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Integrating Business Intelligence and Knowledge Management to Enhance Innovation Capability: Evidence from Jordanian Manufacturing SMEs

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Abstract. Jordanian manufacturing SMEs increasingly invest in analytics and knowledge practices, yet fragmented data and dispersed know-how often prevent these investments from translating into innovation. Drawing on the dynamic capabilities and knowledge-based view, this study conceptualises Business Intelligence–Knowledge Management (BI–KM) integration as a higher-order socio-technical capability that connects data-to-knowledge flows, cross-functional utilisation, shared digital platforms, and integration into decision routines. Using survey data from 283 mid- and senior-level managers in Jordanian manufacturing SMEs and analysing the model with PLS-SEM (SmartPLS 4), the results show that BI–KM integration is positively associated with innovation capability and that top management support partially mediates this relationship. The innovation benefits of BI–KM integration are further amplified under stronger IT infrastructure maturity and higher digital literacy, and the effect is stronger in larger SMEs and in more process- and compliance-intensive sectors (e.g., chemicals and plastics). The findings specify the mechanisms and boundary conditions through which integrated analytics and knowledge practices enhance innovation capability in resource-constrained emerging-economy SMEs.

Keywords: Business intelligence; Knowledge management; Integration; Innovation capability; SMEs; Jordan

1. Introduction

In Jordan, the manufacturing sector plays a pivotal role in economic growth, job creation, and export diversification. Industries such as food processing, textiles, chemicals, and machinery are key drivers of the national economy, contributing substantially to gross domestic product and employment, and mirroring global evidence on the strategic contribution of data-intensive manufacturing to competitiveness and innovation (Babu et al., 2024; Chaudhuri et al., 2024). Yet, these firms face intensifying pressure to innovate in order to remain competitive amid globalization, evolving customer expectations, and rapid technological shifts.

This challenge is exacerbated by the explosive growth of data volumes and dispersed knowledge assets within organizations. Most manufacturers find it difficult to transform large streams of operational data and diffused expertise into timely and valuable business insights that lead to new products, process innovations, or faster adaptation to market changes. Although Business Intelligence (BI) systems provide powerful analytical capabilities and Knowledge Management (KM) systems support the capture, sharing, and reuse of expertise, these tools are often implemented as separate, weakly connected solutions, limiting their combined impact on organizational learning and innovation (Adesina, 2024; Roham & Gomes, 2024).

Existing studies in mature economies have documented the individual benefits of BI and KM for performance, learning, and strategic responsiveness. However, far less attention has been paid to how their integration can enhance innovation capability, particularly in resource-constrained and institutionally diverse settings such as Jordan (Filipe, 2024; Gul, 2025). In Jordanian manufacturing, BI tools are frequently adopted in a functional and compliance-oriented manner rather than as strategic innovation platforms, while KM practices remain fragmented, informal, and weakly institutionalized. This disarticulated adoption—driven by infrastructural constraints, uneven digital skills, and limited managerial sponsorship—further undermines the potential of BI–KM configurations to support innovation (Eyadat et al., 2025).

In response to this gap, this paper investigates how the integration of Business Intelligence and Knowledge Management systems shapes the innovation capability of manufacturing small and medium-sized enterprises (SMEs) in Jordan and under which organizational conditions this relationship is strengthened. Specifically, the study examines the role of leadership engagement, IT infrastructure maturity, employees' digital competence, and firm characteristics in conditioning BI–KM integration effects, thereby offering evidence-based insights for scholars and managers seeking to leverage digital integration as a source of industrial competitiveness in emerging-economy manufacturing sectors (Mansoor & Hussain, 2024).

This study makes three contributions. First, it sharpens the BI–KM integration construct by treating integration as a formative, higher-order capability (a socio-technical configuration) rather than as simple co-adoption of BI tools and KM practices. Second, it specifies the causal mechanism by theorising and testing top management support as a resource-orchestration pathway through which BI–KM integration is converted into innovation capability. Third, it identifies boundary conditions—IT infrastructure maturity, digital literacy, and firm size—and uses sectoral heterogeneity to explain when BI–KM integration is most effective in resource-constrained emerging-economy SMEs.

Consistent with the scope of logistics, informatics, and service science, the model is also interpreted through the lens of information flows and decision quality in manufacturing operations and supply chains. BI–KM integration is argued to improve operational coordination (e.g., production planning, quality control, procurement, and traceability) by linking analytics outputs to codified knowledge and routinised decision processes, thereby enabling service and process innovation within and across manufacturing networks.

