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Research paper

The Impact of Digital Logistics Capabilities on Production Performance in The Manufacturing Sector: The Moderating Role of Sustainability Practices

Muath Albhirat [1]*, Mahmoud Allahham [1], Khalil Alkhatib [1], Wasef Almajali [1], Zain Albashtawi [2], Lana Alawrtani [3]

[1] *Business School, Amman Arab University,*
[2] *University Utara Malaysia, Malaysia*
[3] *Business School, Luminus Technical University College,*
**Corresponding author E-mail: m.allahham@aau.edu.jo*

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Abstract

The purpose: This study examines the impact of digital logistics capabilities on production performance in the Jordanian dairy industry, while also investigating the moderating effect of sustainability practices.
Approach: The quantitative approach was used. The primary data were gathered from 150 production managers and supply chain experts through a structured questionnaire.
Results: Automation integration ($\beta = 0.333$, $p < .001$), product traceability ($\beta = 0.235$, $p < .001$), and spot inventory management ($\beta = 0.415$, $p < .001$) positively impacted production performance, while sustainability practices had no direct effect ($\beta = -0.205$, $p = .102$). Sustainability also hurt product traceability ($\beta = -0.341$, $p < .001$) and a positive effect on spot inventory management ($\beta = 0.175$, $p = .001$). The model explained 64% of the variance in performance ($R^2 \approx .64$).
Conclusions: The direct as well as moderating effects of sustainability practices were examined using structural equation modelling. These results contribute to the engineering and production literature explaining how digital logistics innovations manifest themselves in operational benefits across varying sustainability settings.

Keywords: *Real-time inventory management, Automated Process Integration, Product Traceability. Production Performance, Sustainability*

1. Introduction

The recent emergence of digital technologies, including mobile, Internet of Things, and Blockchain, amongst others, has recently reached the dairy industry, causing a revolution. This revolution allows dairy farms to work more efficiently, changes the transparency and operations of supply chains [1]. Real-time inventory information management, integrated process automation, and trace systems are some of the solutions that enable companies to enhance their performance, quality control, and responsiveness to market fluctuations [2]. Incorporating these digital technologies is becoming a necessity, rather than a choice, for staying competitive in production [3]. The theory of supply chain maturity is an effective way to understand the transition from automating basic processes to fully integrated, data-driven networks of organizations. In the dairy factory of the future, real-time inventory management mitigates stockouts and spoilage, automated system integration accelerates the flow of activities from the farm to the processing plant, and traceability systems ensure safety and compliance [4]. Taken together, these dimensions comprise a theoretical framework that connects digital investment to performance results. Dairy is one of the important sub-sectors within Jordan's agri-economy, supported by approximately 95,000 dairy cattle that yield an annual volume of approximately 315,000 tons of milk. Subsidies, investments in cold-chain infrastructure, and technology demonstrations are promoted by the government to support the adoption of modern farming and processing practices [5]. However, there continue to be production houses that struggle to extract the most value from digital technology [6]. Sustainability has become not only a goal but also a facilitator in digital transformation. The dairy supply chain is a carbon-intensive system, and farms are also key hotspots for greenhouse gas emissions [7]. Management practices, such as the use of renewable energy, waste valorization, and water conservation, can lead to improvements in environmental and social performance, and potentially magnify the returns from digital logistics investments for firms [8]. Despite increased attention to digital supply chains and sustainability, empirical research has yet to investigate how sustainability practices impact the digital–performance relationship in Jordan's dairy industry [9]. The present study fills this void by posing the question:
RQ1: How do the Digital Logistics Capabilities Influence the Production Performance of the Jordanian Dairy Products Companies?

