Theme: Safe, Sustainable and Innovative Dairy and Food Systems for One Health

RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume 45 Special Issue: 76-83 (2026)

Enablers of Digital Traceability for Food Safety in the Indian Dairy Supply Chain: A Structural Analysis

Sandhya Jadhav[1], Sanjivkumar M. Pol[2], Vinod G. Surange[3], Pravin Kumar Bhoyar[3], Sonali Mhatre[1], Smita Dange[4], Deelip B. Radkar[1]

10.18805/ajdfr.DR-2538

ABSTRACT

Background: Digital traceability is increasingly important for strengthening transparency, information visibility and food-safety management in complex dairy supply chains. However, effective implementation in the Indian dairy supply chain depends on the interaction of several organizational, technological, regulatory, human and financial enablers. Identifying the relative influence and interdependence of these enablers is therefore essential for establishing an effective digital traceability system.

Methods: This study employed an integrated Interpretive Structural Modelling (ISM)-Cross-impact matrix multiplication applied to classification (MICMAC) approach to analyse the interrelationships among eight critical enablers of digital traceability for food safety. Expert judgments were used to develop the Structural Self-Interaction Matrix, followed by reachability analysis, level partitioning and MICMAC classification.

Result: The ISM analysis produced a four-level hierarchical structure. Financial Investment and Cost Support (FICS) emerged as the strongest foundational driver, with a driving power of 8 and dependence power of 1, followed by Top Management Support and Leadership (TMSL), with driving and dependence powers of 7 and 2, respectively. Food Safety Regulatory and Compliance Support (FSRC), Employee Digital Skills and Training (EDST), Inter-organizational Data Sharing and Collaboration (IDSC) and Digital Infrastructure and ICT Capability (DICT) occupied the intermediate linkage position, each with a driving power of 6 and a dependence power of 6. Data Transparency, Trust and Traceability Governance (DTTG) and Data Standardization and Interoperability (DSI) were positioned at the highest level, with driving power of 2 and dependence power of 8, indicating their strong dependence on other enablers. MICMAC analysis identified no autonomous enabler, confirming the substantial interdependence among all eight factors. The findings demonstrate that digital traceability should be developed through a coordinated approach beginning with financial support and managerial commitment, followed by strengthening regulatory support, employee capabilities, collaboration and ICT infrastructure to achieve standardized, transparent and trustworthy traceability.

Key words: Digital traceability, Indian dairy supply chain, Interpretive structural modelling, MICMAC, Supply chain enablers.

INTRODUCTION

India is the world's largest milk-producing country, making the dairy sector an important component of its agricultural economy, rural livelihoods and food security (Malik *et al.*, 2023). However, the Indian dairy supply chain is highly dispersed and involves multiple actors, including farmers, collection centres, cooperatives, processors, distributors and retailers (Khanna *et al.*, 2022). The perishability of milk and dairy products makes the supply chain particularly vulnerable to quality deterioration, contamination, improper handling and delays in transportation (Annie Rose Nirmala *et al.*, 2022). Existing studies have highlighted challenges related to cold-chain infrastructure, information systems, transportation, coordination and supply-chain management in the Indian dairy sector (Karwasra *et al.*, 2024).

Food safety in such a complex supply-chain environment requires effective traceability, enabling products and relevant information to be tracked across different stages of the supply chain (Gottschald, 2024). Traditional paper-based and fragmented information systems, however, may limit real-time visibility, information sharing and rapid identification of food-safety issues. Digital traceability, supported by information and communication technologies, can improve the recording, integration, sharing and retrieval of supply-chain information and thereby strengthen transparency and food-safety

[1]Bharati Vidyapeeth College of Engineering, Navi Mumbai-400 614, Maharashtra, India.
[2]Visvesvaraya Technological University, Jnana Sangama, Belagavi-590 018, Karnataka, India.
[3]Symbiosis Institute of Business Management, Nagpur, Symbiosis International (Deemed University), Pune-412 115, Maharashtra, India.
[4]Department of Computer Engineering, Fr. C. Rodrigues Institute of Technology, Navi Mumbai-400 703, Maharashtra, India.

