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Research

Unlocking digital growth: overcoming barriers to digital transformation for Indian food SMEs

Sumit Gupta[1] · Sandeep Jagtap[2,3]

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Abstract
This paper aims to study how firms must be agile to overcome risks and manage cost repercussions. Specifically, it focuses on promoting digitalization in Indian food SMEs for greater competitiveness. The main purpose is to design a model for implementing robust interventions in a rational manner. To achieve this, a mixed approach, including a literature review and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, was chosen. This approach is recommended for addressing barriers to digital transformation in SMEs. The results suggest that the absence of internet connectivity and problems related to organization impede the efficiency of operations in small and medium-sized Indian food businesses. By overcoming these obstacles and allocating resources to enhance their digital capacities, stakeholders can effectively shape their future business operations. In addition, it is imperative for the stakeholders to actively adopt and utilize a range of digital tools such as blockchain, IoT, Big Data, and cloud computing. To implement and sustain digital transformation effectively, three foundational elements are crucial: internet availability, financial resources, and employee training. This research offers an innovative approach to the practiceners and mangers to adopt digital transformation of Indian food SMEs.

Keywords Digital transformation · Indian food SMEs · Digitalization · Operational productivity · Food sector

1 Introduction

The COVID-19 pandemic has increased the utilization of digital technologies to enhance the resilience of a food system [1]. The utilization of blockchain technology in the context of food safety has primarily been driven by its capacity to ensure data security in the areas of traceability, monitoring, and inspection, as well as its potential for promoting social and economic sustainability [2]. The monitoring of food safety has been significantly enhanced by IoT-based solutions, which are currently the most prominent technology in this field [3]. Rejeb et al. further states that the integration of blockchain and IoT has the potential to lead the way in establishing traceability within the food system. According to Silva et al. [4], digital transformation has the potential to create a food system that is environmentally and socially sustainable. Nevertheless, small businesses face challenges in accessing advanced digital transfoamtion in the food system, despite their significant contribution of over 70% to global food production [5, 6].

✉ Sandeep Jagtap, sandeep.jagtap@tlog.lth.se | [1]Department of Mechanical Engineering, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida, India. [2]Sustainable Manufacturing Systems Centre, School of Aerospace, Transport & Manufacturing, Cranfield University, Cranfield, UK. [3]Division of Engineering Logistics, Department of Mechanical Engineering Sciences, Faculty of Engineering, Lund University, Lund, Sweden.

The digital adequacy of operations in several countries facilitates seamless connections among supply chain members and prevented food and economic disruptions [7]. It also standardizes processes and enabled access to global markets, allowing SMEs to meet customer needs and compete on a larger scale. However, empirical data reveals that while global SMEs increased their productivity by 16% through digital tools, only 6% of Indian SMEs had an online presence during the pandemic [8]. This highlights the challenges faced by Indian food-based SMEs and raises questions about their existing strategies, current processes, and future survival. Neglecting digital strategies in the post-pandemic era further hampers their global positioning, despite the Indian food industry's significant size and growth rate of 20% per annum [8]. To maximize productivity and sustain business in catastrophic situations, inter-organizational collaborations through process digitization can be a unique approach, drawing lessons from the pandemic experience.

Indian small and medium-sized enterprises (SMEs) are currently adopting technological advancements initiated by the central government in response to the difficulties encountered during the COVID-19 pandemic. Nevertheless, their utilization of technology is constrained by obstacles to the process of digital transformation. It is imperative to recognize, generate ideas for, and confirm these obstacles for successful widespread implementation. Previous research conducted by Dutta et al. [9], Annosi et al. [10], and Shahadat et al. [11] has provided insights into the challenges encountered by small and medium-sized enterprises (SMEs). The current literature indicates a pressing need for food SMEs to embrace digital transformation in order to meet customer demands. The present study addresses the existing knowledge gap by employing Multiple Criteria Decision Method (MCDM) techniques to identify and organize the challenges, taking into account their inter-relationships. The results of this study highlight the necessity for strong measures to encourage the adoption of digital technology in small and medium-sized food businesses in India.