2. Literature Review

Business Intelligence and Knowledge Management are now fundamental enablers of innovation and competitiveness of the global manufacturing business. In industrialized economies, business intelligent systems made performance enhancements through real-time analytics, strategic planning, and informed decisions. Knowledge Management tools, meanwhile, ensure both explicit and implicit information has been captured, shared, and applied across organizational borders and thereby triggers innovation and ongoing learning (Adesina, 2024; Roham & Gomes, 2024). In Jordan's manufacturing business, however, the integration of the two systems remains as yet underdeveloped, disjointed, and unused.

Business Intelligence in Jordanian manufacturers is adopted in a predominantly functional manner rather than a strategic one. Packages such as SAP, Power Business Intelligence, and Oracle are applied mainly to meet compliance requirements, audit purposes, and operational reporting (Ashal & Morshed, 2024; Jaradat et al., 2024). Business Intelligence systems are simply operated by IT departments and are generally not integrated into overall strategic decision-making. Advanced analytical capabilities and sophisticated dashboards, even when they are in place, are hardly applied to facilitate innovation or forecast market developments. Constraints such as financial costs of implementation, legacy systems, low digital competence, and a shortage of supporting executives serve to inhibit the potential of Business Intelligence to transform (Exner & Zunic, 2025; Kuitert et al., 2024). Business Intelligence adoption in most instances is initiated by external donors or imposed by legislation so is characterized by low end-user ownership and a low degree of alignment to business strategy (Bi et al., 2024).

Knowledge Management activities in Jordan's manufacturing sector are also lacking in consistency and purpose. Most companies resort to unsystematic knowledge-sharing channels—individual memory, e-mail discussions, or unwritten guidelines—instead of formal knowledge repositories, lessons-learned systems, or group digital platforms (Alabaddi et al., 2024; Alkhwaldi, 2024). Some companies have embraced pieces of Knowledge Management models but only in terms of codifying standard operating guidelines without exploiting production insights for process redesign or innovation (Filipe, 2024; Turulja et al., 2024). Most knowledge-sharing attitudes are also hindered by cultural obstacles such as low trust levels, transparency resistance, and reward inadequacy for interdepartmental collaboration in family-owned or traditionally operated companies (Khan & Jin, 2024; Morshed, 2025b).

Innovation capability is treated as a broad firm-level capacity to generate and implement new ideas, routines, and solutions. In manufacturing SMEs, this capability often manifests most strongly through incremental and process-oriented innovation (e.g., improving production efficiency, quality, traceability, and coordination), although product and organisational innovation may also be enabled. Clarifying this scope is important because BI–KM integration is expected to influence innovation primarily by strengthening problem sensing, learning, and reconfiguration routines, which are especially salient for continuous improvement and operational innovation in SME settings (Morshed, 2024b; Proykratok et al., 2024).

The aim of this research is to examine how BI–KM integration affects Jordanian manufacturing SMEs' innovation capability, while specifying (i) the mechanism through which integration is translated into innovation (mediation via top management support) and (ii) the organisational readiness conditions under which the integration–innovation link becomes stronger (moderation via IT infrastructure maturity, digital literacy, and firm size) (Morshed, 2025d, 2025a).

Effective Business Intelligence and Knowledge Management integration depends much on top management support (Alabaddi et al., 2024). Allocating resources, promoting a data-driven culture, and guaranteeing alignment between technical tools and organizational goals all depend on executive leadership in great part (Mansoor & Hussain, 2024; Romm & Nkambule, 2024). In the Jordanian context, where many firms are led by founding entrepreneurs or family-based management, digital initiatives often fail to receive strategic prioritization. Studies consistently show that without strong managerial endorsement, Business Intelligence and Knowledge Management projects remain fragmented, underfunded, or viewed as operational add-ons rather than strategic assets (Berndtsson & Ekman, 2023; Necochea-Chamorro & Larrea-Goycochea, 2023). In contrast, firms with active leadership involvement—especially in digital goal setting, cross-functional engagement, and employee training—demonstrate higher levels of Business Intelligence and Knowledge Management integration and improved innovation performance (Cheng et al., 2023; Pisoni et al., 2023).

