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Unveiling the role of stakeholder involvement for digital transformation of Indian food SMEs

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Abstract

With the advent of digitalization, the economy of the world is quickly changing itself and Indian Small and Medium Enterprises (SMEs) are the front runners. This study sheds light on how digital transformation is crucial to support the growth, competitiveness, and sustainability in the present business environment, and how digital transformation is important to the SMEs in India. To encourage SMEs to take up digital technologies, the Government of India has been creating an environment that encourages such moves by launching several initiatives including Digital India, Make in India and Startup India. This paper studies the role of stakeholder involvement in digital transformation in Indian food SMEs. Structural Equation Modeling (SEM) is used on survey responses from 103 food SMEs using the Statistical Package for the Social Sciences (SPSS). From the findings, there is a close relationship between stakeholder involvement and technological advancement ($\beta = 0.595$, $p < 0.001$) and organizational and political factors ($\beta = 0.709$, $p < 0.001$) as viewed by leadership, which reflects multidimensional factors leading to digital adoption. However, stakeholder involvement does not have any significant effect on financial factors ($\beta = 0.018$, $p = 0.87$), financial constraints being a major barrier to transformation. Moreover, although technological advancement results in a positive effect towards digital transformation ($\beta = 0.694$, $p < 0.001$), organizational and financial challenges act as stumbling blocks altogether. In the case of managers, this study indicates proactive involvement of stakeholders, investment in employees upskilling and alignment of organizational goals with digital initiatives for the support of technology adoption. This information assists decision makers in estimating government incentives and public private partnerships to overcome financial constraints. Digital transformation for food sector SMEs depends on a coordinated support of stakeholders, policy and technological readiness as preconditions for long term competitiveness.

Keywords Stakeholder's involvement, Digital transformation, Food SMEs, SEM

1 Introduction

SMEs are the backbone of economic development as they contribute substantially to employment generation, industrial production, and GDP. The food sector in India is highly dependent on SMEs for food production, processing, and distribution, of which

SMEs constitute a significant portion. These enterprises significantly close the gap between agricultural outputs and consumer demand, securing food and creating rural employment. However, the rapid evolution of worldwide food markets and buyer inclinations, strict administrative necessities, and competitive weights made it important to realize computerized advances to stay ahead. More and more people now realize the crucial role of Digital transformation in integrating digital technologies into business processes, such as efficiency, cost cutting, supply chain visibility, and customer experience enhancement generator. Digital transformation has the capability to increase productivity by 16% of the global SMEs. Indian food SMEs sector improving the growth significantly by 20% [1].

In recent years, various governmental initiatives, including Digital India, make in India, and Startup India, have been launched to modernize the industries and encourage the adoption of Industry 4.0 technologies. Tools such as blockchain, Internet of Things (IoT), cloud computing, artificial intelligence (AI), and cyber-physical systems have been integrated to transform the global food supply chains by enhancing traceability, process automation, and data-driven decision-making. Unfortunately, Indian food SMEs cannot use these technologies due to critical structural and operational challenges. Shahadat et al. [2] and Annosi et al. [3] discussed the various challenges of SMEs in food sector. The reason for many of these challenges is limited stakeholder engagement, where suppliers, employees, investors, government agencies, and customers are key actors that can facilitate or hinder digital transformation. Vahdanjoo et al. [4] and Hendrawan et al. [5]. Discussed the challenges faced by the food sector companies to implement digital transformation.

Involving the stakeholders is fundamental to overcoming the challenges of digital transformation of food SMEs. Suppliers can seamlessly offer digital tools, automation equipment, and software solutions to integrate new technologies with the SME requirements. However, for the successful implementation of digital systems, employees as end users are necessary, and hence, organizations need to provide adequate training and skill development programs. Policies, subsidies, and regulatory frameworks that encourage or restrict digital adoption are the influences of government bodies in the process. Enablers of change are financial institutions, venture capitalists, and investors because digital transformation usually involves a high cost of hardware, software, and labor training. Furthermore, customers drive demand patterns, and SMEs must build digital strategies that meet customer expectations. However, without stakeholder coordination in adopting these, digital adoption is fragmented and prevents the full benefits of technology from being reaped in the long term.

While digital transformation within SMEs is becoming more widely accepted, little research has been done into how stakeholder engagement directly influences the process, specifically within the food industry. Galeotti et al. [6] assessed the Stakeholder engagement in Italian food companies. Most current studies relate to technological and financial barriers to digital adoption without considering the intricate interdependencies among stakeholders that determine the transformation process. It is also true that some research has been conducted that explores stakeholder involvement in large enterprises; however, SMEs face specific challenges, including resource constraints, a low level of bargaining power, and a lower level of digital maturity. It becomes essential to understand how different stakeholders interact with each other and their role in

the digital transformation process to develop customized strategies to meet the needs of food SMEs. This research gap is filled by studying the multidimensionality of stakeholder involvement in determining the digital transformation outcomes in Indian food SMEs. The following research questions are framed on the path to achieving these objectives.

RQ1: How does stakeholder involvement influence organizational, political, technological, and financial practices in food SMEs?
RQ2: How do technological, financial, organizational, and political practices lead to the adoption of digital transformation?

To address the above research questions, the following research objectives were formulated.

RO-1: To identify the stakeholder's involvement for implementation of organizational, political, technological, and financial practices in food SMEs.
RO-2: To assess the impact of technological, financial, organizational, and political practices on digital transformation

To achieve the above discussed research objectives, the current research uses structural equation modeling (SEM) to analyze survey data collected from 103 Indian food SMEs to explore these research questions empirically. This research studies the interrelation among stakeholder involvement, financial constraints, organizational factors, and technological advancements and helps practitioners and policymakers derive actionable insights to address the industry's challenges. Based on these findings, the authors provide strategic recommendations to improve working with stakeholders to secure investment and adopt technology in the business.

The paper is structured as follows: Sect. 2 explains the literature review, research questions, conceptual framework, and the formulated hypothesis. Section 3 elaborates on the research methodology and descriptive statistics in the form of response statistics and the normality of data. Section 4, which is divided into two stages, tests the sampling adequacy, internal consistency, and structural equation modeling. Section 5 discusses the results of hypothesis testing. Sections 6 and 7 describe the study's managerial implication, conclusion, and limitation.

2 Literature review

Many articles can be found in databases such as Web of Science and Scopus, but policymakers and industries do not have complete access to them. It is crucial to identify the pertinent literature review for the study. For this purpose, we have utilized the following search terms to gather literature articles: "Digital transformation" AND "Industry 4.0" OR "Cyber-physical Systems" OR "Digital Twin" OR "4th Industrial Revolution" OR "I4.0" The aforementioned search terms are utilized for the compilation of articles, with only articles written in the English language being taken into account for the study. Digital transformation is accentuated by positive changes that modify an existing framework of industry operations.

The present research study provides two theoretical frameworks. First, the Technology-Organization-Environment (TOE) framework, and second, stockholder theory to know the digital transformation journey of food SMEs in India. Both frameworks give a comprehensive crystalline lens with the complex relationship with technological,

organizational, financial, and stakeholder factors that must be validated. In academic literature, organizations readiness for digital transformation is explained using numerous theoretical frameworks. Technology Organization Environment (TOE) framework explains the influence of functionality, complexity, compatibility, organisation size, its structure and experience within the existing system for technological readiness (Tornatzky and Fleischer 1990). Similarly, Diffusion of Innovation (DOI) theory emphasises upon the importance of ideas, people, behaviour, and process of technology adoption (Rogers 2003). Innovations spread from one group to another throughout the organization. Here perceived usefulness, ease of adoption, and external influences plays a key role [7].