RQ2: To what extent do moderating effects of sustainability practices influence the relationship between the dimensions of digital supply chains on operational performance?
RQ3: What dimensions of the digital logistics have the greatest impact on production efficiency and waste reduction under different sustainability scenarios?
This article is organized as follows. Section 1 presents the basic concepts of digital supply chains, the maturity theory of supply chains, and the role of sustainability in production, with a focus on the Jordanian dairy sector. Section 2 presents the literature, reviewing past empirical and theoretical works in digital logistics dimensions, real-time inventory management, automated process integration, and product traceability, as well as sustainability practices in dairy supply chains. Section 3 introduces the theoretical model and the research hypotheses of the paper. Section 4 presents the research design, including the data sample, the structured questionnaire, and the use of SEM to test both direct and moderating effects. Section 5 presents the results, which highlight how the dimensions of digital logistics contribute to improving yield efficiency and reducing waste, as well as the moderating influence of sustainability practices. These findings are described and interpreted in Section 6, where practical recommendations are suggested to Jordanian dairy product manufacturers, based on engineering and production theory. Finally, in Section 7, study limitations and possible future research directions, including the use of the model in other industry sectors and locations, are presented.

2. Materials and Methods

2.1 Materials

Questionnaire constructs were sourced from established scales in supply chain and sustainability studies. The dimensions of digital logistics were assessed as follows: real-time inventory control (five items) [10], process automation (five items) [11], and product traceability (four items). Sustainable behaviours were assessed by a six-item scale, which includes items from environmental management, social responsibility, and efficient use of resources [12]. Performance was perceived as yield efficiency (three items) or waste reduction (three items) and was expressed as production performance. All measures employed a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

2.2 Sample and Data Collection

Registered dairy farmers in Jordan were used as a convenience sample [13]. Production managers and supply-chain experts with at least two years of experience were the respondents of the study. Data were collected via an online questionnaire between March and May 2025. We distributed 200 questionnaires and received 180 returns (overall response rate = 90%). After screening, 150 usable responses were obtained (usable response rate = 75%, which is 83.3% of the returned questionnaires). Two reminder emails were sent.

2.3 Measurement Procedures

The instrument was pilot-tested with a sample of 20 professionals within the industry to ensure clarity and reliability. The Cronbach's alpha value of the pilot test was greater than 0.80 [14]. For the central research model, the measurement model was analyzed using SmartPLS 4.0. The absolute loadings needed to be greater than 0.70; the composite reliability greater than 0.70; and the average variance extracted greater than 0.50. Concerning discriminant validity, the Fornell-Larcker criterion and the HTMT, which were less than 0.85, were included in the model [15].

2.4 Data Analysis

Smart-PLS 4.0 was used to perform PLS-SEM analyses. First, the measurement model was examined as detailed above. Second, tests were conducted for the structural model to evaluate multicollinearity ($VIF<5$), the significance of path coefficients through bootstrap resampling (5000 subsamples), R^2, and find predictive relevance (Q^2) [16]. The moderating effect of sustainability practices was analyzed by the product indicator approach in Smart-PLS [9]. The path significance was assessed at $p<0.05$.

3. Theoretical Framework and Hypothesis Development

3.1 Supply Chain Maturity Theory

Supply Chain Maturity Theory explains how companies evolve from manual, siloed business operations to an integrated, data-driven ecosystem [17]. In the early stages, companies often rely on paper-based tracking, resulting in limited visibility. As maturity increases, real-time inventory management systems can help monitor stock levels and demand patterns seamlessly [18]. By using automated process integration, procurement, production, and distribution are all linked, filling the gaps that extend lead times and introduce errors [19]. At a high level, product traceability solutions provide end-to-end visibility of material flow, which involves implementing solutions to quality control procedures or ensuring adherence to regulations [20]. Advances in studies about digital logistics and traceability in the agri-food systems have then contributed to the development of new perspectives in the field, potentially affecting the dairy SCs sector. Digital traceability systems among OECD countries highlight how the adoption of traceability mechanisms is sensitive to the national regulatory and technology context and how it affects food safety and transparency. Evidence of digital transformation- i.e., IoT, and blockchain- as enabler of efficiency and resiliency in the agri-food value chain. A systematic literature review reports on the emerging frameworks and trends in agri-food digital technology adoption from 2015 to 2024, revealing an empirical deficit with respect to structural modeling and the incorporation of management theory. Earlier dairy-specific research also gives insight. This emphasizes the significance and uniqueness of our empirical model in Jordan's dairy market. In dairy milk production, these innovations result in more efficient yields and reduced spoilage through smarter planning and quicker responses to disruptions. On that basis, the following direct effects are proposed:

- **H1** Automated process integration is positively associated with production performance.
- **H2 Product** traceability is positively correlated with production performance.
- **H3**Real-Real-time inventory management is positively associated with production performance.

