, SD = 0.8). Finally, the *Hybrid_App* (mean = 3.7, SD = 0.7) shows that BI combined with human expertise is an effective SCM usefulness indicator, and adoption was generally positive, but pretty varied. These results disclose transformative potentials for BI in SCM, as well as the importance of balanced implementations and good scalability.

Table 3. Reliability analysis

Variable	*Cronbach's alpha*
BI_Sys	0.83
SCM_Eff	0.88
Fin_Inv	0.81
Scal_Acc	0.84
Dec_Qual	0.80
Hybrid_App	0.85

Table 3 presents some of the variables related to the BI under SCM, and their corresponding Cronbach's alpha values, providing an explanation of the scales used reliability. *BI_Sys* (Cronbach's alpha = 0.83) enhances logistics and inventory management through data-driven decisions. However, it involves heavy financial and technological investments. *SCM_Eff* (0.88) improves the operation performance via real-time monitoring and advanced analyzing methods. *Fin_Inv* (0.81) identifies the high cost of investment for BI implementation, particularly for SMEs, with an emphasis on the benefit from the use of cost-benefit analysis and scaling through cloud-based solutions. *Dec_Qual* (0.80) improves through BI, but should be human-judgment-balanced against BI to avert simplistic decisions. Last, but not least, a *Hybrid_App* (0.85) combines BI and human expertise, whereby the system provides clarity in data for sound decision-making and operational efficiency with such an approach (Rahayu et al., 2023).

Table 4. Correlation matrix

Variable	*BI_Sys*	*SCM_Eff*	*Fin_Inv*	*Scal_Acc*	*Dec_Qual*	*Hybrid_App*
BI_Sys	1					
SCM_Eff	0.65	1				
Fin_Inv	-0.30	-0.25	1			
Scal_Acc	0.70	0.60	-0.40	1		
Dec_Qual	0.55	0.50	-0.35	0.65	1	
Hybrid_App	0.75	0.70	-0.45	0.60	0.65	1

Table 4 indicates that *BI_Sys* have strong positive effects on the *SCM_Eff, Scal_Acc,* and *Dec_Qual. BI_Sys* positively correlates with *SCM_Eff* (0.65), *Scal_Acc* (0.70), *Dec_Qual* (0.55), and *Hybrid_App* (0.75), including human expertise. *Fin_Inv* is negatively correlated with all the variables, which means that very high costs may be a barrier. *Scal_Acc* of *BI_Sys* seem to positively relate to *Dec_Qual* (0.65) and *Hybrid_App* benefits (0.60). As a whole, it summarizes the need to mesh BI with human judgment for maximum SCM performance.

Table 5. Model fit indices

Fit index	*Value*
Chi-square	250.4
Comparative fit index (CFI)	0.91
Tucker-Lewis index (TLI)	0.90
Root mean square error of approximation (RMSEA)	0.07

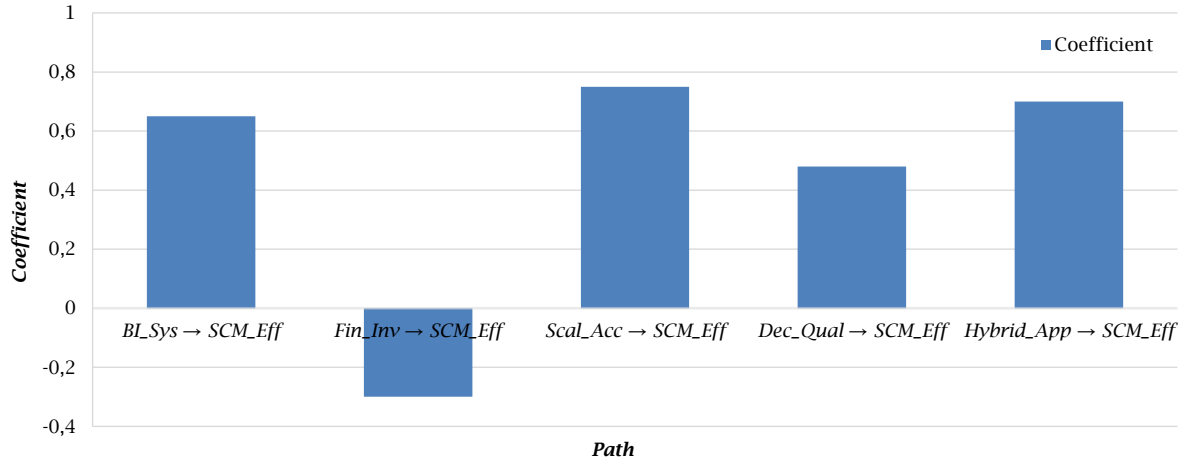
The fit indices in the table indicate the model's adequacy in representing the data collected from 526 supply chain managers in the MENA region. A Chi-square value of 250.4 reflects the model's fit, but is sensitive to large sample sizes. The CFI and TLI values of 0.91 and 0.90, respectively, suggest a good model fit, indicating substantial improvement over the baseline model and a good balance between complexity and fit. An RMSEA value of 0.07 shows a reasonable error of approximation, confirming the model's acceptable fit within the study's context of BI and SCM (Goretzko et al., 2024).