2.1 Stakeholder involvement practices

During digital transformation, stakeholder like employees, suppliers, investors, policymakers, and customers plays a critical role Freeman (1984). Employees as stakeholder are critical to the success of digital transformation. They are the ultimate users of technology which drives such change in organization. Involving employees in planning for technology update through regular meetings and discussion can help firms to improve overall productivity. The experience shared by employees can lead to identify right digital tools. It also boosts their confidence and possibility of rapid adaptability with new technology. Many times, resist to adopt digital transformation. Their limited digital literacy and insufficient knowledge about technical and regulatory aspect of digitization are the key reasons. Similarly, suppliers who are collaborators in maintaining real time supply chains should be involved while bringing in new systems and processes. This not only help them align their goals and capabilities but also strengthen relationship among the supplier's networks. SMEs' decision to make technology investment is driven by consumer demand. Customers expectation about data transparency and personalized services demand higher digital engagement [8].

2.2 Technological practices

Technological practices are the core of digital transformation. Firms utilize technologies such as sensors, networks, robotic process automation (RPA), machine learning (ML) model to automate the processes and accelerate strategic growth [9]. Though, due to high initial costs, underskilled workforce, and resistance to change often prevent firms adopt technology [10]. But affordable automation models, leasing options, and government-backed financial incentives help these players to overcome the limitation. The interventions of IoT and cloud–driven decision making allows maintaining the data locally [11]. It serves as a foundation for Enterprise Resource Planning (ERP) for managing supply chain functions [12]. This brings up the culture of innovation and adaptability in organizations. Firms can remotely monitor their partners and quickly adapt to industrial operations in lieu of production–distribution channels and market conditions [13]. This agility and scalability in system and infrastructure is the key outcome of digital transformation [14].

2.3 Financial practices

Financial practices of an organization are the base of efficient resources allocation, cost management financing and partnership. It allows firms to manage and mitigate risk,

bringing in operational efficiency to attain profitability. Firms can utilize sophisticated methods for allocating resources, budget investment and risk management and forecast financial requirements to emphasize digital transformation [15]. They should estimate the cost of new technologies, operational costs to reduce the cost of inputs and increase efficiency. Some clear matrices on return on investment strategies and its visibility can help firms to overcome the transformation dilemma [16].

2.4 Organizational practices and political practices

Organizational practices foster the culture of innovation. They align organizational processes, policies and strategies to leverage the full potential of technology (Wrede et al. 2020). A strong leadership and organization's vision communicates management commitment towards digital initiatives across the functions. Moving away from classical hierarchal system and redefining the workforce as flexible team sets context, roles and responsibilities during process transformations [17]. Creating a learning environment through training programs development activities on essential digital skills empowers employees [18], Wrede et al. 2020.

2.5 Theoretical model and formulation of hypothesis

A comprehensive literature review helped to identify the stakeholder, technology, organization, financial, political practices to derive digital transformation. Existing research work has discussed these practices as independent factors instead in conjunction. It is essential for researchers and industry practitioners to understand these practices and associated challenges by considering their direct and indirect impact on each other. It led to the identification of research gaps based on these dimensions with special reference to food-based SMEs.

Based on the critical relationship that various practices of digital transformation possess, the following six hypotheses were formulated based on research questions and identified the research gaps.

2.5.1 Stakeholder involvement influences organizational, political, technological, and financial practices in food SME

Firms, adopt digital platforms like e-commerce, AI-based customer insight, digital payment systems to interact with customers, improve brand loyalty and reach more markets. Investors and financial institutions as a stakeholder offer financial landscape to digitise processes to leverage market potential, especially for SMEs [19]. They are part of many political and regulatory systems to shape policies and framework for industry to operate [20]. Companies with powerful multi-stakeholder relations have stages of digital maturity and are less insolvent to technology disruption (Ioana–Catalina [21, 22]). Engagement of stakeholders like employees, suppliers, investors, policymakers, and customers creates an ecosystem promoting more sustainable and scalable digital strategies.

Organizations involve stakeholders while designing transformation reduces resistance for modern technologies. A clear communication plan, feedback loop and change management strategies ensures smooth transition (Wrede et al. 2020). Political decisions to invest in infrastructure such as internet networks, sensors, and cloud-based centers are essential requirements of transformation. Digital literacy curriculum at academic institutions can shape the skills of potential workforce [7]. Local government encouragement

to few technology dependents functions like digital record keeping, digital identity system, e-commerce can push modern technologies in the manufacturing and service sectors [23].

Funds needed to purchase digital tools, implement technology and enhance employee skill set is necessary capital for digital transformation. Firms should secure such funds either through venture capitalists or business partnerships. Financial practices that could account for the monetary impact of operational improvement are needed to various levels of processes to measure the improved profitability [24]. SMEs are more likely to adopt digital tools if technology is readily available, market forces are in their favor and they possess organizational level capabilities (Tornatzky and Fleischer 1990). Digitization brings an innumerable opportunities and benefits for organizations, including SMEs. But challenges associated with financial, technical and strategic barriers create difficulties for them. The firms which go back for strategic collaborations with technology providers, government agencies and industry associations are more likely to combat any adoption challenges [25].

On the basis of the above discussion and research questions RQ1, the following hypotheses were formulated.

RQ1: How does stakeholder involvement influence organizational, political, technological, and financial practices in food SMEs?
H1: There is a relation between stakeholder involvement and organizational & political factors.
H2: There is a relation between stakeholder involvement and technological factors.
H3: There is a relation between stakeholder involvement and financial factors.

2.5.2 Technological, financial, organizational and political practices lead to the adoption of digital transformation

In comparison to large scale enterprises digital transformation of SMEs requires deeper strategic alignment and engaging actively with one's stakeholders [21, 22]. This requires modified framework consisting of stakeholder involvement practices, technological practices, financial and organizational practices faced by the organisation during its digital transformation.

In order to deliver personalized services firms are leveraging upon AI and ML driven analytics that recognize patterns and automate tasks through faster insights with enhanced accuracy [26]. Such an involvement of technology aligns the company's product portfolio with customer expectations to improve customer experience. An adoption of innovative technological practices like RFID tags, blockchain, smart sensors, and automated tracking systems allows firms to differentiate themselves and fetch competitive advantage [27]. It can improve value propositions through critical product information, decision making system, cost reduction, market expansion, better customer insights [26].

The role of regulatory bodies in drafting policies, ensuring incentives and building conducive environment for technology adoption is critical at industry level [28]. Government schemes attract international collaborations by communicating regulatory stability. The economic incentive for technology upgradation, e-governance initiatives,

secured grants for research and development projects, data protection and cyber laws encourages firms to adopt digital tools [29].