Intimately connected with management support is IT maturity. IT maturity is a description of a firm's capacity for scalability, interoperability, and integration of its information systems (Alsarayreh & Buraik, 2025; Jreissat et al., 2024). Infrastructure capabilities in Jordan are varied. Major companies in such industries as pharmaceuticals or chemicals tend to have enterprise-scale systems supporting sophisticated analytical-type capabilities along with centralized data access, while SMEs have a tendency to have older or disparate systems (Jahmani et al., 2025; Olubiyi & Akinlabi, 2025). Limited internet dependability, low systems compatibility, and minimal cybersecurity measures also limit Business Intelligence and Knowledge Management implementation in SMEs located outside industrial clusters (Santos et al., 2025; Widhiastuti et al., 2025). The variabilities in IT readiness emphasize infrastructural spending as a necessary condition for digital integration.

Hypotheses

H1: BI–KM integration positively influences innovation capability in Jordanian manufacturing SMEs.

H2: Top management support mediates the relationship between BI–KM integration and innovation capability.

H3: IT infrastructure maturity positively moderates the relationship between BI–KM integration and innovation capability.

H4: Digital literacy positively moderates the relationship between BI–KM integration and innovation capability.

H5: Firm size positively moderates the relationship between BI–KM integration and innovation capability.

3. Methodology

This study employed a positivist, explanatory research design to investigate how the integration of Business Intelligence (BI) and Knowledge Management (KM) systems affects innovation capability in Jordanian manufacturing small and medium-sized enterprises (SMEs). The research is explicitly contextualized within Jordan's industrial environment and does not generalize findings to global settings. Instead, the study generates empirical insights relevant to countries with similar institutional and technological constraints. The research process—from sample selection through instrument development, ethical approval, data collection, and analysis—was guided by structured procedures to ensure analytical accuracy and methodological rigor (Olubiyi & Akinlabi, 2025).

SMEs constitute an appropriate unit of analysis because BI–KM integration in smaller firms is shaped by resource constraints, informal knowledge practices, and the need to prioritise digital investments; these features make the translation of integrated analytics and knowledge into innovation particularly contingent. Mid- and senior-level managers were selected as key informants because they oversee cross-functional processes, system adoption, and innovation initiatives, and are therefore positioned to assess both integration routines and innovation capability. The exclusion of non-managerial perspectives is acknowledged as a limitation, as frontline employees may experience integration and knowledge-sharing practices differently.

The target population consisted of formally registered Jordanian manufacturing SMEs, defined as firms employing fewer than 250 workers. A stratified random sampling technique was applied to ensure proportional representation across the country's four industrial regions: North Jordan, Central Jordan, South Jordan, and the Amman Industrial Zone. Within each region, additional stratification was conducted across five manufacturing sectors: Food and Beverage, Textiles and Apparel, Chemicals and Plastics, Machinery and Metals, and Other Manufacturing. The sampling frame was derived from records maintained by the Jordan Chamber of Industry and the Jordan Industrial Estates Corporation. A total of 283 SMEs were selected proportionally from these strata. This structure allowed for subgroup comparison across sectors and regions using multi-group analysis (MGA), which served as a quasi-control framework to strengthen causal inference in the absence of experimental controls (Morshed et al., 2024).

Primary data were collected using a structured questionnaire developed from previously validated scales commonly employed in studies on business intelligence, knowledge management, and innovation capability. The items were adapted from peer-reviewed sources to ensure conceptual validity and empirical reliability (Morshed, 2025c). Constructs measured included BI–KM integration (formative), innovation capability, top management support, IT infrastructure maturity, and digital literacy, alongside control variables such as firm size, age, and sector. The instrument was designed through a multistep process: item selection based on recent empirical studies; review by three domain experts in digital innovation; translation into Arabic followed by back-translation; and a pretest with 15 SME managers to ensure linguistic clarity and contextual relevance. All items were rated using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). No items or datasets used in this study appeared in prior publications.

Table 1. Constructs, measurement type, and sample indicators

Construct	Measurement specification	Items / dimensions	Sample indicators (illustrative)	Scale source and adaptation
BI–KM Integration	Formative (higher-order capability)	4 dimensions	Data-to-knowledge flow; cross-functional use; shared digital platforms; embedded decision routines	Adapted from established BI and KM integration measures; contextualised to Jordanian manufacturing SMEs
Top Management Support	Reflective (mediator)	4–5 items	Resource allocation; leadership encouragement; governance oversight; expectations for evidence-based decisions	Adapted from validated IS/innovation top-management-support scales; minor wording adjustments
IT Infrastructure Maturity	Reflective (moderator)	4–5 items	Interoperability; system integration; data quality; secure access; analytics reliability	Adapted from validated IT maturity/capability measures; tailored to manufacturing operations
Digital Literacy	Reflective (moderator)	4–5 items	Interpreting dashboards; using digital tools; documenting/sharing knowledge; collaborating digitally	Adapted from established digital literacy scales; tailored to SME operational and managerial roles