Corresponding Authors: Vinod G. Surange, Deelip B. Radkar, Symbiosis Institute of Business Management, Nagpur, Symbiosis International (Deemed University), Pune-412 115, Maharashtra, India; Bharati Vidyapeeth College of Engineering, Navi Mumbai-400 614, Maharashtra, India.
Email: vinod.surange@gmail.com; dilip.radkar@bvcoenm.edu.in

ORCIDs: https://orcid.org/0000-0002-8342-863X, https://orcid.org/0000-0002-8319-516X, https://orcid.org/0000-0002-3388-9489, https://orcid.org/0000-0003-0707-9674, https://orcid.org/0000-0003-3711-7272, https://orcid.org/0000-0002-3148-8673, https://orcid.org/0000-0002-2446-7727

How to cite this article: Jadhav, S., Pol, S.M., Surange, V.G., Bhoyar, P.K., Mhatre, S., Dange, S. and Radkar, D.B. (2026). Enablers of Digital Traceability for Food Safety in the Indian Dairy Supply Chain: A Structural Analysis. *Asian Journal of Dairy and Food Research*. **45(Special issue):** 76-83. doi: 10.18805/ajdfr.DR-2538.

Submitted: 14-09-2026 **Accepted:** 27-10-2026 **Online:** 14-11-2026

management (Krishnasree *et al.*, 2018; Salokhe and Patil, 2026). Previous dairy supply-chain research has recognized the importance of ICT-based operations, employee training, stakeholder trust and supply-chain collaboration in improving supply-chain effectiveness (Kumar and Shankar, 2024).

Against this background, the present study focuses on the organizational, technological, informational, human, relational, institutional and financial conditions that may enable effective digital traceability for food safety across the Indian dairy supply chain. The specific enablers examined in this study are identified and justified through the literature review, reflecting the need for managerial commitment, technological capability, coordinated information exchange, employee competence, regulatory support, stakeholder trust and adequate financial resources.

Although previous research has examined enablers and challenges in dairy supply chains, including studies employing structural modelling approaches, limited research has examined the structural interrelationships among the enablers specifically associated with digital traceability for food safety in the Indian dairy supply chain (Asif *et al.*, 2024). The existing studies primarily address general dairy supply-chain management rather than digital traceability. Understanding the interrelationships among these enablers is therefore important for identifying which factors act as fundamental drivers and which are dependent on other factors.

Unlike previous studies examining general dairy supply-chain enablers or traceability technologies, this study models the structural interrelationships among eight enablers of digital traceability for food safety in the Indian dairy supply chain using Interpretive Structural Modelling (ISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) (Kumar *et al.*, 2026; Surange *et al.*, 2026). It identifies foundational drivers and dependent enablers to support implementation prioritisation. For example, if a contamination alert is associated with a milk lot collected at a collection centre, digital traceability records can help identify the processing batches containing that lot and their distribution destinations, enabling targeted product withdrawal or recall.

Accordingly, this study aims to model the interrelationships among the critical enablers of digital traceability for food safety in the Indian dairy supply chain using ISM and MICMAC analysis. ISM is used to establish the hierarchical relationships among the enablers, while MICMAC classifies them according to their driving power and dependence power. The resulting model is expected to provide dairy organizations, supply-chain partners and policymakers with a structured basis for prioritizing interventions to strengthen digital traceability and food-safety management.

MATERIALS AND METHODS

Research design

As shown in Fig 1, the study proceeds through a systematic sequence comprising literature review and enabler identification, expert validation, development of the Structural Self-Interaction Matrix (SSIM), construction of the Initial and Final Reachability Matrices (IRM and FRM), level partitioning, development of the ISM model and MICMAC analysis. The expert inputs are used to establish contextual relationships among the identified enablers, while the resulting ISM hierarchy provides the basis for calculating driving and dependence power in the analysis. This integrated approach enables the study to identify the foundational, linkage and dependent enablers influencing digital traceability for food safety in the Indian dairy supply chain.