Digital Transformation needs to be a combination of technological advancements, financial support, management attention and stakeholder's involvement [30]. The combination of all these practices can assure digital transformation in SMEs as the base for any digital change lies in the managerial tactics that lead to the promotion of the need to implement new changes [31]. It could either include new available technology, modify existing technology or discover and experiment for new technology so that the outcome can lead to digitalization of the enterprise [32].

RQ2: How do technological, financial, organizational and political practices lead to the adoption of digital transformation?
H4: There is a relationship between organizational & political factors and digital transformation.
H5: There is a relationship between technological factors and digital transformation.
H6: There is a relationship between financial factors and digital transformation.

Based on the critical relationship that various factors of digital transformation possess, the following six hypotheses were formulated.

3 Methodology

The purpose of the study is to investigate the role of stakeholder's involvement for Digital Transformation of Indian Food SMEs. On the basis of research gaps identified in the literature review and research questions, the theoretical framework was developed, and six hypotheses were formulated. To assess the research hypotheses, the questionnaire was developed using a 5-point Likert Scale, with a range from 1 to 5. The value of 1 represents the minimum level of importance or influence, while the value of 5 represents the maximum level of importance or influence. The questionnaire is partitioned into two sections. Section A contains the overall details regarding the respondent and company profile, while section two provides information specifically about the research constructs. Section B contain the research constructs and items are discussed in Table 1.

3.1 Pilot study

A systematic validation process of the questionnaire was undertaken before data collection to ensure the validity and reliability of the questionnaire. An extensive literature review and expert evaluation established the content validity. From previously validated constructs of digital transformation in SMEs, stakeholder involvement, technological readiness, and organisational factors, the questionnaire is framed. Three subject matter experts in digital transformation and SME management were engaged for a review of clarity, relevance and completeness in furthering refining the questionnaire. The question clarity and the response consistency were initially assessed with the help of a pilot test conducted with 15 SMEs managers from Indian food sector with minor refinements. A Cronbach's Alpha test was carried out to ensure internal consistency where all construct values exceeded 0.7 implying high reliability. Furthermore, Confirmatory Factor Analysis (CFA) is run to test the construct validity and results found in the Average Variance Extracted (AVE) values are above 0.5, thus displaying that the questionnaire items

Table 1 Research Constructs and Items

Constructs	Item Code	Statement	Source
Stakeholder's Involvement (SI)	SI1	Investment in enterprise's resources development	[20–22, 33]; Alhawari et al. 2021
	SI2	Supporting effective implementation of reform, regulation or project and using government policies for benefit of enterprise	
	SI3	Encouraging employees to learn and practice new technological trends available and providing knowledge and expertise	
	SI4	Willingness and commitment to upgrade existing enterprise's technological infrastructure and resources	
Technological Factor (TF)	TF1	Update/Upgrade to Automation practices	[8, 9, 25, 34, 35]
	TF2	Utilization of Cloud Computing	
	TF3	Support for Information Technology (IT)	
	TF4	Connectivity for the Internet of Things (IoT) applications	
	TF5	Utilization of traceability tools such as Radio Frequency Identification (RFID)	
	TF6	Integration of Sensors to achieve Cyber-Physical System functionality	
	TF7	Implementation of digital tools for information flow in the organization	
Financial Factor (FF)	FF1	Providing funds for investment in the enterprise's resources	[19, 21, 22, 36, 37]
	FF2	Encourage online tax payment, rebates, salary deposits, and funds transfer	
Organizational and Political (OPF)	OPF1	Supporting effective implementation of a policy, reform or regulation	[38–40]
	OPF2	Providing training and expert knowledge	
	OPF3	Management of information within the organization	
	OPF4	Management of Supply Chain and its integration in the organization	
Digital Transformation (DT)	DT1	Senior employees promote the need to urgently implement transformation changes	[30–32, 41]
	DT2	Modification of standard operations and procedures to include modified digital transformation	
	DT3	Senior leaders promote experimentation with new ideas	

have sufficient representation for its corresponding constructs. To make sure that the questionnaire was methodologically sound and that it will be able to generate insights on digital transformation in Indian food SMEs, a rigorous validation process has been undertaken.

3.2 Sample data collection

Sample data was collected from the various small and medium enterprises comprise food processing, manufacturing, logistics, and service sector. A total of 510 food SMEs is selected from Delhi NCR Region in India. The data was collected through Google Form as well as offline with face-to-face discussion. The online survey was sent to every contact generated and collected in the database and offline surveys were floated through various sources to gather a higher number of responses for the data analysis. After recirculation and follow-ups from the respondents, a total of 103 responses were recorded that would be utilized as a foundation for the application of various statistical tools as a part of data analysis and future research work.

3.3 Descriptive statistics

To ensure the representativeness of the sample, we included SMEs from various food industry segments, geographical location, diverse firm size. It is observed that medium-scale enterprises having 10 to 19 employees contributed 35% of the responses whereas the response rate of firms with more than 30 employees was 31%. Firms with 20 to 30 employees contributed 25%. A very small number of responses were obtained from the

firm's employees ranging between 1 and 9 i.e. 9%. It is inferred that 73% of responses were generated from Northern India region followed by 19% from Western India region and 8% Southern India region. The food manufacturing sector has the highest response rate i.e. 49%, followed by food processing sector with 28%, the food service sector with 15% and food logistics sector with 8%. It is observed that 47% of the respondents have experience between 5 to 9 years, 30% of the respondents have experience between 10 to 14 years, and 13% of the respondents are between the experience of 15 to 19 years and 7% have experience between 20 and 24 years and 3% of them have experience above 25 years. The respondents are experienced managers in SME companies with more than 5 years of experience, making well-informed insights with regards to SME digital transformation. Thus, sample size in spite of being moderate, but diverse represent findings to be translatable within the Indian food SME sector.

3.4 Normality of data

Normality test was done on the collected data to confirm the suitability of data used for statistical analysis using kurtosis and skewness values. The observed values lie between 1.161 and 0.353, which is close to an acceptable range between − 1 and + 1, thus depicting consistency of the data response and that the data doesn't deviate from normality. There are no potential biases found. The results are normal enough to proceed with Structural Equation Modeling (SEM) because minor deviations from normality don't affect the robustness of SEM-based analysis. Since SEM techniques, particularly MLE, are appropriate at the expense of approximately normal distribution, the values obtained indicate that the dataset is suitable for conducting reliable hypothesis testing and model validation. For this reason, the normality assessment confirms the applicability of the study's analytical approach, since relationships among stakeholder involvement, technological factors, financial constraints and the digital transformation can be approached with statistical support. Table 2 showcases the various statistical constructs such as

Table 2 Descriptive statistics

Code Group	Code	Mean	Std. Deviation	Skewness	Kurtosis
SI	SI1	3.63	0.78	− 1.018	1.149
	SI2	3.19	0.793	− 0.484	− 0.246
	SI3	3.1	1.089	− 0.242	− 0.466
	SI4	3.57	0.709	− 0.179	− 0.134
OPF	OPF1	4.1	0.679	− 0.504	0.601
	OPF2	4.15	0.954	− 1.058	0.585
	OPF3	4.39	0.66	− 0.828	0.545
	OPF4	3.83	0.733	− 0.322	0.037
FF	FF1	2.29	0.882	0.353	− 0.495
	FF2	3.69	1.076	− 1.131	0.943
TF	TF1	3.68	0.888	− 0.09	− 0.343
	TF2	3.94	0.712	− 0.415	0.294
	TF3	4.24	0.664	− 0.725	1.161
	TF4	4.12	0.718	− 0.501	0.129
	TF5	3.8	0.746	− 0.372	0.074
	TF6	3.71	0.636	− 0.365	0.297
	TF7	3.6	0.809	− 0.054	− 0.452
DT	DT2	3.31	0.686	0.066	0.965
	DT3	3.35	0.622	− 0.655	0.778
	DT4	3.39	0.931	− 0.335	− 0.385