Innovation Capability	Reflective (outcome)	4–6 items	Process/quality improvement; continuous improvement; new routines; incremental product/service changes	Adapted from innovation capability scales; emphasis on process and incremental innovation in manufacturing SMEs

To ensure respondent relevance and data validity, only mid-level and senior managers responsible for innovation, operations, or IT strategy were invited to participate. These individuals were identified through company records and pre-survey screening to confirm role suitability. Data collection was conducted between February and April 2025 to avoid seasonal business disruptions such as Ramadan, fiscal year-end closures, or national holidays. Both face-to-face distribution and encrypted electronic survey forms were used to maximize geographic coverage and response accuracy. Responses were anonymized and indexed by firm region, sector, size, and age to support subgroup analysis and detect any structural biases.

Given that human subjects were involved, all ethical procedures were strictly followed. Participation was voluntary, and informed consent was obtained prior to survey initiation. To protect confidentiality, no personally identifying information was collected or stored. Ethical approval for the study was granted by the Institutional Research Ethics Committee of Middle East University, Jordan (Approval No. MEU-REC/INT/2025/21). The study complied with national research ethics regulations and adhered to international standards, including the Declaration of Helsinki (2013 revision) and ESOMAR's guidelines for organizational and market research.

Quantitative analysis utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) and estimation program SmartPLS 4. This procedure was selected due to its ability to deal effectively with high complexity models with both formative and reflective constructs and small-to-medium sample sizes. Construct validity and reliability were assessed by utilizing Composite Reliability (CR), Average Variance Extracted (AVE), and Heterotrait-Monotrait Ratio (HTMT). Variance inflation factors (VIF) were also computed to identify multicollinearity among formative constructs. Bootstrapping with 5,000 subsamples computed standard errors and confidence intervals and tested moderation and mediation effects and path significance (Cheah et al., 2024). Multi-group analysis by region and sector was used to establish structural invariance across subpopulations. Common method bias was further tested utilizing Harman's single-factor test and indicated there was no severe inflation of correlations. A sensitivity analysis also included skipping the five most influential SME observation points, and this confirmed the findings' robustness (Ciechan-Kujawa et al., 2018).

The method integrates theoretical grounding, statistical soundness, ethical conformity, and contextual suitability. Stratified sampling, usage of only expert informants, and written ethical clearance address significant objections with regard to the quality of SME survey-based studies. The paper does not include extrapolation from this empirical sphere and provides focused insight into innovation dynamism in Jordan's manufacturing economy.

4. Results

Table 2. Descriptive Statistics and Data Screening

Construct	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
BI–KM Integration	3.75	0.72	1.40	5.00	0.11	0.35
Innovation Capability	3.88	0.76	1.20	5.00	0.08	0.42
Top Management Support	3.67	0.81	1.00	5.00	0.09	0.29
IT Infrastructure Maturity	3.71	0.79	1.00	5.00	0.07	0.31
Digital Literacy	3.84	0.74	1.50	5.00	0.06	0.28
Firm Size (employees)	2.32	0.89	1.00	3.00	0.20	0.47

All core construct in table 2 mean levels are between 3.67 and 3.88 and indicate moderate to high SME managers' agreement on Business Intelligence and Knowledge Management integration, innovation capability, and enabling conditions such as digital literacy and infrastructures. Standard deviations are moderate and indicate appropriate variability in response.

Skewness and kurtosis fall within ±1, satisfying normality assumptions and supporting the use of PLS-SEM. These distributions confirm the quality and balance of the data across respondents. The relatively high scores also suggest strong awareness of digital strategy components in participating SMEs.

Table 3. Reflective Constructs Evaluation

Construct	Indicators	Loading range	CR	Cronbach's α	AVE
Innovation Capability	IC1–IC4	0.72–0.85	0.89	0.84	0.66
Top Management Support	TMS1–TMS4	0.74–0.86	0.91	0.88	0.70
Digital Literacy	DL1–DL3	0.71–0.82	0.87	0.81	0.65

All reflective constructs in Table 3 exhibit excellent psychometric properties. Indicator loadings exceed 0.70, ensuring item reliability. Composite Reliability (CR) values surpass the 0.70 threshold (ranging from 0.87 to 0.91), and Cronbach's alpha values confirm strong internal consistency. The Average Variance Extracted (AVE) values are all above 0.50, affirming convergent validity. These results confirm that the constructs are robust and reliable measures for modeling innovation outcomes in Jordanian SMEs (Morshed, 2024c).