3.2 Resource-Based View and Sustainability

The Resource-Based View posits that sustainable competitive advantage arises from resources that are valuable, rare, inimitable, and non-substitutable [21]. Sustainability initiatives, environmental management, social responsibility, and resource efficiency are strategic capabilities that enhance operational resilience and stakeholder trust [22]. Shifting to a profit-making model, a few argue that incorporating sustainability into the supply chain can bring returns by linking technological advancements to resource stewardship in the long run [23]. On the other hand, in the Jordanian dairy sector, although it is in the process of adopting renewable energy, waste valorization, and water-saving measures, the use of digital tools will enable it to perform even better.
Accordingly, sustainability is expected to have both a direct effect and a moderating influence on digital capabilities:

- **H4**Sustainability practices are positively associated with production performance.
- **H5**Sustainability practices moderate the relationship between automated process integration and production performance, such that the positive effect is stronger at higher levels of sustainability.
- **H6**Sustainability practices moderate the relationship between product traceability and production performance, such that the positive effect is stronger at higher levels of sustainability.
- **H7 Sustainability** practices moderate the relationship between real-time inventory management and production performance, such that the positive effect is stronger at higher levels of sustainability.

These seven hypotheses form the basis of the empirical model tested in this study.

4. Methodology

4.1 Research Method and Data Collection Process

A control study was conducted to analyze the effect of digital logistics capabilities on production performance of the Jordanian dairy industry and the moderating role of sustainability practices [24]. Respondents were dairy production managers and supply-chain professionals from both major dairy companies, whom we sampled using a non-probability judgment technique based on the use of digital tools and sustainability [25]. The survey was conducted from 2024 to 2025. A total of 200 structured questionnaires were distributed via email. Follow-up reminders were sent out twice; 150 valid responses were received (75% response rate). The questionnaires were found to require, on average, 15 minutes to complete. The purpose of the study was explained to all participants, assurances of confidentiality and anonymity were provided, and voluntary participation was emphasized. The ethical principles of human experimentations were conscientiously adhered to [26].

4.2 Survey Instrument

The measurement items were derived from the existing studies of supply chain digitalization, SCS, and performance measurement [27]. There were five items used to measure real-time inventory management, automated process integration with five items, and product traceability with four items. Energy conservation behavior. This section included six items: environment management, social responsibility, and resource utilization. Production efficiency was measured by six measures of labour productivity and waste reduction [28]. All measures were rated on a five-point Likert scale (1=strongly disagree to 5=strongly agree). A pilot study involving 15 professionals from the field was conducted to confirm the clarity and relevance of all items. The feedback resulted in some slight wording changes to clarify understanding and response.

4.3 Data Analysis

The data were processed and coded in MS Excel, then transferred to SmartPLS 4 for PLS-SEM [28]. First, the measurement model was assessed to verify the reliability and internal consistency of the indicators, as well as their convergent and discriminant validity. Subsequently, the proposed structural model was examined to measure the direct impacts of each dimension of digital logistics on production performance and the moderating roles of sustainability practices. Collinearity was checked based on VIFs (<5). Path coefficients, significance, and confidence intervals were determined by bootstrapping with 95% confidence intervals (5000 bootstraps). R^2 values were presented to assess explanation and prediction.

5. Data Analysis and Findings

5.1 Demographic Profile

The sample comprised 150 respondents. The ages of those questioned were distributed according to the following frequency pattern: 42% between 30 and 39, 35% between 40 and 49, and the rest were less than 30 or over 50. Males constituted 55% and females 45%. 40 percent worked at larger companies with at least 200 employees, 35percent at companies with 100–200 workers, and 25 percent at smaller businesses. Sixty percent of respondents had more than five years of industry experience

5.2 Measurement Model Results

Indicator loadings exceeded 0.70. Composite reliability values ranged from 0.82 to 0.91. Average variance extracted values exceeded 0.50. Fornell-, Larcker, and the HTMT criteria confirmed discriminant validity.