Identification of enablers

The critical enablers were identified through a focused review of recent literature (2021-2026) covering digital traceability, food safety, digital technologies, supply-chain collaboration and dairy supply-chain management (Krstić *et al.*, 2023; Sinha and Mishra, 2023). The identified factors

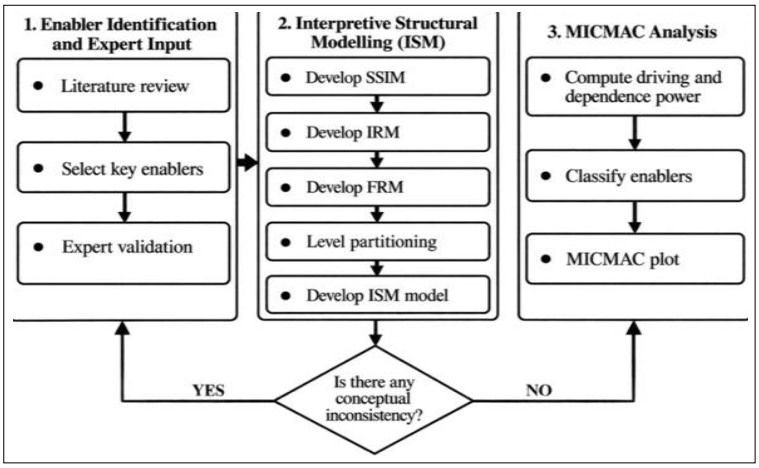


Fig 1: Research methodological framework for ISM-MICMAC analysis of digital traceability enablers.

were subsequently examined for their relevance to the Indian dairy supply-chain context and validated by domain experts. Based on the literature review and expert validation, eight critical enablers were retained for the ISM-MICMAC analysis, as presented in Table 1.

The eight enablers were selected based on their relevance to digital traceability and food safety in the Indian dairy supply chain, as identified in the reviewed literature and validated by domain experts.

The selected enablers collectively represent the organizational, technological, relational, human, institutional and financial dimensions required for effective digital traceability in the Indian dairy supply chain. These enablers were subsequently subjected to expert assessment to establish their contextual interrelationships for the ISM analysis.

Expert validation and data collection

The study employed 11 experts to obtain contextual judgments regarding the relationships among the identified enablers of digital traceability for food safety in the Indian dairy supply chain. The experts were purposively selected based on their professional experience, domain knowledge and direct or academic involvement in the Indian dairy supply chain. The selection of experts aimed to capture diverse perspectives from functional areas that are directly relevant to digital traceability and food-safety management.

The expert panel represented key domains of the Indian dairy supply chain, including milk procurement and collection, dairy processing and operations, food safety and quality management, supply-chain and logistics management, digital technologies and information systems and academic research related to dairy supply chains, operations management, food safety and digitalization. Experts from milk procurement and collection provided insights into activities at the farm-to-collection stage, including milk handling and information capture. Experts from dairy processing and operations contributed knowledge related to processing, production and product-handling activities. Food safety and quality management experts provided perspectives on food-safety requirements, quality assurance, regulatory compliance and traceability controls. Experts in supply-chain and logistics management contributed knowledge concerning transportation, distribution, cold-chain operations and information flows across different stages of the supply chain. Professionals with expertise in digital technologies and information systems provided perspectives on digital infrastructure, ICT capability, data sharing, information integration and interoperability. Academic experts contributed broader conceptual and research-based perspectives on dairy supply chains, operations, food safety and digitalization.

All 11 experts had more than five years of relevant professional or academic experience. Among them, 4 experts had 10 or more years of experience, including 3 experts with 15 or more years of experience. Thus, the panel included experts ranging from mid-career professionals to highly experienced professionals and academics with substantial knowledge of the Indian dairy supply-chain environment. The combination of different experience levels was considered appropriate for obtaining informed judgments on both operational and strategic relationships among the identified enablers.

The multidisciplinary composition of the expert panel was particularly relevant to the present study because the identified enablers encompass organizational, technological, informational, human, relational, institutional and financial dimensions. Experts from different functional domains were therefore able to assess the interrelationships among these dimensions from their respective areas of expertise. This diversity helped provide a broader basis for evaluating how managerial commitment, technological capabilities, information exchange, employee competencies, regulatory support, stakeholder trust and financial resources may influence digital traceability implementation.