Table 6. Path coefficients

Path	*Coefficient*	*p-value*	*Interpretation*
BI_Sys → SCM_Eff	0.65	< 0.001	Significant positive effect
Fin_Inv → SCM_Eff	-0.30	0.02	Significant negative effect
Scal_Acc → SCM_Eff	0.75	< 0.001	Significant positive effect
Dec_Qual → SCM_Eff	0.48	0.005	Significant positive effect
Hybrid_App → SCM_Eff	0.70	< 0.001	Significant positive effect

The hypotheses testing results indicate the significant impact of various factors on *SCM_Eff*. *BI_Sys* significantly enhance *SCM_Eff* (0.65, $p < 0.001$), consistent with literature that highlights how BI optimizes logistics, inventory management, and customer service through data-driven decision-making. However, high *Fin_Inv* in *BI_Sys* negatively impacts *SCM_Eff* (-0.30, $p = 0.02$), underscoring the literature's point about the prohibitive costs of BI, especially for smaller enterprises. *Scal_Acc* of *BI_Sys* greatly improve *SCM_Eff* (0.75, $p < 0.001$), aligning with findings that cloud-based BI solutions offer scalability and reduced costs. Improved *Dec_Qual* positively influences *SCM_Eff* (0.48, $p = 0.005$), as BI tools enhance strategic decision-making. Lastly, a *Hybrid_App* combining data-driven insights with human expertise significantly boosts *SCM_Eff* (0.70, $p < 0.001$), supporting the literature's advocacy for integrating human judgment with BI to ensure contextual understanding and nuanced decision-making. Overall, these results confirm the transformative potential of *BI_Sys* and *Hybrid_App* in enhancing SCM efficiency while highlighting the need for cost-effective BI solutions (Brau et al., 2024).

Figure 2. Path coefficients



5. DISCUSSION

This research thus supports the basic findings of prior studies on the ability of advanced technologies, such as BI, AI, and BDA, to improve efficiency, scalability, and decision-making in SCM. These results give evidence of the technological transformational potential, along with their challenges:

Efficiency gains versus cost barrier: Surrounded by the fact that the study finds a good influence of BI adoption on SCM efficiency, thus improving logistical, inventory, and customer service operations. Nevertheless, financial investment remains a big obstacle mainly for SMEs. This result corroborates a number of studies that have highlighted the costliness of the initial and operational expenditure related to BI systems at the inception stage. The analysis in this study goes on to detail there is indeed a negative correlation between financial investment and SCM efficiency, underlining, even more, the importance of structured cost-benefit analysis tailored to smaller businesses to ensure ROI on BI implementations.

Human expertise and BI integration: Besides, a high reliance on insights led by data, if not moderated by human expertise, is bound to be simplified to the point of flawed decisions. The research depicts that this hybrid model integrates human judgment with the insights provided by BI, thereby enhancing decision quality and adding contextual nuances essential in SCM. This again brings out the need for balance, as Hussain et al. (2023) call for human judgment to stem the risks of technology-driven decision-making. In fact, the positive impact of the hybrid approach on the efficiency of SCM in this study will be in congruence with calls for human expertise in interpreting complex BI data.

Scalability due to cloud-based solutions: Cloud-based BI solutions are quite critical in driving

scalability, besides reducing upfront costs to make BI even more accessible for smaller enterprises. These results support the findings of researchers, who, while arguing that cloud BI democratizes access to advanced analytics, found a strong positive correlation between scalability and efficiency in SCM. Cloud solutions, due to the scalability advantage provided, may diffuse more widely among different-sized organizations, thereby supporting the long-term performance of SCM with improved flexibility.