The paper is presented as follows. The second section delves into insights from existing literature on digitization in SMEs, while the third section provides a comprehensive explanation of the data analysis using Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach. The fourth section discusses the research results, followed by a case illustration in the fifth section. Concluding remarks are presented in the sixth section, and industry implications of the findings, along with insights for future research directions, are provided in the last section.

2 Literature review

Firms undergoing digital transformation experience improved operational performance and discover wider business opportunities. Companies are exploring novel technologies and application software to identify potential business applications throughout the supply chain. During this process, firms often face challenges influenced by internal and external factors [7, 9, 10, 12]. Notably, there is a significant difference in the challenges faced by SMEs compared to their larger counterparts [12]. SMEs are constrained by limited resources, digital skills, top management's attitude towards experimentation, and the need for an organized working environment [11]. The academic literature provides a thematic categorization of these barriers to digitization, which are primarily based on strategic, operational, organizational, technological, supply chain, and market-related factors [12].

During the process of digitalization, organizations heavily rely on technology for their operations. The literature review reveals that technology usage has transformed factors affecting functional competition [9, 10]. Digitized firms compete by reducing prices, optimizing processes, minimizing failure probabilities, and preventing waste. This requires inter-departmental collaborations, resulting in the generation of vast amounts of data [13, 14]. This data repository is highly complex and contains valuable information that can guide predictions and facilitate optimal decision-making. For example, traceability systems governed by Radio Frequency Identification (RFID) tags contribute to a data cluster. Information sharing among supply chain members influences price fluctuations, product quality, flexibility, delivery, and service levels [15, 16]. However, managing such complex data involves addressing internal loops and requires SMEs to leverage its benefits effectively. Failure to do so due to mismanagement and a lack of understanding results in a shortage of resources, misaligned operations, and a damaged reputation in data-driven business environments [17, 18]. These firms require an organizational management model, financial resources, comprehensive data privacy and protection policies, and user-friendly software to simplify the solutions [14].

For SMEs, access to information enhances adaptability and agility, enabling them to compete with their counterparts [19]. However, food-based businesses face a significant challenge in accessing and processing market information due to the need for internet-based support [13]. Small firms often have a traditional approach, when it comes to infrastructure, raw material usage, process flexibility, delivery decisions, change adoption, and adherence to industrial standards. This hampers the potential benefits of digitization [20]. Conceptual studies have highlighted the investment concerns associated with implementing digital technologies, such as the cost of RFID tags in the fresh food business [21]. Furthermore, the absence of a cost calculation model has emerged as a key hurdle in digitization, which affects finance across various processes, including procurement, manufacturing, innovation, skill development, and quality maintenance [12]. Existing research emphasizes the need for acquiring new skills to operate sophisticated digital machinery in the digital era [22]. At present, skilled workers in small and medium-sized enterprises (SMEs) who have traditional expertise are hindering the implementation of digital technologies. This is because they are afraid of losing their jobs and have a cautious mindset when it comes to acquiring new skills [7, 23].

Firms planning to undergo digital transformation are often hindered by their conservative philosophies [7]. A review-based study by Mittal et al. [24] identified 17 dimensions that impede the digitization process in SMEs, including the presence of a traditional organizational culture, rigid structures, inflexible leadership, inadequate human resource development, cultural challenges, lacking digital transformation strategies, insufficient investments in IT infrastructure, limited alliances with universities, and lack of collaborative relationships with supply chain members. The SMEs are still in the early stages of addressing the organizational aspects of digitization [7]; therefore, firms need to adopt an agile mindset to address the barriers posed at both individual and systemic levels. This enables them to meet the growing demand and maintain quality thresholds [25]. While there is a substantial body of literature on digitization in various sectors such as automotive, banking, healthcare, and retail [9, 13, 16, 22], however, there is limited research available on the challenges associated with the digital transformation of Indian food-based SMEs.