Expert consultation and data collection were conducted over a five-month period from March to August 2026 with professionals from the Maharashtra region of the Indian dairy supply-chain sector. A structured questionnaire containing the eight enablers and their operational definitions was provided to the experts. For each pair of enablers, the experts assessed the direction of influence using the V, A, X, O notation. The symbol receiving the highest number of responses for each pair was retained in the SSIM. For example, if V received the maximum number of responses for a pair, V was assigned to that pair in the SSIM. The same rule was applied to A, X and O.

Table 1: Critical enablers of digital traceability for food safety in the indian dairy supply chain.

Code	Enabler	Source
TMSL	Top management support and leadership	(Alsadi *et al.*, 2021; Nayal *et al.*, 2023)
IDSC	Inter-organizational data sharing and collaboration	(Gottschald, 2024)
EDST	Employee dgital skills and training	(Kuhn and Lucke, 2021; Kumar and Shankar, 2024)
DICT	Digital infrastructure and ICT capability	(Gottschald, 2024; Kumar and Shankar, 2024)
FSRC	Food safety regulatory and compliance support	(Zhou *et al.*, 2022)
FICS	Financial investment and cost support	(Nayal *et al.*, 2023)
DTTG	Data transparency, trust and traceability governance	(Casino *et al.*, 2021)
DSI	Data standardization and interoperability	(Gottschald, 2024)

SSIM

These V, A, X, O conventions are consistent with the established ISM procedure used in dairy supply-chain research (Asif *et al.*, 2024).

Following the identification and expert validation of the eight enablers, their contextual relationships were examined using the SSIM. Expert judgments were recorded using the V, A, X, O notation, where V indicates that enabler *i* leads to enabler *j*, A indicates that enabler *j* leads to enabler *i*, X represents mutual influence between the two enablers and O indicates the absence of a significant contextual relationship.

The SSIM captures the experts' perceptions regarding the directional relationships among the eight enablers of digital traceability for food safety (Table 2). The resulting SSIM was subsequently converted into a binary matrix to facilitate the ISM analysis.

The SSIM provides the qualitative foundation for establishing the structural relationships among the identified enablers. The V, A, X, O relationships were subsequently converted into binary values to construct the IRM.

Initial and final reachability matrix

The SSIM was transformed into the IRM by employing binary values of 0 and 1. A number of 1 indicates the presence of a relationship while 0 indicates the lack of a direct tie. The SSIM was converted into the IRM using binary values: V = (1,0), A = (0,1), X = (1,1) and O = (0,0) for each pair of enablers. Diagonal entries were assigned 1 (Table 3). Then the IRM was checked for transitivity, which is a necessary condition in ISM, to find the indirect linkages between the enablers. The FRM thus obtained contains direct and transitive linkages (Table 4). It is the basis for determining the hierarchical levels and computing the driving and reliance power of the enablers.

The Final Reachability Matrix provides the basis for level partitioning and MICMAC analysis. The driving power of an enabler is obtained from the total number of elements

Table 2: SSIM of digital traceability enablers.

Variables	TMSL	IDSC	EDST	DICT	FSRC	FICS	DTTG	DSI
TMSL	-	V	V	V	V	A	V	V
IDSC		-	X	O	O	A	V	V
EDST			-	X	O	A	O	O
DICT				-	X	A	V	V
FSRC					-	A	O	O
FICS						-	O	O
DTTG							-	X
DSI								-

Table 3: Initial reachability matrix.

Variables	TMSL	IDSC	EDST	DICT	FSRC	FICS	DTTG	DSI
TMSL	1	1	1	1	1	0	1	1
IDSC	0	1	1	0	0	0	1	1
EDST	0	1	1	1	0	0	0	0
DICT	0	0	1	1	1	0	1	1
FSRC	0	0	0	1	1	0	0	0
FICS	1	1	1	1	1	1	0	0
DTTG	0	0	0	0	0	0	1	1
DSI	0	0	0	0	0	0	1	1

Table 4: Final reachability matrix.