Table 3 Bartlett's Test of Sphericity and Kaiser–Meyer–Olkin (KMO)

Test		Statistics
Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.756
Bartlett's Test of Sphericity	Approx. Chi-Square	1028.173
	df	190
	Sig	0.000

Table 4 Internal consistency analysis

S. No	Construct name	Items	Cronbach's alpha
1	Stakeholder's Involvement (SI)	4	0.801
2	Organizational and Political Factors (OPF)	4	0.799
3	Financial Factors (FF)	2	0.895
4	Technological Factors (TF)	7	0.844
5	Digital Transformation (DT)	3	0.734

kurtosis, skewness, mean and standard deviation for a comprehensive inference regarding the consistency of the data.

4 Data analysis

Twenty variables identified from literature were used to construct a 5-point Likert scale questionnaire. It was administered at the 103 Indian food SMEs. The questionnaire was administered at food processing food service and food logistics firms. Managers who are responsible for technology selection and implementation in these organizations were the respondents.

4.1 Step I: testing sampling adequacy and internal consistency

As a first stage of data analysis, as shown in Table 3, Bartlett's Test of Sphericity and Kaiser-Mayer-Olkin (KMO) were carried out. The Bartlett's test which is governed by correlation matrix has obtained the significance value as 0. It simply means that the collected data is robust enough to apply factor analysis technique of dimension reduction. Then, a KMO test was conducted to measure sampling adequacy. Here also, the obtained KMO value of 0.756 which is in the range of 0 to 1 and above 0.6 indicated that factor analysis is a best suited technique to analyze the collected set of data.

The internal consistency of the constructs was checked using a Cronbach's Alpha test of reliability. The coefficient value of all the five constructs as shown in Table 4 is between the range of 0 to 1, with all the values greater than 0.7. This signifies the selected model constructs are reliable.

4.2 Step II: structural equation modelling (SEM)

A sufficient number of 100–150 responses was established for reliable statistical analysis by Structural Equation Modeling (SEM) according to Piriyakul [42]. A total of 103 SME food businesses were surveyed as an appropriate sample since it covers statistical requirements without compromising the practicality of data acquisition. A statistical method that combines conventional multivariate models like factor analysis, regression analysis, and simultaneous equation modelling is called structure equation modelling [43]. This tool would help in analysing the impact of various factors that are selected for this study to leverage digital transformation of Indian SMEs.

4.2.1 Examination of measurement model

To implement SEM, it is advised to run a fitness test for the various model constructs. Thus, Adjusted Goodness of Fit Index (AGFI), Root Mean Square of Error Approximation (RMSEA), Root Mean Square Residual (RMR), Goodness of Fit Index (GFI), Normed Fit Index (NFI), Chi-Square Probability with Degree of Freedom (χ^2) (CMIN) and Comparative Fit Index (CFI) were conducted on the data collected during questionnaire survey. The measurement model is developed using the Confirmatory Factor Analysis (CFA) for the constructs SI, TF, FF, OPF, and DT. The value of Average Variance Extracted (AVE) defines the Convergent Validity (CV) of the constructs. The values of AVE of SI, OPF, and FF are observed to be above 0.5, which implies an acceptable degree of validity convergence whereas the AVE for TF and DT have an affinity towards 0.5, which denotes the acceptable validity convergence of the constructs. To obtain high convergent validity, the value of Composite Reliability should be greater than 0.7, the value of Cronbach's Alpha should be greater than 0.7 and the value of standard estimates should be greater than 0.5. The values of AVE and CR for all the constructions along with their Cronbach's Alpha value is shown in Table 5. Multicollinearity issues are related to discrimination validity. In the current study the value of composite reliability (CR) is greater than 0.7, which confirmed the discriminate validity. Hence, there is no multicollinearity issues exists (Fig. 1).

4.2.1.1 Examination of structural model A multifactor structural equation model was developed to study the relationship between twenty constructs and test formulated six hypotheses. A unified theory where all the variables exist in a system at one moment rather than individual construct, was used. The interrelationship between various constructs along with their standardized estimates that govern the model framework is shown in Fig. 2.

Table 5 CFA results for measurement model

Construct in model	Measurement items	Estimate (standardized)	AVE	CR	Cronbach's alpha
SI	SI1	0.808	0.51703	0.809158	0.801
	SI2	0.747			
	SI3	0.614			
	SI4	0.693			
OPF	OPF1	0.867	0.504227	0.798579	0.799
	OPF2	0.735			
	OPF3	0.637			
	OPF4	0.565			
FF	FF1	0.938	0.812307	0.896273	0.895
	FF2	0.863			
TF	TF1	0.728	0.437511	0.843974	0.844
	TF2	0.724			
	TF3	0.666			
	TF4	0.654			
	TF5	0.61			
	TF6	0.567			
	TF7	0.666			
DT	DT1	0.699	0.478917	0.733825	0.734
	DT2	0.695			
	DT3	0.682			