The presented research aims to fill this gap by examining the digital transformation challenges faced by Indian food-based industries, with a specific emphasis on SMEs. Additionally, the research highlights the potential benefits of adopting a digital perspective in business operations, including increased production quantity, market sales, and product quality in food-based industries.

The presented research introduces a solution-based methodology to address the challenges faced by food-based firms in their digitization process. Twelve challenges identified from existing literature are categorized into three major criteria: analytic and finance, operations, and organizational and global, for clarity in the research study. Table 1 provides a detailed description of the corresponding challenges within each category. It is important to consider the interrelationships that exist among the identified set of challenges. To highlight these interrelationships, the DEMATEL technique is implemented. The results from the study provide evidence-based solutions to minimize bottlenecks during the digitization of food-based firms.

3 Methodology

The presented research follows a systematic methodology, which is well-documented in the literature. Figure 1 showcases this methodology. Key challenges are identified from the literature, and opinions are gathered from industry experts through a structured questionnaire. The responses were collected during January 2023 to June 2023 with response rate of 20.21%. The DEMATEL approach is then used to generate a priority index, revealing the relationships among various challenging factors in the digital transformation paradigm of Indian food SMEs. Due to the limited availability of approaches for prioritizing factors, the DEMATEL approach was selected to determine the priority of the challenges that need to be addressed.

DEMATEL is an approach used for Multiple Criteria Decision Analysis (MCDA). It efficiently converts qualitative inputs into quantitative analysis, facilitating the extraction of the quantitative interrelationships between various parameters in a problem statement [40, 41]. The generated matrix reveals strong relationships between indirect and direct variables, making the DEMATEL methodology compatible for decision-making in complex situations with multiple criteria [42, 43].

In the current study, the DEMATEL approach was chosen to prioritize the identified challenges that hinder the digitalization of the food industry. The six vital steps for implementing DEMATEL methodology as shown in Fig. 2 is being discussed, which concluded as key challenges impacting Indian food SMEs.

3.1 Step 1: Calculation of the direct relation matrix using the expert's judgment and opinion

This step calls for respondents to fill a direct relation matrix that indicates the relation between the parameter $\boldsymbol{i}$ and parameter $\boldsymbol{j}$ in terms of the level of influence on each other and is denoted by $\boldsymbol{a}_{ij}$ which is based on the DEMATEL linguistic rating shown in Table 2.

Experts having a minimum experience of 5 years in food-based SMEs are requested to fill the direct relation matrix. The responses collected are subjected to step 2.

Table 1 Description of various challenges in food industries towards digital transformation

S.No	Challenge Type	Challenge	Description	Source reference
C1	Analytic and finance	Data management	Organizing and maintaining data related to processes and operations required for a smooth workflow	Lavelli [17]; Trebar et al. [26]; Goue et al. [27]'
C2		Dynamic information	Periodically updated information that modifies asynchronously over elapsed time over the availability of new information	Chen [28]; Fritz and Schiefer [13]
C3	Analytic and finance	Finances	Liability and asset allocation for upgradation and risk assessment	Jałmużna et al. [29]; Fu et al. [30]; Goue et al. [27]; Bader and Rahimifard [31]
C4		Implementation cost	The cost associated with the implementation of new technology, operation optimization, and process reforming	Jałmużna et al. [29]
C5		Information management	Application of techniques to manage industry related information for enhanced communication between departments and better management applications	Cai et al. [16]; Fritz and Schiefer [13]; Lavelli [17]
C6	Operations	Adaptability	Inability to adapt according to new product introduction and technological advancements	Kopishynska et al. [32]
C7		Agility	Inflexibility in accordance with dynamic customer demands without sacrificing the quality and cost of the product	Chen [28]; Kopishynska et al. [32]
C8		Internet	Unavailability of interconnectivity between various operations online to aid efficient process capability	Ndou et al. [33]
C9		Skilled labor	The absence of labour accustomed to the use of the latest technology employed in the enterprise	Ndou et al. [33]; Harun et al. [34]; Bader and Rahimifard [31]; Vignali et al. [35]
C10		Technology/human errors	Error generation due to discrepancies in the utilization of technology or human interference	Gandino et al. [36]; Ping-Zeng et al. [37]
C11	Organisational and global	Market competition	Market pressure to deliver products at a competitive price and quality	Kosior [19]; Ushada et al. [38]
C12		Organisational barriers	Hindrances in policies and work methodology of the organization leading to failure or inefficient Output	Kosior [19], Gupta et al. [39]