Variables	TMSL	IDSC	EDST	DICT	FSRC	FICS	DTTG	DSI	Driving power
TMSL	1	1	1	1	1	0	1	1	7
IDSC	0	1	1	1*	1*	0	1	1	6
EDST	0	1	1	1	1*	0	1*	1*	6
DICT	0	1*	1	1	1	0	1	1	6
FSRC	0	1*	1*	1	1	0	1*	1*	6
FICS	1	1	1	1	1	1	1*	1*	8
DTTG	0	0	0	0	0	0	1	1	2
DSI	0	0	0	0	0	0	1	1	2
Dependance power	2	6	6	6	6	1	8	8	

*in FRM table indicates incorporation of transitivity.

it can reach, while its dependence power is determined from the number of elements from which it can be reached.

Level partitioning and ISM model development

The FRM was used to determine the reachability set, antecedent set and intersection set for each enabler. Iterative level partitioning was then performed to determine the hierarchical position of the enablers. Enablers whose reachability and intersection sets were identical were assigned to the highest level of the hierarchy, after which the identified level was removed and the procedure was repeated until all enablers were assigned a level. The hierarchical relationships were subsequently represented through a directed graph (digraph), while redundant transitive links were removed to obtain the final ISM model (Hasani *et al.*, 2025).

The Final Reachability Matrix was iteratively partitioned in levels by the reachability, antecedent and intersection sets. The process resulted in a four-level hierarchical structure among the eight enablers, as presented in Table 5.

MICMAC analysis

MICMAC analysis was applied to the FRM to examine the structural characteristics of the identified enablers. The driving power and dependence power of each enabler were calculated from the FRM by considering the total number of elements that an enabler can influence and the number of elements influencing it, respectively. Driving power was calculated using the row totals of the FRM, while dependence power was calculated using its column totals. The resulting values were used to position the eight enablers on a driving power-dependence power matrix.

The enablers were subsequently grouped into the four conventional MICMAC clusters-autonomous, dependent, linkage and independent (driver)-according to their relative driving and dependence characteristics (Hota, 2024). The resulting classification was used in conjunction with the ISM hierarchy to support the interpretation of the structural relationships among the digital traceability enablers.

RESULTS AND DISCUSSION

Interpretation of the hierarchical model

The results of level-partitioning indicate that FICS is at the bottom of the hierarchy at Level IV, followed by TMSL at Level III. IDSC, EDST, DICT and FSRC are at Level II while DTTG and DSI are at Level I.

Fig 2 illustrates a clear bottom-up dependence pattern. The model is based on FICS as the base, reflecting the driving function of FICS. TMSL is at the next level. Four enablers occupy the intermediate level, namely IDSC, EDST, DICT and FSRC. At the highest level, DTTG and DSI are set up as dependent enablers.

The ISM hierarchy suggests that FICS is the foundation of digital traceability execution. Its position indicates that financial resources are a critical precondition for the development and maintenance of the infrastructure, technology, training and organizational capabilities required for digital traceability in the dairy supply chain.

Level III is home to TMSL and is a major driver for the system. The model suggests that leadership commitment may support resource allocation, strategic prioritisation and institutional support for digital traceability initiatives. Its position immediately above FICS suggests that financial

Table 5: Level partitioning of digital traceability enablers.

ISM Level	Enablers	Interpretation
Level I	DTTG, DSI	Highly dependent/upper-level enablers
Level II	IDSC, EDST, DICT, FSRC	Linkage/intermediate enablers
Level III	TMSL	Strong driver
Level IV	FICS	Foundational/strongest driver