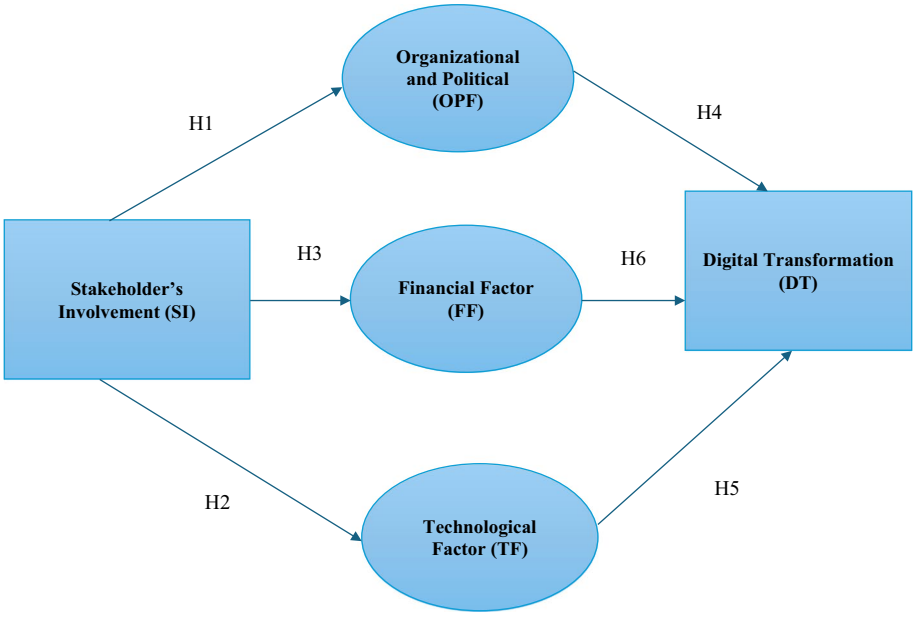

Fig. 1 Theoretical framework

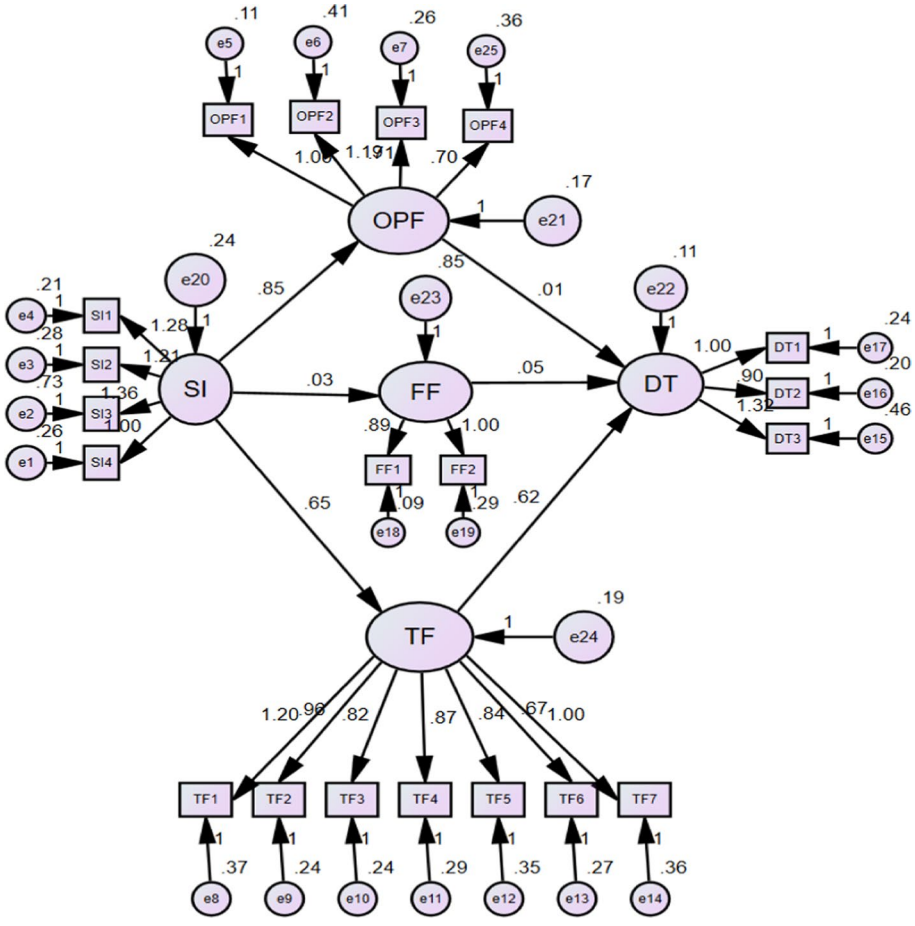

Fig. 2 Multi-factor structural equation model

SEM fit indices were used to assess the measurement model fit, then the results were compared to thresholds for commonly accepted standards of fit in the literature. The ratio of chi-square to degrees of freedom (χ^2/df) was 2.106 indicating a good model fit since χ^2/df ≤ 3.0. The Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) are within the moderate fit range (GFI ≥ 0.80 and AGFI ≥ 0.70, respectively), GFI = 0.776 and AGFI = 0.714. In addition, the Root Mean Square Residual (RMR) = 0.055 is also less than the recommended threshold of ≤ 0.08, also an indication of the model adequacy. Likewise, the Comparative Fit Index (CFI) = 0.803 and Normed Fit Index (NFI) = 0.689 also indicate moderate fit because values of ≥ 0.90 are desirable for strong fit. To the first data set, which delivers predictions, the Root Mean Square Error of Approximation (RMSEA) is = 0.104, which lies above the accepted threshold of ≤ 0.08 though (Levitas 2009) but still holds within an acceptable range for exploratory studies. These results suggest that while some indices indicate good fit, parameters such as χ^2/df, RMR, and AGFI confirm that the model is statistically adequate as a test of hypotheses and structural analysis.

The outcome of the measurement model assessment validates that the model is fit for the purpose of evaluating the role of stakeholder involvement in digital transformation in the case of Indian food SMEs. Since the acceptable values of χ^2/df, RMR, AGFI, and GFI were found, it can be concluded that the model represents adequately the observed data, implying that stakeholder involvement, technological readiness, financial constraints, and digital adoption have statistically valid relationship among them. The mild fit values of NFI, CFI, and RMSEA indicates that while the model catches the essence of the relationships, there can be other unaccounted variance as a result of external issues like industry inherent barriers, firm size restraints, or unaccounted moderating variables. Given this insight is quite important to the practitioners and policymakers since it reminds them of the requirement of unique digital transformation strategies rather than going for one size fits all. Validation of the overall model demonstrates that the stakeholder involvement factors, and digital enablers identified are the core success factors when it comes to technology adoption and asserting the need for structured stakeholder engagement and for financial support mechanisms for SMEs.

5 Discussion and inferences from hypothesis testing

Digital transformation is a big step in industrial development. Including others, food industries are also struggling to cope with the challenges arise due to technological, managerial, organizational and stakeholders' issues. This research highlights these challenges that hinders the fourth industrial revolution in food-based businesses. The items identified from literature were subjected to questionnaire-based survey. The obtained SEM results as shown in Table 6 is used to infer the formulated six hypotheses. Out of the six, three hypotheses are found to be supported and three as rejected by the results. The detailed inference of each hypothesis is given in the following discussion.

These findings are consistent with prior research on stakeholder involvement and digital transformation, especially regarding the relationship between stakeholder engagement and organizational and political factors (H1), and technological adoption (H2). In line with Turi et al. [44], stakeholder coordination enhances technology integration and organizational readiness, which is in line with the results. Likewise, we agree with the

Table 6 Result of hypotheses

Hypothesis	Estimates (standardized) (β)	Standard error (S.E.)	Critical ratio (C.R.)	P	Result
H1: SI → OPF	0.709	0.152	5.597	***	Supported
H2: SI → TF	0.595	0.151	4.339	***	Supported
H3: SI → FF	0.018	0.213	0.164	0.87	Unsupported
H4: OPF → DT	0.013	0.097	0.112	0.911	Unsupported
H5: TF → DT	0.694	0.143	4.326	***	Supported
H6: FF → DT	0.102	0.053	0.995	0.32	Unsupported

***Path loadings are significant at P < 0.001

findings of Rachmawati et al. [45] that the technological advancements help to promote digital transformation in SMEs (H5).

Nevertheless, contrary to some previous studies, the rejection of H3 (stakeholder involvement → financial factors), H4 (organisational and political factors → digital transformation) and H6 (financial factors → digital transformation) was observed. According to Lefebvre et al. [19] and Garzoni et al. [20] financial investment is seen as a crucial enabler of SME digitalization, while our results show that stakeholders get involved in overcoming these financial constraints. Since external financial support such as government incentives of venture capital are quite limited in Indian food SMEs, stakeholder efforts are not sufficient to tackle funding barriers on their own.