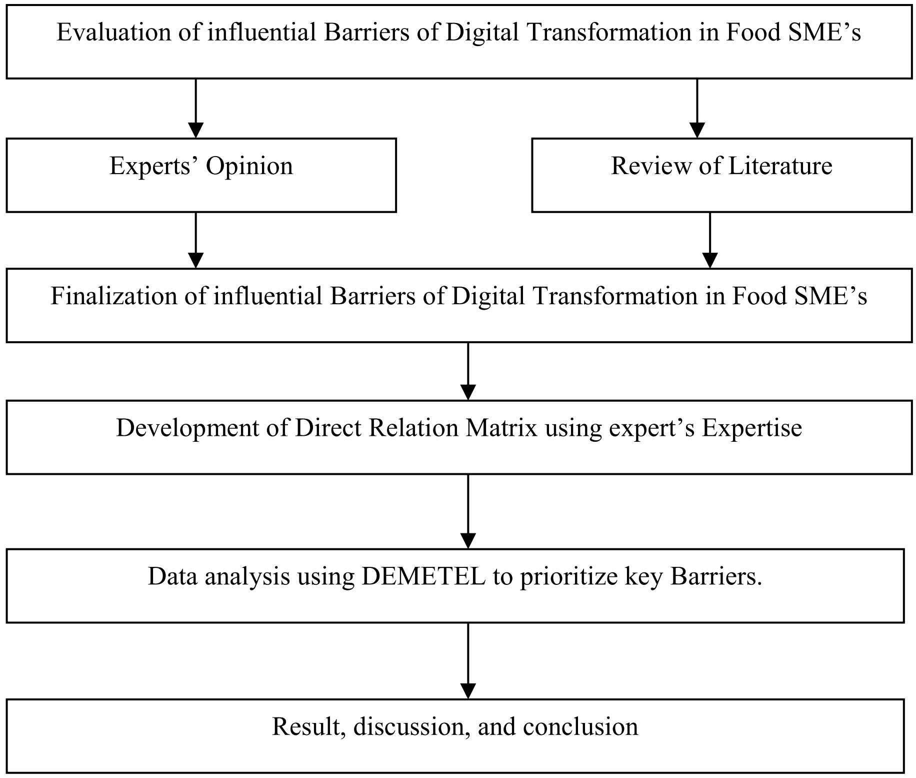


Fig. 1 Research methodology

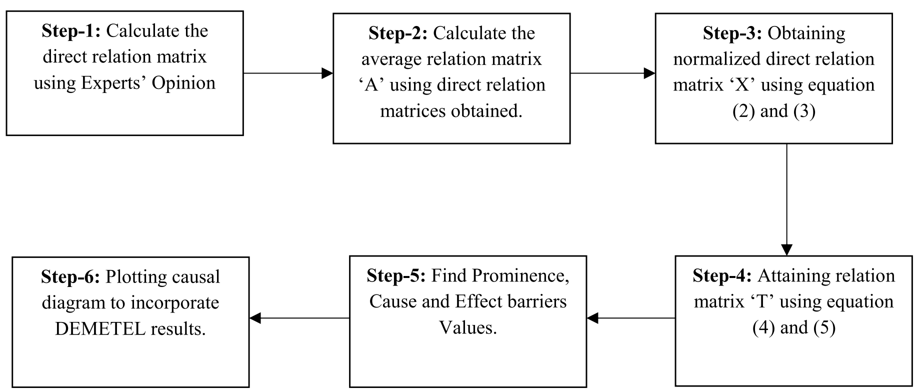


Fig. 2 DEMATEL methodology flow chart

3.2 Step 2: Calculation of the average direct relation matrix

This step summarizes the multiple direct relation matrices obtained by various experts into a simplified single average direct relation matrix $\boldsymbol{A}_{avg}$ as displayed in Eq. (1).

$$\boldsymbol{A}_{avg} = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

Table 2 DEMATEL Linguistic Score

Degree of influence	Influence value
Zero	0
Minimal	1
Moderate	2
Excessive	3
Extreme	4

3.3 Step 3: Derivation of the normalized direct relation matrix or full direct/indirect influence matrix

This step converts the average direct relation matrix $\boldsymbol{A_{avg}}$ to the normalized initial influence matrix $\boldsymbol{X}=\left[\boldsymbol{X_{ij}}\right]_{\boldsymbol{n}\times\boldsymbol{n}}$. This step converts the matrix $\boldsymbol{X}$ into values ranging from zero to one using Eq. (2) and (3), where $\boldsymbol{A_{avg}}$ is shown by the values ranging from $0 \leq \boldsymbol{X_{ij}} \leq 1$, which is also referred to as the fuzzy cognitive matrix. The Eqs. (2) and (3) transform the principal diagonal elements of the matrix, equating to zero value. The indirect influences of the challenges show a continuous decrease along the powers of $\boldsymbol{X}$, for example, $\boldsymbol{X}^2, \boldsymbol{X}^3 \ldots \boldsymbol{X^h}$ and $\lim_{h\to\infty} \boldsymbol{X^h} = [0]_{\boldsymbol{n}\times\boldsymbol{n}}$ where $0 \leq \sum_i \boldsymbol{X_{ij}} \leq 1$ or $0 \leq \sum_j \boldsymbol{X_{ij}} \leq 1$ and deriving at least, but not all, one row or column summation equating to zero value.