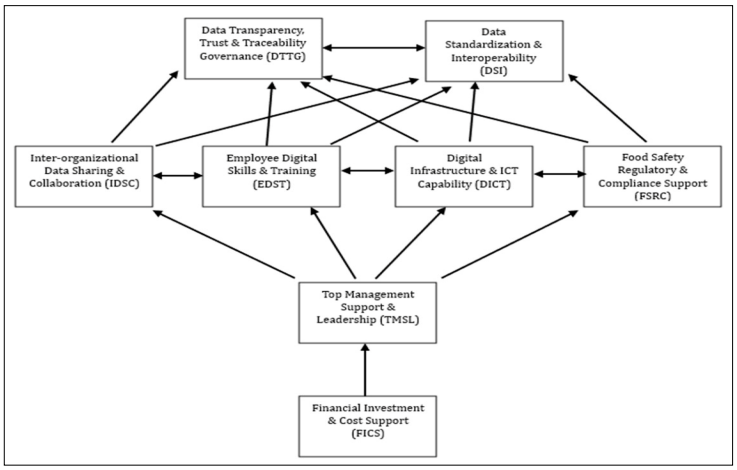


Fig 2: ISM hierarchical model.

resources alone are insufficient without the corresponding managerial commitment and direction.

IDSC, EDST, DICT and FSRC form the intermediary layer of the framework at Level II. These facilitators have a substantial dual function since they are influenced by the subordinate drivers, while they also influence the superior results. IDSC enables information to be shared between farmers, collection centers, processors, distributors and other players in the supply chain. The EDST program enables efficient use of digital platforms and accurate data management. Digital Infrastructure and Information and Communication Technology Capability (DICT) is the technology basis for acquiring, maintaining and distributing traceable data. The FSRC delivers organizational guidance and supports compliance with food safety and traceability requirements.

The major components of Level I are DTTG and DSI. Their position implies that effective transparency, trust, governance and interoperability require the systematic development of foundational financial, managerial, regulatory, human, relational and technological capabilities. Therefore, the ISM hierarchy shows that improvements in digital traceability require a bottom-up implementation approach, starting from the provision of funds and commitment of management to organizational capabilities, collaboration, technological infrastructures, interoperability and trustworthy traceability governance.

MICMAC analysis

The MICMAC analysis shows three clusters: independent/ driver, linking and dependent. There is no autonomous enabler. The classification points out the distinct structural responsibilities of the enablers inside the digital traceability system. The driver factors are the foundation of system development, The linkage factors exhibit strong interrelationships, whereas the dependent factors are strongly influenced by other enablers. Overall, the findings of the analysis complement the ISM hierarchy since it clarifies the interconnection and relative significance of the identified enablers.

Fig 3 shows that FICS and TMSL are independent/ driver enablers, which means they have a great impact on the other elements of the system. IDSC, EDST, DICT and FSRC are placed in the linkage quadrant because they have high driving and reliance power. DTTG, DSI are in the dependent quadrant, meaning that their development is highly dependent on the other enablers. There is no enabler in the autonomous quadrant.

Overall discussion

The integrated ISM-MICMAC analysis indicates that implementing digital traceability for food safety in the Indian dairy supply chain involves highly interconnected enablers. The results indicated that the largest foundational driver was FICS followed by TMSL. Their independent (driver) classification suggests that these enablers have substantial structural influence over other elements of the traceability system.

The linkage position of IDSC, EDST, DICT and FSRC is particularly important because these factors both influence and depend on other elements. Their equal driving and dependence power indicates that they can act as critical points of interaction within the system. Consequently, interventions in one linkage factor may affect the functioning of other interconnected factors.

In contrast, DTTG and DSI occupy the dependent category and the highest level of the ISM hierarchy. This suggests that transparent, trusted and governed traceability information, together with standardized and interoperable data, is unlikely to be achieved effectively without first establishing adequate financial, managerial, technological, human, collaborative and regulatory foundations.

Practically, at milk collection centres, financial support and management commitment can facilitate digital recording of milk lot identifiers and quality-test results. At processing facilities, digital infrastructure and inter-organizational data sharing can link incoming milk lots with processing batches. At distribution stages, traceability records can help identify destinations receiving affected batches during a food-safety incident, supporting targeted product withdrawal. However, the suggested implementation sequence is derived from expert judgments and structural modelling and has not yet been empirically tested in dairy organizations. It should therefore be considered a proposed framework requiring practical validation.