5.3 Structural Model Results

Real-time inventory management (β=0.32, p 0.35)

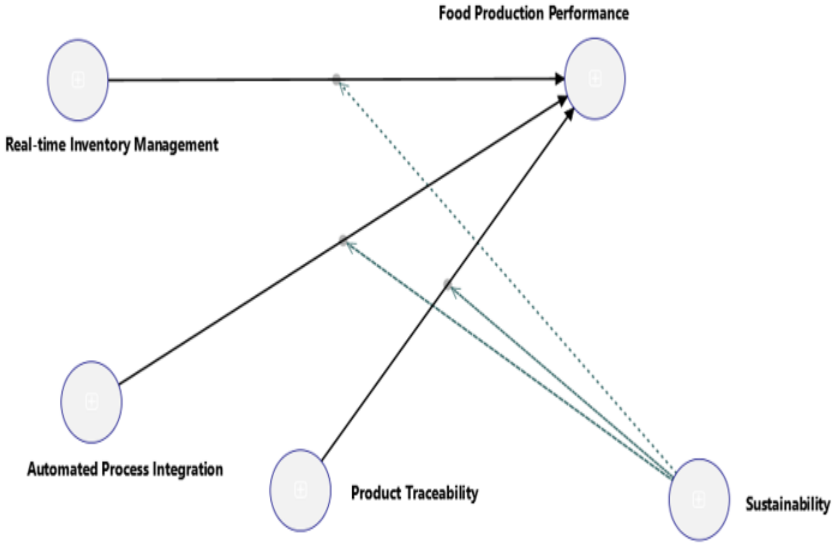

Fig. 1: Structural model.

Figure 1 : Automated Process Integration (H1), Product Traceability (H2), and Real-time Inventory Management (H3) are modeled as direct antecedents of Production Performance. Sustainability Practices have a direct path to performance (H4) and moderate the three digital-capability links (H5–H7). Dashed arrows denote moderation terms (Sustainability × Automated Process Integration; Sustainability × Product Traceability; Sustainability × Real-time Inventory Management).

For this study, evidence was collected using electronic and paper questionnaires distributed to production managers and supply-chain managers working in large dairy companies in Jordan. The questionnaire consisted of closed-ended constructs taken from established scales related to digital logistics capabilities, sustainability practices, and production performance. A complete response was achieved in 150 patients. PLS-SEM was conducted in Smart-PLS 4 to examine the direct and moderated relationships between latent constructs as proposed. We first tested the measurement model of reliability and validity. The values of Cronbach's alpha and composite reliability were both greater than 0.70, and all the indicator loadings ranged above 0.50. Convergent validity was signified by AVEs greater than 0.50; discriminant validity was demonstrated using Fornell–Larcker criterion and HTMT thresholds, less than 0.85. The concept of digital logistics was operationalized through real-time inventory management, automated process integration, and product traceability. Environmental practice included environmental management, social responsibility, and resource efficiency. Product performance was evaluated by the indicators of productivity and waste. After verifying the measurement model, we examined the structural model using bootstrapping (with 5,000 subsamples) to obtain path coefficients and t-values. We examined the separate direct influences of each digital logistics dimension and sustainability practices on production performance, and tested the moderating effect of sustainability using product-indicator interaction terms. Refer to the next section for details on hypothesis testing and moderation analysis.