5.1 H1: There is a relation between stakeholder involvement and organizational & political factors

The hypothesis H1 where $\beta = 0.709$ and $P < 0.001$ describes that the relationship between Stakeholder Involvement and Organizational & Political Factors is significant. The Indian government has laid down various policies for the operation of food SME's in India. These policies either act as an influencer or a barrier. Here, involvement of stakeholders is significant to habituate the policies that serve as positive enforcement for managerial applications. Hence, it is safe to say that stakeholders hold importance and value when it comes to organizing and managing the enterprise. The responses depict a similar result with high responses that conclude a strong inter-relationship between the stakeholder involvement and organizational & political factors. The results resonate with the following study: Stakeholder involvement encourages the growth of cooperation and common objectives [46].

5.2 H2: There is a relation between stakeholder involvement and technological factors

The hypothesis H2 where $\beta = 0.595$; $P < 0.001$ describes the relationship between Stakeholder Involvement and Technological Factors is significant. Stakeholders are the visionaries of the enterprise. They help to define ideology and long-term objectives in an organization. Hence, they are actors for any technological advancement that takes place in the organization. Technology upgradation also requires financial aid which is governed by the interest of stakeholders and the future prospect of the enterprise. It is clear from the survey data collected that the stakeholders are proactive and interested in transforming traditional technology and inculcate advanced machinery so that the productivity of the enterprise can be increased and value addition can take place. The results match with the following research: In order to guarantee the development of the

technologies and create viable choices for their future application, stakeholder engagement is essential [47]

5.3 H3: There is a relation between stakeholder involvement and financial factors

The hypothesis H3 where $\beta = 0.018$; $P = 0.87$ describes the relationship between Stakeholder Involvement and Financial Factors is insignificant. Majority of the food SMEs are outsourced into large enterprises and MNC's. These SMEs have to rely on other small suppliers for their product demand which limits their profits. Moreover, a constant demand with marginal benefits does not convince stakeholders to invest more in a firm. It widens the financial gap for SMEs. It is also inferred from the survey responses that high percentage of the food SMEs in India are family run businesses. Many stakeholders are not willing to invest in the transformation of these enterprises. Stakeholders of these SMEs usually found themselves to have shirt-term vision. They are willing to shut down production once the breakeven on initial investment is reached. So, they do not face a situation of no profit, hence, they can halt the existence of the firm with zero loss incurred.

5.4 H4: There is a relationship between organizational & political factors and digital transformation

The hypothesis H4 where $\beta = 0.013$ and $P = 0.911$ describes the relationship between Organizational & Political Factors and Digital Transformation is insignificant. Theory suggests that organizational and political factors play an important role in the digitization of industries. Digital transformation requires complete change in the way the management operates. Due to the huge cost of resource enhancement management do not like to bring transformation. Rather, they focus on improving the traditional approaches to organize the workflow by management. Moreover, policies and regulations aimed to support digitization pose conflict with the existing organizational viewpoint of the enterprise. Digitalization is only possibly when employees are aware of the benefits and are trained for the same.

5.5 H5: There is a relationship between technological factors and digital transformation

The hypothesis H5 where $\beta = 0.694$ and $P < 0.001$ describes the relationship between Technological Factors and Digital Transformation is significant. Digital transformation is an adoption of advanced technologies that can streamline the workflow of an enterprise. an emergence of advanced technologies has reduced human intervention and interaction on the shop floor. Use of sensors to assist traditional machinery helps to control the devices remotely and transform the way industries use to control operations. Connectivity with cloud computing and introduction to newer traceability tools have helped food SMEs to synchronize their processes in conjunction with other enterprises that are located in a different region and optimize their supply chain management. It is evident from the survey responses that Indian food SME's do not hesitate to implement new technologies to improve the effectiveness and ergonomics of the enterprise. The results are in line with the following study: Using digital platforms has a significant impact on business actors' adoption of digital transformation [45]

5.6 H6: There is a relationship between financial factors and digital transformation

The hypothesis H6 where $\beta = 0.102$ and $P = 0.32$ describes the relationship between Financial Factors and Digital Transformation is insignificant. Digitalization requires resource input which depends upon financial support and assistance. Since digitalization has slow return of investment and low expectancy of high-profit margin the Indian food SMEs are not willing to invest in the resources. It also requires transformation of many traditional ways of operations which do not convince the top management of food SMEs in India. Their traditional practices suffice the production capacity and demand of the market which refrain the management and the stakeholders to invest in digital transformation.

5.7 Linking theories to hypotheses

The theoretical model developed for this research integrates these hypotheses frameworks to validate the relationship between technological, organizational, political, and financial factors and their collective influence on digital transformation (H4, H5, H6). This research's finding supports the TOE framework's assertion that technological readiness is a crucial driver of digital transformation, as indicated by the significant relationship between technological factors and digital adoption ($\beta = 0.694$, $p < 0.001$). Therefore, the results align with stakeholder theory, which highlights the crucial and significant role of stakeholder association in addressing organizational and political blockades to digital adoption ($\beta = 0.709$, $p < 0.001$).

However, the findings provide those financial constraints (H3: $\beta = 0.018$, $p = 0.87$) remain a significant barrier, suggesting that stakeholders involvement alone is insufficient to overcome funding challenges, thereby spreading the current understanding of the stakeholder theory within the SME context.

5.8 Justification for unsupported hypotheses

H3: Stakeholder involvement (SI) → Financial factors (FF): The lack of a significant relationship between stakeholder involvement and financial factors can be attributed to the unique financial dynamics of Indian food SMEs. Most of the SMEs depend on deeply on internal funding, traditional financial mechanisms, or family businesses, where stakeholder engagement is often limited to operational decisions rather than financial investments. Many Indian food SMEs are still family owned and risk averse businesses that are unwilling to go beyond isolated digital investments to the immediate operational needs [39]. A previous study [21, 22] also highlights stakeholders in SMEs, especially in developing economies, may lack the financial capacity or risk appetite for digital fund initiatives. This aligns with the Resource-Based View (RBV), which suggests that financial constraints in SMEs are often ingrained in structural limitations rather than stakeholder engagement alone.

H4: Organizational and Policial factors (OPF) → Digital Transformation (DT): The absence of a significant relationship between organizational and political factors and digital transformation suggests that these factors may be indirect enablers rather than direct drivers of digital adoption. Indian food SMEs don't have the internal leadership nor the expertise to effectively implement digital strategy [41]. Qadri et al. [48] argue that organizational readiness and political support create a favourable environment for digital adoption but do not necessarily trigger its implementation. In Indian food SMEs,

bureaucratic barriers, resistance to change, and lack of leadership commitment can dilute the impact of organizational and political factors, making technological readiness a more immediate driver of transformation.

H6: Financial factors (FF) → Digital transformation (DT): The financial factors are insignificant in driving digital transformation and can be linked to the cautious investment approach prevalent among Indian food SMEs. Financial investment is crucial, development of the industrial sector requires, among other factors, improvement in technological awareness, development of workforce that is ready for the challenge, ensuring appropriate alignment of supply chain [33]. Its findings are in line with Singh et al. [18] who maintain that financial accessibility is coupled with strategic planning and efforts to build digital capability [49] show that SMEs often perceive digital transformation as a high-risk venture with slow return on investment. As a result, financial constraints act as a barrier rather than a catalyst for change. Also, various SMEs prioritize operational continuity over digital innovation, external support or government incentives to offset digitalization costs.