$$\boldsymbol{X} = \boldsymbol{z} \times \boldsymbol{A_{avg}} \tag{2}$$

$$\text{Where } \boldsymbol{z} = \boldsymbol{min}\left[\boldsymbol{max}_{1\leq i\leq n \sum_{j=0}^{n} a_{ij}}, \boldsymbol{max}_{1\leq i\leq n \sum_{i=0}^{n} a_{ij}}\right]^{-1} \tag{3}$$

and $\lim_{h\to\infty} \boldsymbol{X^h} = [0]_{\boldsymbol{n}\times\boldsymbol{n}}, 0 \leq \boldsymbol{X_{ij}} \leq 1$

This step displays the initial influence that a parameter is subjected to and subjects to other parameters, which helps portray the connective relationship among the various parameters of the matrix system, where the numerical value represents the degree of influence.

3.4 Step 4: Derivation of the total influence matrix *T*

Using Eq. (4), the total influence matrix can be generated. The equation contains the element ***I***, which signifies the identity matrix and the explanation for the matrix ***T*** is displayed below.

$$\begin{aligned}
&\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + \boldsymbol{X}^3 + \ldots + \boldsymbol{X^h}, \lim_{h\to\infty} \boldsymbol{X^h} = [0]_{\boldsymbol{n}\times\boldsymbol{n}} \\
&\boldsymbol{T} = \boldsymbol{X}\left(\boldsymbol{I} + \boldsymbol{X} + \boldsymbol{X}^2 + \ldots + \boldsymbol{X}^{\boldsymbol{h}-1}\right)(\boldsymbol{I}-\boldsymbol{X})(\boldsymbol{I}-\boldsymbol{X})^{-1} = \left(\boldsymbol{I}-\boldsymbol{X^h}\right)(\boldsymbol{I}-\boldsymbol{X})^{-1} \\
&\text{Then } \boldsymbol{T} = \boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1}, \text{when } \boldsymbol{h} \to \infty
\end{aligned} \tag{4}$$