Table 1: Cross-Loading Analysis

Constructs	Items	Factor loadings	Cronbach's Alpha	CR	(AVE)
	API1	0.825			
	API2	0.757			
Automated Process Integration	API3	0.776	0.867	0.904	0.653
	API4	0.803			
	API5	0.875			
	FPP1	0.801			
	FPP2	0.791			
	FPP3	0.84			
Production Performance	FPP4	0.884	0.92	0.936	0.677
	FPP5	0.81			
	FPP6	0.871			
	FPP7	0.756			
Product Traceability	PT1	0.871	0.885	0.916	0.686
Product Traceability	PT2	0.829	0.885	0.916	0.686
	PT3	0.754			
	PT4	0.854			
	PT5	0.829			
	RTIM1	0.854			
	RTIM2	0.846			
Real-time Inventory Management	RTIM3	0.853	0.93	0.943	0.736
	RTIM4	0.801			
	RTIM5	0.91			
	RTIM6	0.879			
	SU1	0.844			
	SU2	0.868			
Sustainability	SU3	0.91	0.912	0.934	0.738
	SU4	0.816			
	SU5	0.854			

The measurement model demonstrated strong reliability and validity for all constructs. API received a CR of 0.904, AVE of 0.653, and Cronbach's alpha of 0.867, with each of its five items' loadings ranging from 0.757 to 0.875, well above the threshold of 0.70. Organic Production Performance demonstrated slightly better internal consistency (α = 0.920, CR = 0.936, AVE = 0.677), with all seven of its indicators loading between 0.756 and 0.884. Product Traceability registered α=0.885, CR=0.916, and AVE=0.686, with five items loading from 0.754 to 0.871. Real-time Inventory Management demonstrated good reliability (α = 0.930; CR = 0.943; AVE = 0.736) and indicator loadings ranging from 0.801 to 0.910. Lastly, Sustainability obtained α = 0.912, CR = 0.934, and AVE = 0.738, with loadings ranging from 0.816 to 0.910. All AVEs were higher than the 0.50 threshold, indicating that convergent validity was good. The high CR and factor loading values demonstrated a good measure of the constructs. These findings provide evidence in favor of the measurement model for further structural equation modeling.

Table 2: Discriminant Validity HTMT

	Automated Process Integration	Production Performance	Product Traceability	Real-time Inventory Management	Sustainability
Automated Process Integration					
Production Performance	0.69				
Product Traceability	0.5	0.559			
Real-time Inventory Management	0.389	0.33	0.302		
Sustainability	0.427	0.348	0.399	0.303	

Table 2 shows the HTMT values for the five constructs, all of which are below the threshold of 0.85, confirming discriminant validity. The highest value is 0.69 for Automated Process Integration and Production Performance, and the lowest is 0.30 for Real-time Inventory Management with both Production Performance and Sustainability. All other ratios fall between 0.33 and 0.56. These results demonstrate that each construction measures a unique concept and that overlap between constructs is minimal.

Table 3: Discriminant Validity Fornell-Larcker's

	Automated Process Integration	Production Performance	Product Traceability	Real-time Inventory Management	Sustainability
Automated Process Integration	0.808				
Production Performance	0.628	0.823			
Product Traceability	0.439	0.5	0.828		
Real-time Inventory Management	0.367	0.322	0.268	0.858	
Sustainability	0.397	0.327	0.363	0.912	0.859

Table 3 shows the Fornell–Larcker criterion for discriminant validity. Every column and row diagonal value (the square root of the AVE) is greater than the corresponding off-diagonal correlations. Automated Process Integration has relatively higher correlation than other correlations, with a square root AVE of 0.808 and AVEs than Production Performance (0.628), Product Traceability (0.439), Real-time Inventory Management (0.367), and Sustainability (0.397). The square root AVE of Production Performance is 0.823, which is larger than all of them. Product Traceability (0.828), Real-time Inventory Management (0.858), and Sustainability (0.859) all also outperform the inter? Construct correlations for these constructs. These findings support the notion that the variance of each indicator of a construct with respect to its own construct is higher than the variance between indicators and other constructs, thus demonstrating discriminant validity.

6. Hypothesis Testing

The PLS-SEM results indicate that automated process integration, product traceability, and real-time inventory management each have positive and significant effects on production performance, as supported by H1–H3. Sustainability does not exhibit a direct effect, H4 unsupported, β = −0.205, p = 0.102. The moderation by sustainability is non-significant for automated process integration (H5), β = −0.021, p = 0.777, negative and significant for product traceability (H6), β = −0.341, p < 0.001, and positive and significant for real-time inventory management (H7), β = 0.175, p = 0.001. These results align with Table 4 and indicate heterogeneous moderation patterns across digital logistics dimensions. The model explains about 64% of the variance in production performance ($R^2 \approx 0.64$).