Table 4. Formative Constructs Evaluation

Construct	Indicator	Weight	Loading	VIF
BI–KM Integration	BIKM1	0.39	0.74	2.12
	BIKM2	0.42	0.77	2.08
	BIKM3	0.36	0.70	1.97
IT Infrastructure Maturity	IT1	0.41	0.76	2.10
	IT2	0.38	0.73	2.14

Note: VIF values < 3.3 (or < 5.0) generally indicate no critical multicollinearity concerns.

The formative constructs in table 4 of Business Intelligence and Knowledge Management Integration and IT Infrastructure Maturity show acceptable statistical quality. All indicator weights are substantial and positive, indicating meaningful contributions to the respective constructs. Loadings above 0.70 further confirm indicator relevance. VIF values range between 1.97 and 2.14, well below the conservative cutoff of 3.3, indicating no multicollinearity. These outcomes validate the formative constructs and affirm their readiness for inclusion in the structural model (Kalnins & Praitis Hill, 2025).

Table 5. Fornell-Larcker Criterion

Construct	BIKM	IC	TMS	ITIM	DL
Business Intelligence and Knowledge Management Integration (BIKM)	0.73				
Innovation Capability (IC)	0.52	0.81			
Top Management Support (TMS)	0.45	0.48	0.84		
IT Infrastructure Maturity (ITIM)	0.49	0.53	0.46	0.80	
Digital Literacy (DL)	0.50	0.55	0.47	0.51	0.81

The Fornell-Larcker criterion in table 5 allows this table to confirm the discriminant validity of every latent construct. The diagonal value of each build is the square root of its AVE, which has to be more than its correlations with all other constructions. This condition meets all comparisons. The square root of AVE for Digital Literacy (0.81) for instance shows that the construct is more closely linked with its own indicators than with others since it exceeds its connection with Innovation Capability (0.55) and Business Intelligence and Knowledge Management Integration Integration (0.50). These results verify that every construct is statistically distinct, which is necessary for a consistent interpretation of structural route coefficients in the SEM analysis (Fornell & Larcker, 1981).

Table 6. Heterotrait-Monotrait (HTMT) Ratios

Construct Pair	HTMT Value
BI-KM Integration – Innovation Capability	0.78
BI-KM Integration – Digital Literacy	0.71
BI-KM Integration – IT Infrastructure Maturity	0.66
BI-KM Integration – Top Management Support	0.61
Top Management Support – Innovation Capability	0.83
IT Infrastructure Maturity – Innovation Capability	0.79

The HTMT ratios in table 6 offer a robust, alternative assessment of discriminant validity, especially recommended in variance-based SEM. All values are below the conservative threshold of 0.85, indicating that each pair of constructs is empirically distinct. The highest ratio observed is between Top Management Support and Innovation Capability (0.83), which is still within acceptable limits. This suggests that although these constructs are related, they are not redundant. These results reinforce the reliability of the model structure and support the claim that the constructs measure different underlying dimensions in the context of Business Intelligence and Knowledge Management Integration in Jordanian manufacturing SMEs (Morshed, 2024a).

Table 7. Structural Model Evaluation

Endogenous Construct	R^2	Q^2	Effect Size (f^2)
Innovation Capability	0.64	0.39	BIKM → IC: 0.26 TMS → IC: 0.22 DL → IC: 0.18

The coefficient of determination ($R^2 = 0.64$) in table 7 shows that the model explains 64% of the variance in Innovation Capability, indicating strong explanatory power. The predictive relevance ($Q^2 = 0.39$) confirms accuracy in cross-validation. Business Intelligence and Knowledge Management Integration Integration has the largest effect ($f^2 = 0.26$), followed by Top Management Support (0.22) and Digital Literacy (0.18), all within small-to-medium or medium ranges. These findings highlight the combined importance of technological, managerial, and human factors in driving SME innovation (Cadogan & Lee, 2013).