6 Implications of the study

The presented research work serves as an informative study for the managers. This study reveals that the significance of implementation cost of newer technologies and stakeholder involvement can be increased so that the enterprise has a better understanding of the necessary changes required to uplift the transformation processes in the food industry. This requires training employees with technical and managerial skills. Employees are expected to sustain the transformation of highly efficient, productive and value engineered products. Identification of the strongest and the weakest enabler in this study can also help to brainstorm the solution to efficiently utilize them and further check for bottlenecks that might hinder the growth of the enablers active in the system.

6.1 Theoretical contribution

This research enriches the digital transformation literature by bringing the TOE framework and stakeholders theory, offering a nuanced understanding of the interdependencies between technological, organizational, financial, and stakeholder factors in digital transformation. The research highlights the need for a more inclusive approach for the role of stakeholder's involvement in digital adoption processes in Indian SMEs, where SMEs, policymakers, and financial institutions collaboratively address technological and financial barriers.

6.2 Practical contribution

The findings the research are underscore the need for Indian food SMEs to foster stronger partnerships with technology providers and policymakers to support financial and organizational issues. Practitioners are encouraged to implement structured training programs to improve digital literacy among employees, ensuring a smooth transition to digital operations. Also, government bodies and financial institutions can utilize these insights to design more accessible funding schemes and supportive policies tailored to the unique challenges faced by food SMEs.

6.3 Managerial implications

The findings of the research indicate that a stakeholder involvement is essential for technological adoption and Manager must work with technology provider and suppliers in integration of cloud computing, automation and IoT-based traceability systems. Through application, a food processing SME could nurture its supply chain visibility by working with IoT vendors for real time tracking solutions to reduce inventory losses and better meet regulatory compliance. The government initiatives like Digital India provides subsidies and very low domestic interests loans to facilitate digital adoption, which SMEs can use to finance automation, AI enabled quality control and ERP system. It can help accelerate the technological upgradation to bring this industrial sector in line with other booming sectors.

7 Conclusion

Due to global market competition and increasing food consumption, smaller as well as big firms are working to optimize their operations so as to keep pace with the growing demand. Such a process optimization of the food SME's can be achieved by digitalization. This will increase production rates, improve product quality, reduce production cost and minimize human errors and irregularities in the supply chain. The research gaps identified from literature review were converted into research questions. on the basis of which a conceptual framework and six hypotheses were formulated. The data collected through the questionnaire survey was subjected to analysis and modelling. Structural Equation Modelling is implemented to generate a multi-factor measurement and structural model that validated the hypothesis. The inference obtained were showcased with an ambition to motivate and capture the attention of academic researchers and industry managers to pursue brief insight regarding the digital transformation priorities of food SMEs in India. Small and medium-sized enterprises (SMEs) have the potential to generate innovation, leverage collective wisdom, and assure alignment of digital activities with business goals by means of proactive engagement and collaboration with stakeholders. Furthermore, sufficient funding is necessary to launch and maintain initiatives for digital transformation. By investing in cutting-edge technologies, infrastructure, hiring new employees, and training initiatives, SMEs can improve their digital skills and competitiveness in the market which is made possible by having access to funds.

7.1 Limitations and future research directions

While the present study offers valuable knowledge regarding the role played by stakeholder involvement in the digital transformation of Indian food SMEs, it must be noted that there are some limitations. The first limitation is that the study is cross-sectional; therefore, it is based on survey data that are responses taken at one instance in time. Longitudinal studies could be used in future research by analysing how stakeholders' engagement with the technology and adopting it longitudinally. Second, the sample size is sufficient for SEM but restricted to only 103 Indian food SMEs making it possible that not all diversity within SMEs represented across various regions and segments of industry are represented within this study. The study would benefit from the expansion of sample size to cover a larger scope of SMEs located in different geographically and industrially segregated regions. Further research could involve qualitative case studies or mixed methods to understand firm specific digital transformation problems.

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Author contributions
S.G. and D.J.—Conceptualization; S.G. and H.T.—Methodology; S.G.—Software; S.G., S.G., D.J. and V.K.V—Validation; S.G. and H.T.—Formal analysis; V.K.V.—Investigation, S.J.—Resources; S.G.- Data curation; S.G. and D.J.—Writing—Original Draft Preparation; S.J.—Writing—Review and Editing; S.G.—Visualization; H.T. and S.J.—Supervision; H.T. and V.K.V.—Project administration; S.J. and H.T.—Funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Data availability
The datasets generated and/or analysed during the current study are available from the authors on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Amity University, Noida, India. The research was conducted in accordance with the ethical guidelines of the institution.

Consent for publication
Informed consent was obtained from all participants involved in the study. No participants were below the age of 18 years. Consent to participate and to publish was documented for each participant.

Competing interests
The authors declare no competing interests.

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References

1. FICCI. Food processing. 2020. https://ficci.in/sector-details.asp?sectorid=15. Accessed 20th Sep. 2020.
2. Shahadat MH, Nekmahmud M, Ebrahimi P, Fekete-Farkas M. Digital technology adoption in SMEs: what technological, environmental and organizational factors influence in emerging countries? Glob Bus Rev 09721509221137199. 2023.
3. Annosi MC, Brunetta F, Bimbo F, Kostoula M. Digitalization within food supply chains to prevent food waste. Drivers, barriers and collaboration practices. Ind Mark Manage. 2021;93:208–20.
4. Vahdanjoo M, Sørensen CG, Nørremark M. Digital transformation of the agri-food system. Curr Opin Food Sci. 2025;63:101287.
5. Hendrawan SA, Chatra A, Iman N, Hidayatullah S, Suprayitno D. Digital transformation in MSMEs: challenges and opportunities in technology management. Jurnal Informasi dan Teknologi 2024, 141–149.
6. Galeotti RM, Camilleri MA, Roberto F, Sepe F. Stakeholder engagement disclosures in sustainability reports: Evidence from Italian food companies. Bus Ethics Environ Resp. 2025;34(1):260–79.
7. Oliveira KKDS, De Souza RA. Digital transformation towards education 4.0. Info Educ. 2022;21(2):283–309.
8. Mahdad M, Hasanov M, Isakhanyan G, Dolfsma W. A smart web of firms, farms and internet of things (IOT): enabling collaboration-based business models in the agri-food industry. Br Food J. 2022;124(6):1857–74.
9. Ferrero R, Gandino F, Montrucchio B, Rebaudengo M. A cost-effective proposal for an RFID-based system for agri-food traceability. Int J Ad Hoc Ubiquitous Comput. 2018;27(4):270–80.
10. Jałmużna IB, Królikowski J, Sadok M. Visualization system design for the process of packaging egg powders. In: International Conference on Human Systems Engineering and Design: Future Trends and Applications (pp. 1113–1119). Springer, Cham. 2018.
11. Fritz M, Schiefer G. Market monitoring in dynamic supply networks and chains: an internet-based support system for the agri-food sector. J Chain Netw Sci. 2002;2(2):93–100.
12. Ndou V, Schina L, Passiante G, Del Vecchio P, De Maggio M, Toward an open network business approach. In: 4th IEEE International Conference on Digital Ecosystems and Technologies (pp. 282–287). IEEE. 2010.
13. Fu N, Cheng TCE, Tian Z. RFID investment strategy for fresh food supply chains. J Operat Res Soc 2010, pp. 1–15.
14. Gupta S, Joshi D, Jagtap S, Trollman H, Haddad Y, Atescan Yuksek Y, Salonitis K, Raut R, Narkhede B. From failure to success: a framework for successful deployment of Industry 4.0 principles in the aerospace industry. Int J Indus Eng Operat Manage. 2024;6(4):277–98.
15. Xu X, Zhang H. Analysis of enterprise financial management under the background of digital transformation. In: SHS Web of Conferences (Vol. 181, p. 02030). EDP Sciences. 2024.
16. Ebert C, Duarte CHC. Digital transformation. IEEE Softw. 2018;35(4):16–21.
17. Sklyar A, Kowalkowski C, Tronvoll B, Sörhammar D. Organizing for digital servitization: a service ecosystem perspective. J Bus Res. 2019;104:450–60. https://doi.org/10.1016/j.jbusres.2019.02.012.
18. Singh RK, Luthra S, Mangla SK, Uniyal S. Applications of information and communication technology for sustainable growth of SMEs in India food industry. Resour Conserv Recycl. 2019;147:10–8.
19. Lefebvre VM, De Steur H, Gellynck X. External sources for innovation in food SMEs. Br Food J. 2015;117(1):412–30.
20. Garzoni A, De Turi I, Secundo G, Del Vecchio P. Fostering digital transformation of SMEs: a four levels approach. Manag Decis. 2020;58(8):1543–62.