Figure 2. Structural model results using PLS-SEM (standardized path coefficients).

Direct effects: Automated Process Integration → Performance (β = 0.333, p < 0.001), Product Traceability → Performance (β = 0.235, p < 0.001), Real-time Inventory Management → Performance (β = 0.415, p < 0.001). Sustainability → Performance is non-significant (β = −0.205, p = 0.102). Moderation effects: Sustainability × Automated Process Integration is non-significant (β = −0.021, p = 0.777); Sustainability × Product Traceability is negative and significant (β = −0.341, p < 0.001); Sustainability × Real-time Inventory Management is positive and significant (β = 0.175, p = 0.001). Notes: Coefficients are standardized; dashed lines denote moderation; n.s. = not significant. Values match Table 4.

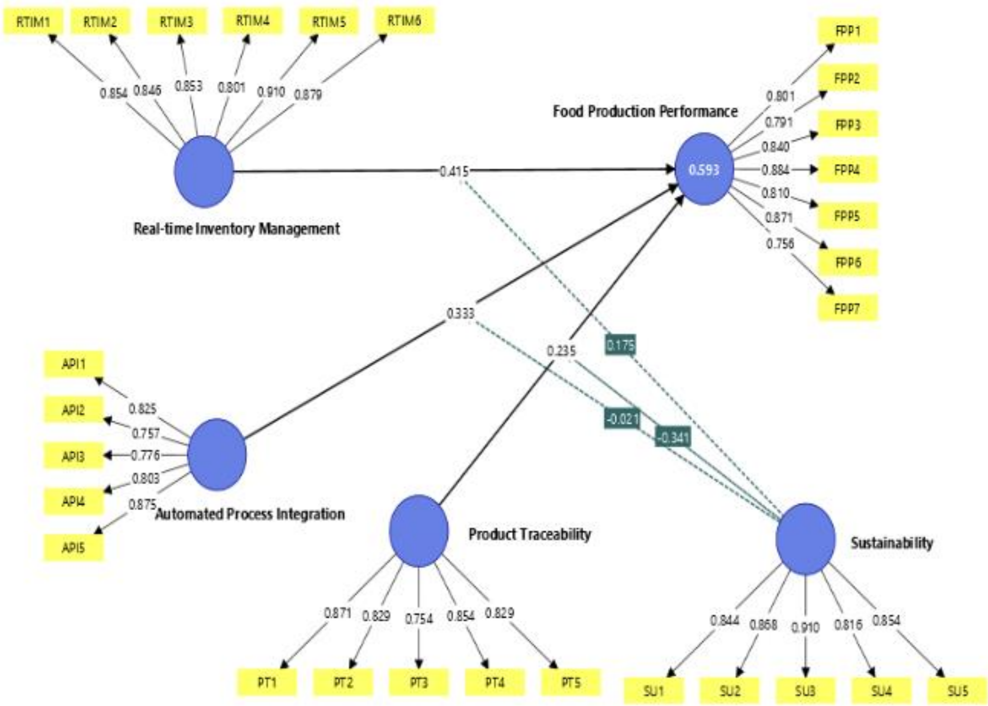

Fig. 2: Structural Model Results Using PLS-SEM

Table 4: Structural model estimates (Path coefficients)

Hypo	Relationships	Std. Beta	Std. Error	T-Value	P-Values	Decision
H1	Automated Process Integration -> Production Performance	0.333	0.068	4.928	0	Supported
H2	Product Traceability -> Production Performance	0.235	0.054	4.348	0	Supported
H3	Real-time Inventory Management -> Production Performance	0.415	0.114	3.63	0	Supported
H4	Sustainability -> Production Performance	-0.205	0.125	1.635	0.102	Unsupported
H5	Sustainability x Automated Process Integration -> Production Performance	-0.021	0.074	0.283	0.777	Unsupported
H6	Sustainability x Product Traceability -> Production Performance	-0.341	0.066	5.18	0	Supported
H7	Sustainability x Real-time Inventory Management -> Production Performance	0.175	0.055	3.192	0.001	Supported