Table 8. Path Coefficients and Hypothesis Testing

Hypothesis	Path	Coefficient (β)	t-Value	p-Value
H1	BI–KM integration → Innovation capability	0.48	6.77	< 0.001
H3	BI–KM integration × IT infrastructure maturity → Innovation capability	0.20	3.44	≈ 0.0006
H4	BI–KM integration × Digital literacy → Innovation capability	0.18	3.05	≈ 0.002
H5	BI–KM integration × Firm size → Innovation capability	0.16	2.82	≈ 0.005

Table 8 summarises the hypothesis tests for the direct and moderation effects. BI–KM integration shows a strong positive association with innovation capability ($\beta = 0.48$, $p < 0.001$), supporting H1. The significant interaction terms indicate that IT infrastructure maturity, digital literacy, and firm size strengthen the BI–KM integration → innovation capability relationship (supporting H3–H5). The mediation hypothesis (H2) is assessed through the indirect effect reported in Table 8.

Table 9. Mediation Analysis

Path	Indirect Effect (β)	t-Value	95% Confidence Interval	VAF	Mediation Type
BIKM → TMS → IC	0.19	4.23	[0.10, 0.27]	35.8%	Partial Mediation

The mediation analysis in Table 9 confirms that Top Management Support partially mediates the relationship between Business Intelligence and Knowledge Management Integration and Innovation Capability. With an indirect effect of $\beta = 0.19$ ($t = 4.23$, 95% CI = [0.10, 0.27]) and VAF = 35.8%, the result indicates that over one-third of the total effect is transmitted via the mediating variable. This means that while Business Intelligence and Knowledge Management systems directly enhance innovation, their impact is also strengthened by leadership involvement. This underscores the strategic importance of managerial engagement in converting digital integration into actionable innovation within SMEs (Igartua & Hayes, 2021).

Table 10. Moderation Analysis

Moderation path	Coefficient (β)	t-value	p-value
BI–KM × IT infrastructure maturity → Innovation capability	0.20	3.44	≈ 0.0006
BI–KM × Digital literacy → Innovation capability	0.18	3.05	≈ 0.002
BI–KM × Firm size → Innovation capability	0.16	2.82	≈ 0.005

Table 10 provides a focused summary of the moderation effects. Consistent with organisational readiness and capability maturity arguments, the positive impact of BI–KM integration on innovation capability becomes stronger when SMEs have more mature IT infrastructure, higher digital literacy, and greater organisational scale (firm size). These results reinforce the view that integration generates innovation benefits only when complementary technical and human capabilities are present.

Table 11. Multi-Group Analysis (MGA) by Region

Group	Sample Size (n)	Max Δ Path Coefficient (β)	p-Value Range	Conclusion
North Jordan	58	—	—	—
Central Jordan	90	—	—	—
South Jordan	73	0.07	> 0.10	No significant differences across regions

The MGA reveals in Table 11 that no statistically significant differences in path coefficients across North, Central, and South Jordan ($\Delta\beta = 0.07$; $p > 0.10$). This indicates regional consistency in how Business Intelligence and Knowledge Management Integration and contextual factors influence innovation. The findings suggest that digital transformation strategies and leadership effects are equally applicable across geographic zones, reinforcing the generalizability of the model for Jordanian SMEs (Ngah et al., 2023).

Table 12. Common Method Bias (CMB) – Harman's Single-Factor Test

Statistic	Value	Threshold	Conclusion
Variance explained by first factor	34.5%	< 50%	Common method bias is not a significant concern

The Harman's single-factor test in Table 12 shows that the first factor explains 35.5% of the variance, which is below the commonly used 50% threshold. In addition, the study applied procedural remedies (role-based screening, voluntary participation, and assurance of anonymity) and evaluated common method bias using complementary diagnostics recommended in PLS-SEM research (e.g., full collinearity assessment as a robustness check). Taken together, these steps reduce—though do not fully eliminate—the likelihood that the reported relationships are driven primarily by common method variance.

Table 13. Sector-Based Multi-Group Analysis (MGA)

Sector	Sample Size (n)	Path: BIKM → IC (β)	Difference from Other Sectors	p-Value	Conclusion
Chemicals & Plastics	50	0.55	+0.11	0.041	Significantly stronger effect than other sectors
Other Manufacturing	233	0.44	—	—	Baseline

The sectoral MGA in Table 13 indicates a significantly stronger effect of Business Intelligence and Knowledge Management Integration on Innovation Capability in the Chemicals & Plastics sector ($\beta = 0.55$) compared to other sectors ($\beta = 0.44$), with a path difference of 0.11 and $p = 0.041$. This would also assume that corporations from capital-intensive or regulated industries are all the more reactive to investment in Business Intelligence and Knowledge Management due to higher reliance on accuracy, adherence, and innovation. It also upholds the fact further that digital tools are never uniformly impactful and are vulnerable to absorptive capacity and requirements of the industry.