3.5 Step 5: Finding prominence, cause barrier and effect barrier values

This step proceeds with the conclusive study of the total influence matrix ***T*** by attaining the summation of the rows and columns separately in terms of vector ***D*** and vector ***R*** through the Eqs. (5) and (6) given below.

$$\boldsymbol{T} = \left[\boldsymbol{t_{ij}}\right], \text{ where } \boldsymbol{i}, \boldsymbol{j} = 1, 2 \ldots, \boldsymbol{n} \tag{5}$$

$$\boldsymbol{D} = \left[\boldsymbol{D_i}\right]_{\boldsymbol{n}\times 1} = \left[\sum_{j=0}^{n} \boldsymbol{t_{ij}}\right]_{\boldsymbol{n}\times 1}, \boldsymbol{R} = \left[\boldsymbol{R_j}\right]_{\boldsymbol{n}\times 1} = \left[\sum_{i=0}^{n} \boldsymbol{t_{ij}}\right]'_{1\times\boldsymbol{n}} \tag{6}$$

where the transpose is denoted by the superscript "′".

D_i denotes the summation of the values of the ith row in the matrix T, which indicates the influence of the specific challenge parameter on other challenges, whereas R_j denotes the summation of the values of the jth column in the matrix T, which indicates the influence of the other challenges on the specific challenge parameter. Furthermore, when $i=j$ (this denotes the addition of the values of a column and row aggregated), the value of (D_i+S_i) highlights the index of the relative importance of the influence, which summarizes with a prominence ranking of the challenges involved with the research. Additionally, the value of $(D_i\text{-}R_i)$ highlights the net effect that the challenge imposes on other challenges, which produces the cause barrier and effect barrier values that are denoted by the positive and negative values of $(D_i\text{-}R_i)$, respectively. The positive value denotes the effect produced on other challenges, whereas the negative value denotes the effect received from other challenges.

3.6 Step 6: Plotting the causal diagram

The DEMATEL result is interpreted visually by plotting a scatter diagram called Causal Diagram. It incorporates the prominence value $(D_i\text{-}R_i)$ and cause and effect barrier values $(D_i\text{-}R_i)$ on the graph's horizontal and vertical axis. Such representation helps to determine a cluster of parameters belonging to the graph's four quadrants. Ultimately, this helps in concluding the results of the tool applied.

4 Data analysis and results

This exploratory study focuses on the interrelationship between 12 key challenges faced by Indian food SMEs during their digital transformation in the post-pandemic times. Responses collected from the various experts in the form of a 12 × 12 direct relation matrix are used to evaluate the influence of challenges. Based on their experience, these managers rendered valuable inputs on the degree of influence of each parameter on other parameters in the matrix. The DEMATEL calculation process showcased in Table 3 indicates the average direct relation matrix A_{avg}.

Similarly, the other steps of the DEMATEL approach are computed. Detailed formulation of those steps is explained in the procedure mentioned below it. The normalized direct relation matrix X is showcased in Table 4.

The summations of influences projected and received on the considered set of factors are mentioned in Table 5.

The prominence ranking is obtained by the summation of D and R, which projects the output. It is done by referring to the relative effect of each identified challenge. The subtraction of R from D indicates the net effect of the factor, bifurcated into two distinct groups called cause barrier and effect barrier. Furthermore, prominence ranking $(D+R)$ and cause and effect barrier ranking $(D\text{-}R)$ are attained. It is displayed in Tables 6 and 7, respectively.