There was strong support for most hypotheses based on the results of the structural model. Process automation integration has a substantial effect on production performance ($\beta = 0.333$, $t = 4.928$, $p < 0.001$), indicating that supply chain processes are more effective when coordinated without disruptions. Product traceability also had a favorable impact on performance ($\beta = 0.235$, $t = 4.348$, $p < 0.001$), suggesting that increased visibility of product flows yields better yields and less waste. The strongest direct effect was from real-time inventory management ($\beta = 0.415$, $t = 3.630$, $p < 0.001$), highlighting the importance of the attribute in aligning supply and demand practices. In contrast, the direct effect of sustainability practice on production performance was not significant ($\beta = –0.205$, $t = 1.635$, $p = 0.102$), indicating that sustainability alone might not lead to immediate performance improvement. As a further moderating hypothesis, no interaction effect was found between sustainability and automated process integration ($\beta = –0.021$, $t = 0.283$, $p = 0.777$), indicating no improvement due to the combined implementation of these practices. However, sustainability was significantly negatively related to the product traceability–performance relationship ($b = –0.341$, $t = 5.180$, $p < 0.001$), and positively associated with the real-time inventory management–performance link ($b = 0.175$, $t = 3.192$, $p = 0.001$). In conclusion, five out of seven proposed hypotheses are supported, indicating that core digital logistics capabilities, when combined with sustainability, are significant enablers of production performance in the Jordanian dairy industry.

7. Conclusions

7.1 Discussion and Conclusions

When dairy firms embrace Industry 4.0, digital logistics becomes a primary lever for production optimization and competitiveness [33]. This study examined the effects of automated process integration, product traceability, and real-time inventory management on production performance in Jordan's dairy sector and assessed whether sustainability practices reinforce these relationships. Results show that all three digital capabilities are positively and significantly associated with performance (H1–H3), with real-time inventory management exerting the largest effect, underscoring the need for rapid responses to demand and stock conditions [34]. Contrary to expectations, sustainability practices do not have a direct effect on production performance (H4 unsupported), and the moderation of automated process integration by sustainability is non-significant (H5 unsupported). In contrast, sustainability negatively moderates the product traceability–performance relationship (H6: $\beta = -0.341$, $p < 0.001$) and positively moderates the real-time inventory management–performance relationship (H7: $\beta = 0.175$, $p = 0.001$), indicating mixed moderation patterns across digital logistics dimensions.

A plausible mechanism for the negative moderation on traceability is a scope–cost trade-off. As sustainability requirements intensify, firms expand the breadth, depth, and verification of traceability, introducing batch segregation, additional checks, geolocation, supplier attestations, and auditable data chains. These steps lengthen lead times, reduce sourcing flexibility by excluding less-digitized suppliers, and reallocate resources from production optimization to compliance administration, which can dampen near-term performance gains from traceability. This reconciles the negative moderation with the literature and aligns with the view that complementarities are contingent on fit between the traceability scope, the targeted ESG outcome, and the firm's digital maturity.

Managerially, operations leaders should calibrate traceability to risk and intended ESG outcomes, phase deployments to avoid compliance shocks, and use risk-based due diligence. Taken together, five of seven hypotheses were supported, indicating that core digital logistics capabilities and their careful alignment with sustainability are important levers for improving production performance in Jordan's dairy industry. Future research should test the model in other segments and geographies and examine additional contingencies such as firm size and technological readiness.