Continuous training and skill development: Adoption of BI and advanced technologies requires special skills related to data analysis, strategic thinking, and contextual judgment. The study has also underscored that continuous upskilling of the workforce is highly essential in order to reap maximum benefit from the technologies. This is again supported by recent studies, as they stamp the importance of ongoing training of workers by organizations in bridging the technical skill gaps. This will ensure that SCM professionals are able to use BI tools accordingly and synchronize them with strategic objectives to enhance the key aspects of operational efficiency and resilience.

Gaining insights from these findings coupled with the literature review provides an enhanced understanding of how best to balance advanced technologies with cost management and human judgment in SCM. It suggests a pragmatic approach that aligns technologies with human expertise, cost structure optimization, and scalable cloud solutions to see wider BI adoption across organization types.

Implications: Because AI, BDA, and BI can be very important enablers in SCM, some key best practices for full utilization of these technologies by organizations include the following:

Adopt a hybrid decision-making model: Organizations need to adopt a hybrid decision-making model that aligns insights from BI with human expertise. This needs to be imbibed through organizational processes and training programs to make data-driven decisions contextually relevant. This would also diminish some of the risks associated with automation, such as decision fatigue and oversimplification of complex issues.

Optimize cost structures to invest in technology: The basis for wider adoption of BI, especially for SMEs, has to be an affordable approach. Strategies such as modular implementation done in a gradual manner and adoption of scalable cloud solutions would eliminate high upfront costs and allow full spread and impact of BI across different organization sizes.

Cloud-based BI for accessibility and scalability: With a positive correlation between cloud BI scalability and SCM efficiency, the focus on cloud infrastructure should be high to ensure access to more flexible and scalable BI tools. It not only reduces costs, but also meets the demand of a growing business without substantial new investments in hardware or IT infrastructure.

Continual upskilling of the workforce: Due to the shortage of technical skills, an upskilling program needs to be heavily invested in. This will enable the SCM teams to map the technological landscape more firmly, maximize the usage of tools, and align advanced analytics with strategic objectives.

Ethics and standards for BI implementation: Mechanization of ethical and security standards needs to be considered concerning BI and BDA, particularly on data privacy and cybersecurity. Because BI systems are becoming increasingly held responsible for sensitive supply chain information, robust ethical mechanisms will protect the integrity of organizational and consumer data.

This, in summary, underlines the fact that, as advanced technologies are transforming SCM, there is an urgent need to baseline a balanced approach wherein technology is merged with human expertise, and scalability and cost-effectiveness concerns are taken into account. It is then that organizations will be able to leverage these best practices to achieve full utilization of BI, BDA, and AI in developing agile, responsive, and efficient supply chains.

6. CONCLUSION

This work, therefore, underlines the key advantages of integrating AI, BDA, and BI in SCM, which results in significant gains along the dimensions of efficiency, decision-making, and scalability. A survey conducted on 526 SCM managers shows that the adoption of BI — resulting from large-scale cloud solutions — facilitates logistics management, inventory management, and customer service. However, financial constraints, especially for SMEs, can hold back a situation of full adoption. Moreover, the discoveries have underlined how important it would be to include a hybrid approach that combines BI insights with human expertise so that data-driven decisions remain contextually robust and avoid risks associated with over-reliance on automation.

This is a study whose results may be bound within the MENA region, which may differ from other areas in terms of technological adoption and the state of supply chain practices. Moreover, being a survey-based study, it captures broad trends, but lacks deeper qualitative insights that might have come forth through interviews. These facets suggest that further exploration across regions and methodologies may contribute to the findings.

- Scalable BI solution implementation: Cloud-based BI might be one of the ways through which more affordable scalability can be implemented to reduce some of the financial challenges to the usage of business analytics, especially by SMEs.
- Embrace hybrid decision-making models: Integrating BI with human judgment will drive more effective decision-making, balancing data-driven insight with context.
- Prioritize training: The investment in ongoing training for SCM professionals will enable them to increase the value of the BI tools and connect them to the strategy.
- Establish ethics standards: Certainly, organizations, with ever-increasing reliance on data, must spearhead the initiative in establishing ethical standards for data security and privacy.

Future research might investigate the influence of new technologies like IoT and blockchain on BI in SCM and employ mixed-method approaches to gain more valuable insights. Longitudinal studies that assess the long-term impact of BI on SCM performance would add even greater depth to any such understanding of how these technologies are evolving and what the potential roles in the field could become.

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