The absence of autonomous enablers suggests that all eight factors are structurally interconnected within the model. The combined findings therefore suggest that dairy organizations should adopt a staged implementation strategy, beginning with financial support and management commitment, followed by strengthening regulatory support, employee capabilities, inter-organizational collaboration and ICT infrastructure. These developments can subsequently support data standardization, interoperability, transparency, trust and traceability governance.

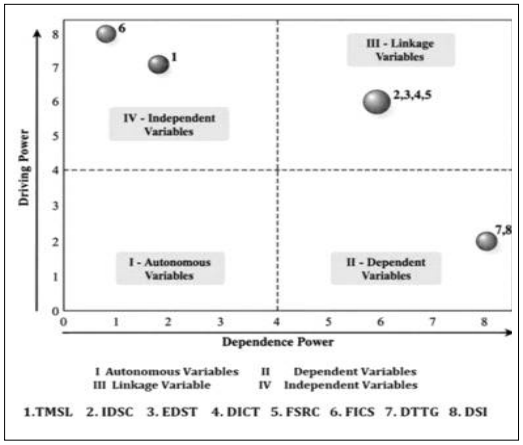


Fig 3: MICMAC analysis of digital traceability enablers.

CONCLUSION

This study develops an ISM-MICMAC framework to explain the structural relationships among eight enablers of digital traceability for food safety in the Indian dairy supply chain. The findings establish that traceability implementation is a system-level transformation, in which enabling conditions at different levels are interconnected rather than isolated. The model points to financial support and leadership commitment as the core foundations. The intermediate variables connect the foundations to the higher-level capabilities of standardized, transparent and trustworthy traceable information. The absence of independent components points to the integrated character of the system. From a management point of view, the results show that investment priorities should be made according to the structural logic of the system and not only on the digital technology. The framework therefore provides a basis for dairy companies and policy makers to sequence initiatives and increases traceability capabilities.

The work provides a context-specific structural model of the Indian dairy sector and lays a foundation for future empirical validation using bigger stakeholder samples and other complementing analytical methodologies.

ACKNOWLEDGEMENT

The present study was not supported by any specific funding agency in the public, commercial, or not-for-profit sectors.

Disclaimers

The views and conclusions expressed in this article are solely those of the author and do not necessarily represent the views of the affiliated institution. The author is responsible for the accuracy and completeness of the information provided and does not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

Informed consent and ethical approval are not applicable.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

REFERENCES

Alsadi, A., Alaskar, T. and Mezghani, K. (2021). Adoption of big data analytics in supply chain management. *International Journal of Information Systems and Supply Chain Management*. **14(2):** 20. https://doi.org/10.4018/IJISSCM.2021040105.

Annie Rose Nirmala, D., Ramaswamy, S., Logesh, K. and Joe Patrick Gnanaraj, S. (2022). Empirical study on risk mitigation for dairy supply chain management of Aavin Co-operative milk producers' Union Ltd. *Materials Today: Proceedings*. **49(8):** 3657-3660. https://doi.org/10.1016/j.matpr.2021.09.243.

Asif, M., Sarim, M., Khan, W. and Khan, S. (2024). ISM- and MICMAC-based modelling of dairy supply chain: A study of enablers in Indian economy perspective. *British Food Journal*. **126(2):** 578-594. https://doi.org/10.1108/BFJ-04-2023-0307.

Casino, F., Kanakaris, V., Dasaklis, T.K., Moschuris, S., Stachtiaris, S., Pagoni, M. and Rachaniotis, N.P. (2021). Blockchain-based food supply chain traceability: A case study in the dairy sector. *International Journal of Production Research*. **59(19):** 5758-5770. https://doi.org/10.1080/00207543.2020.1789238.

Gottschald, M. (2024). Advancing food safety through digital traceability, interoperability, harmonized data and collaborative partnerships. *Journal of Consumer Protection and Food Safety*. **19(3):** 257-258. https://doi.org/10.1007/s00003-024-01522-8.

Hasani, A., Haseli, G. and Deveci, M. (2025). Analyzing operational risks of digital supply chain transformation using hybrid ISM-MICMAC method. *OPSEARCH*. **62(2):** 583-607. https://doi.org/10.1007/s12597-024-00792-y.