7.2 Theoretical Implications

The study contributes to Supply Chain Maturity Theory by illustrating the varying degrees of digital integration and the implications of digital integration. and when' it what areas and processes result in tangible production efficiencies in the dairy sector in the form of real-time inventory control, automated process integration, and product traceability [38]. Earlier work has considered these dimensions separately, whereas our results provide an integrated model that combines these dimensions into a coherent framework, accounting for more than 60% of the variance in performance. In doing so, we empirically bridge the stages of maturity with operational effort, thereby broadening the applicability of the theory from manufacturing to the sector. Additionally, the specific results enrich the Resource-Based View by demonstrating that sustainability practices serve not only as independent resources but also as enhancers of digital investments [39]. Whereas RBV typically conceptualizes resources as static, our moderation findings suggest a dynamic relationship: organizations that integrate environmental management and resource efficiency with digital configurations can capture more value from traceability systems and inventory controls. This highlights the importance of considering an internal coherence of capabilities in technology sustainability combinations. Novel directions for theory expansion emerge from these contributions taken together. Further research may consider other boundary conditions, such as firm size, technological readiness, or regulatory environments, that influence the relationship between digital maturity performance and other factors. These contributing factors may evolve in both positive and negative ways; hence, future studies might explore other types of complementary resources, such as human capital or organizational culture, in shaping the co-evolution of digital and sustainable supply chains.

7.3 Practical Implications

Managerial Implications: These findings provide good guidelines for dairy producers in Jordan. First, enterprises should focus on investing in a real-time inventory management system to have the right amount of stock available, thereby avoiding spoilage. Secondly, those who are best placed to deploy fully baked traceability solutions will enhance quality control and regulatory compliance, while automated system integration can significantly streamline procurement, production, and supply chain workflows. Third, sustainability should not be considered a separate initiative, but rather it should be incorporated as a fundamental part of digital logistics programs. For instance, waste valorization and water-saving approaches can be integrated with automated operations for enhanced performance. Managers should create cross-functional teams, involving experts from production, supply chain, sustainability, and IT, to ensure that digital and environmental goals are harmonized. Finally, staff training is essential. Plant managers and supply-chain experts need more hands-on workshops to learn how to operate new systems and analyze data in real-time. Being clear on roles and responsibilities enables each team to understand the significant impact they have on the bottom line. By doing so, dairy companies can achieve increased yield efficiency and waste reduction by combining digital and sustainability capabilities. Enhancing generalizability. Although consideration of a moderating effect of LOG on the relationship between TFD and PP and on the relationship between TFD and SP has been contextualized within the Jordanian dairy sector, the model relating digital LOG capabilities to PP and incorporating sustainability as a moderator is more broadly generalizable. In the agri-food sector, specifically in crop supply chains, blockchain-based traceability and IoT-based inventories are found to enhance transparency and responsiveness in fruit and vegetable logistics, with sustainability requirements influencing patterns of adoption. Similar dynamics can be observed in meat and seafood supply chains, where digital traceability enhances food safety and increases regulatory compliance, while also potentially increasing costs and slowing throughput when combined with stringent sustainability certifications. Outside of the agri-food context, an equivalent set of insights can be found in pharmaceutical logistics, where the need for real-time tracking and automated processes is crucial for both efficiency and compliance for different reasons. In this regard, environmental and social performance, green packaging, and reverse logistics may moderate cost-to-performance relationships. In the hospitality and retail industries, recent research has shown that the adoption of digital eco-responsibility in supply chain collaboration enhances resilience and customer service, but performance is contingent on how well environmental practices align with technological capabilities.

7.4 Limitations and Future Research

This study has several limitations. First, it was based solely on dairy producers in Jordan, which may affect the generalizability of the findings to other subsectors or regions. Second, the data were obtained using a self-reported questionnaire, which provided the opportunity for common method bias. Third, sustainability was considered as the only potential moderating variable, without considering other contingencies, such as firm size, technological preparedness, or organizational culture. Lastly, the cross-sectional nature of the study means that relationships are captured at a single point in time, which prohibits an assessment of the long-term effects of digital investments and sustainability activities. To increase the validity of the model and the instrument, future research may extend the model to include other parts of the sector and collect data from corporations in other countries to test the transferability and generalizability of the model. Longitudinal research would have the potential to track the impacts of DMS as firms mature. More qualitative approaches, such as case studies or interviews, may help to understand how managers implement and embed digital logistics solutions in conjunction with environmental practices. Other moderators (workforce digital skills, leadership support, or external regulatory pressures) need to be explored to obtain deeper insights into the contingencies under which digital and sustainable strategies are most impactful in driving performance.

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