21. Fiore M, Galati A, Gołębiewski J, Drejerska N. Stakeholders' involvement in establishing sustainable business models: the case of Polish dairy cooperatives. Br F J. 2020;122(5):1671–91.
22. Fiore M, Galati A, Gołębiewski J, Drejerska N. Stakeholders' involvement in establishing sustainable business models: the case of Polish dairy cooperatives. Br Food J. 2020;122(5):1671–91.
23. Zulkifli N, Bunawan AA, Sufi A, Idris A. Digital transformation from paper to electronic records at Government Linked Company (GLC). Int J Acad Res Bus Soc Sci 2023:13(10.6007).
24. Rojas-García JA, Elias-Giordano C, Quiroz-Flores JC, Nallusamy S. Profitability enhancement by digital transformation and canvas digital model on strategic processes in post-Covid-19 in logistics SMEs. Soc Sci Hum Open. 2024;9: 100777.
25. Trebar M, Grah A, Melcon AA, Parreno A. Towards RFID traceability systems of farmed fish supply chain. In: SoftCOM 2011, 19th International Conference on Software, Telecommunications and Computer Networks (pp. 1–6). IEEE. 2011
26. Gandino F, Montrucchio B, Rebaudengo M, Sanchez ER. On improving automation by integrating RFID in the traceability management of the agri-food sector. IEEE Trans Industr Electron. 2009;56(7):2357–65.
27. Iqbal J, Khan ZH, Khalid A. Prospects of robotics in food industry. Food Sci Technol. 2017;37(2):159–65.
28. Minich SA. Improving the system of mandatory requirements to business under the digital transformation of economy. J Dig Technol Law. 2023. https://doi.org/10.21202/jdtl.2023.34.
29. Guo L, Xiao F, Guo F. Incentives, penalties, and digital transformation of enterprises: evidence from China. Environ Sci Pollut Res. 2023;30(43):97426–46.
30. Majchrzak A, Markus ML, Wareham J. Designing for digital transformation. MIS Quart. 2016;40(2):267–78.
31. Heavin C, Power DJ. Challenges for digital transformation–towards a conceptual decision support guide for managers. J Decis Syst. 2018;27(sup1):38–45.
32. Hanelt A, Bohnsack R, Marz D, Antunes Marante C. A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. J Manage Stud. 2021;58(5):1159–97.
33. Schiefer G, Deiters J. Transparency for sustainability in the food chain: challenges and research needs EFFoST critical reviews# 2 (Vol. 2). Elsevier. 2013.
34. Benavides-Espinosa MDM, Ribeiro-Soriano D, Gieure C. How can agrifood businesses improve their performance? The role of digital transformation. Br Food J. 2024.
35. Ribeiro-Navarrete B, Calderon-Monge E, Simón-Moya V. Digitalisation and digital transformation in the social economy: the cases of Anecoop and Consum. Br Food J. 2023;125(10):3489–505.
36. Kosior K. Digital transformation in the agri-food sector-opportunities and challenges. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu. 2018;20(2):98–104.
37. Trivelli L, Apicella A, Chiarello F, Rana R, Fantoni G, Tarabella A. From precision agriculture to industry 40: unveiling technological connections in the agrifood sector. Br Food J. 2019;121(8):1730–43.
38. Bin Othman R. Strategic HRM: evidence from the Irish food industry. Pers Rev. 1996;25(1):40–58.
39. Krishnan U. The Industry 40 and its associated technologies. J Emerg Technol. 2021;1(1):1–10.
40. Vial G. Understanding digital transformation: a review and a research agenda. Manag Dig Transf. 2021. https://doi.org/10.4324/9781003008637-4.
41. Silvestri R, Ingrao C, Fiore M, Carloni E. Digital innovation through networking among agro-food SMEs: the role of R&D projects. Br Food J. 2023;125(4):1217–31.
42. Piriyakul M. Sample size determination for structural equation modeling (SEM). J Indus Technol. 2021;17(3):232–46.
43. Srivastava P, Ansari H, Alrasheedi M, Sharma R, Prakash S, Gupta S. Leveraging supply chain collaboration with digital technologies for supply chain performance: an empirical investigation of Indian meat industries. Int J Food Sci Technol. 2024;59(5):3514–22.
44. Turi JA, Al Kharusi S, Khwaja MG, Razzak MR, Bashir S. Requirement engineering and project performance: mediating effect of communication effectiveness, change readiness, stakeholder engagement and moderating effect of team cohesion. Eng Constr Arch Manage. 2024.
45. Rachmawati I, Widayani A, Normawati RA. Indonesia's MSEs on the path to digital transformation. In: International Conference on Intellectuals' Global Responsibility (ICIGR 2022) (pp. 549–556). Atlantis Press. 2023.
46. Wayne Gould R. Open innovation and stakeholder engagement. J Technol Manag Innov. 2012;7(3):1–11.
47. Nygaard K, Graversgaard M, Dalgaard T, Jacobsen BH, Schaper S. The role of stakeholder engagement in developing new technologies and innovation for nitrogen reduction in waters: a longitudinal study. Water. 2021;13(22):3313.
48. Qadri UA, Ghani MBA, Abbas U, Kashif AR. Digital technologies and social sustainability in the digital transformation age: a systematic analysis and research agenda. Int J Ethics Syst. 2025;41(1):142–69.
49. Trang PH, Nam V, Nguyen HLD, Le TL, Dang-Pham D. Sustaining the future of tourism logistics through digital technologies: a roadmap for digital transformation. In: Transforming Logistics in a Developing Nation: Vietnam's Technology Imperative (pp. 387–413). Singapore: Springer Nature Singapore. 2024.

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