Hota, Jyotiranjan. (2024). Framework of challenges affecting adoption of people analytics in India using ISM and MICMAC analysis. *Vision*. **28(1):** 76-86. https://doi.org/10.1177/09722629211029007.

Karwasra, K., Soni, G., Mangla, S.K. and Kazancoglu, Y. (2024). Assessing dairy supply chain vulnerability during the Covid-19 pandemic. *International Journal of Logistics Research and Applications*. **27(11):** 2378-2396. https://doi.org/10.1080/13675567.2021.1910221.

Khanna, A., Jain, S., Burgio, A., Bolshev, V. and Panchenko, V. (2022). Blockchain-enabled supply chain platform for Indian dairy industry: Safety and traceability. *Foods*. **11(17):** 2716. https://doi.org/10.3390/foods11172716.

Krishnasree, V., Nethra, P.V., Dheeksha, J., Madumitha, M.S., Vidyaeswari, R. and Lakshya, P. (2018). A pilot study on assessing the sustainability of food safety and hygienic practices in street food handling system. *Asian Journal of Dairy and Food Research*. **37(4):** 321-325. doi: 10.18805/ajdfr.dr-1381.

Krstić, M., Agnusdei, G.P., Tadić, S. and Miglietta, P.P. (2023). Prioritization of e-traceability drivers in the agri-food supply chains. *Agricultural and Food Economics*. **11(1):** 42. https://doi.org/10.1186/s40100-023-00284-5.

Kuhn, C. and Lucke, D. (2021). Supporting the digital transformation: A low-threshold approach for manufacturing related higher education and employee training. *Procedia CIRP*. **104:** 647-652. https://doi.org/10.1016/j.procir.2021.11.109.

Kumar, R., Kalani, M., Hashmi, T. and Wali, H. (2026). Modelling the structural determinants of households' indebtedness among agricultural households: An ISM-MICMAC approach. *Agricultural Science Digest*. doi: 10.18805/ag.D-6572.

Kumar, U. and Shankar, R. (2024). Smart dairy: Unleashing emerging ICT-enabled lean dairy supply chains through data-driven decision-making. *International Journal of Information Management Data Insights*. **4(2):** 100297. https://doi.org/10.1016/j.jjimei.2024.100297.

Malik, M., Malik, A., Gahlawat, V.K. and Mor, R.S. (2023). Traceability in the Indian dairy industry: Concept and practice. *International Journal of Dairy Technology*. **76(4):** 758-778. https://doi.org/10.1111/1471-0307.12999.

Nayal, K., Raut, R.D., Narkhede, B.E., Priyadarshinee, P., Panchal, G.B. and Gedam, V.V. (2023). Antecedents for blockchain technology-enabled sustainable agriculture supply chain. *Annals of Operations Research*. **327(1):** 293-337. https://doi.org/10.1007/s10479-021-04423-3.

Salokhe, S. and Patil, S. (2026). Unleashing the game-changing potential of blockchain technology in agriculture supply chains: A Review. *Indian Journal of Agricultural Research*. **60(8):** 1137-1146. doi: 10.18805/IJARe.A-6474.

Sinha, G.K. and Mishra, S. (2023). Sustainable supply chain management practices in the dairy industry: A comparative study of leading dairy firms and future research directives. *Asian Journal of Dairy and Food Research*. **42(4):** 435-446. doi: 10.18805/ajdfr.DR-2120.

Surange, V.G., Teli, S.N., Hublikar, S., Pol, S.M. and Danawade, B.A. (2026). Reverse logistics barriers in circular agri-food supply chains: An ISM-MICMAC Approach. *Indian Journal of Agricultural Research*. **60(8):** 1294-1301. doi: 10.18805/IJARE.A-6545.

Zhou, J., Jin, Y. and Liang, Q. (2022). Effects of regulatory policy mixes on traceability adoption in wholesale markets: Food safety inspection and information disclosure. *Food Policy*. **107:** 102218. https://doi.org/10.1016/j.foodpol.2022.102218.