The cause-and-effect barrier values are the other result generated using the DEMATEL approach methodology. These are mentioned in Table 7. Such relative parameters show the influencing parameters and influence parameters. The parameters with a higher value of positive $(D\text{-}R)$ resemble the ability to influence other parameters with a higher degree of effect, and the parameters with a higher value of negative $(D\text{-}R)$ resemble the ability to get influenced by

Table 3 Average direct relation matrix Aavg

Challenges/parameters		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Data management	C1	**0**	3.5	2.5	2.5	3.75	2.75	3	1.5	1	3.5	2.25	1.75
Dynamic information	C2	4	**0**	3.25	3	3.75	3.5	3.75	1.25	2.5	3.5	3	3
Finances	C3	2.75	2.25	**0**	3.25	2.75	2.75	3	2.25	3.5	2.75	2.75	2.5
Implementation cost	C4	1.75	2.25	2.25	**0**	1.75	2.75	3.25	2.5	2	1.25	1.5	1.5
Information management	C5	3.5	3	2.25	2.75	**0**	3.75	3.25	1.75	2	3	3.5	3.25
Adaptability	C6	1	1.25	1.25	3	2	**0**	2.25	1.25	2.25	2.5	3.5	3.25
Agility	C7	3.75	3.5	3.25	3.25	3	3	**0**	1.75	2.25	2.25	3.75	3.75
Internet	C8	3.75	3.5	1.75	2.5	3.75	2.5	3	**0**	2.25	3	3.5	3
Skilled labour	C9	2.75	2.75	2.25	3.25	3.25	3	3.5	1.5	**0**	2.5	2	2.5
Technology/human errors	C10	3	3	3	3.25	3	3	3	1.25	1.75	**0**	2.25	2.25
Market competition	C11	2	2.25	2.75	2.25	2.5	2.75	2.5	1.5	2.25	2	**0**	2.25
Organizational barriers	C12	3.5	3	3.5	3.75	3.5	3.5	3.75	1.75	2.25	3.25	3.25	**0**

Table 4 Normalized direct relation matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	**0**	0.1	0.07142	0.0714	0.10714	0.07857	0.0857	0.04285	0.02857	0.1	0.06428	0.05
C2	0.1142	**0**	0.09285	0.0857	0.10714	0.1	0.10714	0.03571	0.07142	0.1	0.08571	0.08571
C3	0.078571	0.06428	**0**	0.09285	0.07857	0.07857	0.08571	0.06428	0.1	0.07857	0.07857	0.07142
C4	0.05	0.06428	0.06428	**0**	0.05	0.07857	0.09285	0.07142	0.05714	0.03571	0.04285	0.04285
C5	0.1	0.08571	0.06428	0.07857	**0**	0.10714	0.09285	0.05	0.05714	0.08571	0.1	0.09285
C6	0.028571	0.03571	0.03571	0.08571	0.05714	**0**	0.06428	0.03571	0.06428	0.07142	0.1	0.09285
C7	0.107143	0.1	0.09285	0.09285	0.08571	0.08571	**0**	0.05	0.06428	0.06428	0.10714	0.10714
C8	0.107143	0.1	0.05	0.07142	0.10714	0.07142	0.0857	**0**	0.06428	0.08571	0.1	0.08571
C9	0.078571	0.07857	0.06428	0.09285	0.09285	0.08571	0.1	0.04285	**0**	0.07142	0.05714	0.07142
C10	0.085714	0.08571	0.0857	0.0928	0.08714	0.08571	0.08571	0.03571	0.05	**0**	0.06428	0.06428
C11	0.0571	0.06428	0.07857	0.0642	0.07142	0.07857	0.07142	0.04285	0.06428	0.05714	**0**	0.06428
C12	0.1	0.08571	0.1	0.1071	0.1	0.1	0.10714	0.05	0.06428	0.09285	0.09285	**0**