Table 14. Sensitivity Analysis

Test	Method	Result	Conclusion
Exclusion of Influential SMEs	Removed 5 highest-leverage cases	Model paths remained significant	Results are robust and not driven by outliers

Sensitivity testing in Table 14 with omission of the top 5 most substantial SME observations—revealed insignificant variation in the outcome of models ($\Delta\beta < 0.04$). The path coefficients were all significant, verifying there was no outlier significantly affecting the results. This enhances the credibility and solidity of findings, and it also ensures the sample remains reliable and consistent throughout the structural model (Ciechan-Kujawa et al., 2018).

5. Discussion

The findings show that integrating Business Intelligence (BI) and Knowledge Management (KM) systems is a key driver of innovation capability in manufacturing SMEs. The model explains 64% of the variance in innovation capability, and the direct path from BI–KM integration to innovation is strong ($\beta = 0.48$, $p < 0.001$). This confirms that combined use of analytics and organised knowledge processes generates innovation outcomes beyond what either system could achieve alone, extending research that treated BI and KM as separate enablers of learning or strategic responsiveness (Gul, 2025). In an environment of fragmented data and informal knowledge flows, integration allows information to be captured, shared, and reused systematically in support of product and process renewal.

The mediating role of top management support adds a socio-organisational dimension. Around one-third of the total impact of BI–KM integration on innovation operates through leadership support, indicating that technology alone is insufficient. Systems must be sponsored, legitimised, and resourced by senior decision-makers if they are to reshape routines (Mansoor & Hussain, 2024). In family-owned or founder-led firms, visible executive endorsement also signals that BI–KM initiatives are strategic rather than peripheral IT projects (Fang, 2023).

The moderating roles of IT infrastructure maturity and digital literacy show that integration benefits depend on organisational readiness. BI–KM integration has stronger innovation effects when firms operate on interoperable platforms and employees have the skills to interpret dashboards, contribute to repositories, and participate in data-informed discussions (Alsarayreh & Buraik, 2025; Holm, 2025). This supports work identifying infrastructure and human capital as core enablers of digital transformation in manufacturing (Babu et al., 2024). For many SMEs, legacy systems and uneven training mean that, without parallel investment in infrastructure and skills, integration may remain largely symbolic.

Interpreted through absorptive capacity and organisational readiness, these moderation effects suggest that BI–KM integration is not self-sufficient: firms must be able to acquire, assimilate, transform, and exploit analytical insights. Mature infrastructure provides reliable data capture, integration, and access, while digital literacy enables staff to interpret analytics, codify experiential learning, and participate in knowledge-sharing routines. Together, these conditions increase the likelihood that analytics-driven learning is translated into operational and service/process innovations across manufacturing workflows and supply-chain interfaces.

Firm size further conditions the integration–innovation link. Medium-sized firms translate BI–KM integration into innovation capability more effectively than smaller entities, reflecting greater financial and managerial capacity to support complex digital projects and institutionalise new practices (Chaudhuri et al., 2024; Ravat et al., 2024). Smaller manufacturers may struggle to hire specialised staff, upgrade systems, or devote time to knowledge codification, which dilutes innovation returns even when integrated platforms are present (Alshemmari, 2023).

Sectoral and regional patterns add contextual nuance. The multi-group analysis reveals a particularly strong effect of BI–KM integration on innovation in the Chemicals & Plastics subsector, where regulation is tighter and capital intensity higher. In such settings, integrated analytics and knowledge architectures support compliance, risk management, and continuous improvement, amplifying innovation payoffs (Lara-Pérez et al., 2024; Turulja et al., 2024). By contrast, the absence of significant differences across Jordan's main industrial regions suggests that national-level institutions—shared regulatory frameworks, similar infrastructure constraints, and comparable labour-market conditions—are more influential than regional location in shaping digital transformation trajectories (Eyadat et al., 2025; Ngah et al., 2023).

Overall, the results position BI–KM integration as a central component of innovation capability in resource-constrained industrial settings and move the discussion beyond technology adoption towards a socio-technical understanding of how analytics and knowledge systems co-evolve with leadership, infrastructure, skills, and sectoral context to shape innovation outcomes.

6. Implications

6.1 Theoretical Implications

The study advances theoretical understanding of digital transformation and innovation in manufacturing in several ways. First, conceptualizing BI–KM integration as a formative construct and demonstrating its strong influence on innovation capability confirms that analytics and knowledge processes function as complementary, mutually reinforcing capabilities rather than separate tools. This reframes innovation models—particularly within SMEs—to treat BI and KM as interdependent pillars of a unified digital knowledge architecture.

Second, the partial mediation of leadership support enriches theory on the role of top management in digital initiatives. Leadership is not merely an antecedent to technology adoption but acts as a catalytic mechanism that transforms integrated BI–KM resources into innovation outcomes. This finding extends capability-based perspectives by showing that intangible assets—such as data repositories, analytic routines, and knowledge platforms—require deliberate managerial orchestration to generate value.

Third, the moderating influences of IT infrastructure maturity, digital literacy, and firm size reveal that digital innovation capabilities are layered, contingent, and context-sensitive. BI–KM integration emerges as a dynamic capability whose impact depends on both technological readiness and human capital, thereby supporting multi-level frameworks that connect technology, people, and organizational structure. The stronger effects observed in the Chemicals and Plastics subsector highlight the importance of sector-specific theorization, where integration proves particularly powerful in process-intensive, compliance-driven, and traceability-dependent industries.

6.2 Practical Implications

For managers in Jordanian manufacturing SMEs, the results emphasize that innovation gains are best achieved not through isolated BI systems or sporadic KM initiatives, but through developing an integrated capability that links data, knowledge, and decision-making routines. Since leadership support partially mediates the relationship between integration and innovation, managers should approach BI–KM integration as a governance and resource orchestration challenge rather than a purely technical project.

A staged roadmap can guide implementation:

- Stage 1: Governance and Process Alignment – Assign an integration owner, establish shared data and knowledge standards, and identify key decision points where analytics and lessons learned can enhance outcomes (e.g., production, quality, procurement).
- Stage 2: Platform and Workflow Integration – Link dashboards to repositories such as after-action reviews, incident logs, and best-practice libraries, embedding these into recurring routines like operational reviews and improvement meetings.
- Stage 3: Capability Building and Scaling – Invest in digital literacy programs for managers and frontline staff, create cross-functional communities of practice, and extend integration to supply chain partners where responsiveness and traceability are vital.

Given that firm size amplifies integration effects, smaller SMEs should begin with “minimum viable integration” by targeting a few high-impact use cases—such as connecting quality dashboards to root-cause analyses or linking maintenance analytics with corrective action databases—before scaling further.

6.3 Policy Implications

Policy-makers and industry associations can enhance these outcomes by investing in enabling environments. This includes subsidizing shared digital infrastructure (e.g., cloud analytics and standardized sector data frameworks), providing certified training programs, and supporting advisory services that guide SMEs in integration governance. In highly regulated subsectors such as chemicals and plastics, targeted support for audit-ready data pipelines and standardized knowledge repositories can accelerate innovation while ensuring regulatory compliance and operational resilience.

7. Conclusion

This study examined how the integration of BI and KM systems shapes innovation capability in Jordanian manufacturing SMEs and under which organisational conditions these effects are amplified. Drawing on survey data from 283 firms across four industrial regions and five manufacturing subsectors, and using a PLS-SEM framework with moderation, mediation, and multi-group analysis, the research demonstrates that BI–KM integration is a powerful driver of innovation, explaining a substantial share of variance in innovation capability. The results show a strong direct effect of integration, a sizeable indirect pathway through top management support, and additional strengthening effects from mature IT infrastructure, high digital literacy, and larger firm size.

Several limitations should be acknowledged. The cross-sectional design limits causal inference and raises the possibility of reverse causality (more innovative SMEs may be more likely to invest in BI–KM integration). Relatedly, unobserved factors may create endogeneity in the estimated relationships. Although the study implemented procedural and statistical remedies, common method variance cannot be ruled out entirely because the data rely on single-respondent self-reports. In addition, the measurement of innovation capability is perceptual and may be influenced by cultural response styles in the Jordanian context. Future research could address these issues using longitudinal designs, multi-informant data, objective innovation indicators, and cross-country comparisons to test the stability of the mechanisms and boundary conditions identified here.

These limitations point to a set of avenues for future research. Longitudinal designs could track how changes in BI–KM integration and leadership practices translate into innovation trajectories over time. Comparative studies across countries or sectors could examine how institutional arrangements, regulatory intensity, or competitive pressures condition the integration–innovation relationship. Further work might also incorporate objective performance indicators, case studies of exemplary firms, or mixed-method approaches to unpack the micro-level processes through which employees and managers co-create value from BI–KM integration. The sections above synthesise the study’s core empirical insights and outline a clear agenda for future research on BI–KM integration in resource-constrained manufacturing contexts.

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