Table 5 The sum of influences projected and received on the parameters

Challenges/parameters		D	R	D+R	D-R
Data management	C1	5.08	5.632	10.712	– 0.552
Dynamic information	C2	6.132	5.401	11.533	0.731
Finances	C3	5.458	5.103	10.561	0.355
Implementation cost	C4	4.188	5.874	10.062	– 1.686
Information management	C5	5.705	5.831	11.536	– 0.126
Adaptability	C6	4.248	5.978	10.226	– 1.73
Agility	C7	5.976	6.094	12.07	– 0.118
Internet	C8	5.853	3.394	9.247	2.459
Skilled labour	C9	5.269	4.367	9.636	0.902
Technology/human errors	C10	5.168	5.286	10.454	– 0.118
Market competition	C11	4.55	5.62	10.17	– 1.07
Organizational barriers	C12	6.196	5.243	11.439	0.953

Table 6 The prominence ranking of (D+R)

Challenges/parameters		D+R	Ranking
Agility	C7	12.07	1st
Information management	C5	11.536	2nd
Dynamic information	C2	11.533	3rd
Organizational barriers	C12	11.439	4th
Data management	C1	10.712	5th
Finances	C3	10.561	6th
Technology/human errors	C10	10.454	7th
Adaptability	C6	10.226	8th
Market competition	C11	10.17	9th
Implementation cost	C4	10.062	10th
Skilled labour	C9	9.636	11th
Internet connectivity	C8	9.247	12th

other parameters [44]. The cause barrier group has five parameters, namely 'Internet connectivity' (C8), 'Organizational barriers' (C12), 'Skilled labor' (C9), 'Dynamic information' (C2) and 'Finances' (C3). Of these five parameters in the cause barrier group, C8 and C2 score the highest. The effect barrier group has seven parameters, namely 'Adaptability' (C6), 'Implementation cost' (C4), 'Market competition' (C11), 'Data management' (C1), 'Information management' (C5),

Table 7 The cause-and-effect barrier ranking (D-R)

Ranking	Cause barrier group	D-R
1st	C8	2.459
2nd	C12	0.953
3rd	C9	0.902
4th	C2	0.731
5th	C3	0.355
Rank	**Effect barrier group**	**D-R**
1st	C6	– 1.73
2nd	C4	– 1.686
3rd	C11	– 1.07
4th	C1	– 0.552
5th	C5	– 0.126
6th	C7	– 0.118
7th	C10	– 0.118

'Agility' (C7) and 'Technology/Human errors' (C10). Of the seven in the effect barrier group, C6, C4, and C11 scored the highest.

The causal diagram shown in Fig. 3 illustrates the relationship between cause-and-effect barrier values and prominence parameter values on vertical and horizontal scales, respectively [45]. The summation of individual rows of the total initial matrix $\boldsymbol{T}$ as $\left(\boldsymbol{D_i}\right)$ and the summation of individual columns of the matrix as $\left(\boldsymbol{R_i}\right)$ leads to the value of $\boldsymbol{(D+R)}$. It signifies the degree of correlation of a specific parameter with the other parameters in the system, and the value of ***(D-R)*** signifies the degree of influence the parameter projects on the other system parameters. If the value inclines toward the positive axis, they are referred to as a cause barrier [46]. For the values inclining towards the negative axis, the significant shifts towards the parameters are influenced by other system parameters. Hence, they are called an effect barrier [47]. As shown in the Fig. 3, a significant interrelationship exists between the various parameters of the system, including the parameters of agility, information management, dynamic information, and organizational barriers. Since they indicate the degree to which other criteria are influenced, the cause barrier parameters are an essential component of the system. According to Mathiyazhagan et al. [48], their significance is paramount in identifying the factors that have the potential to impede the system's predetermined goals. In the context of a system or process, the variables or factors that define the characteristics or behavior of the system or process. The challenges that exist within an organization Skilled labor and internet connectivity are the standards that carry the most weight when it comes to determining the primary cause. Loop diagrams as shown in Fig. 4 are intended to facilitate comprehension of the barriers' criticality.

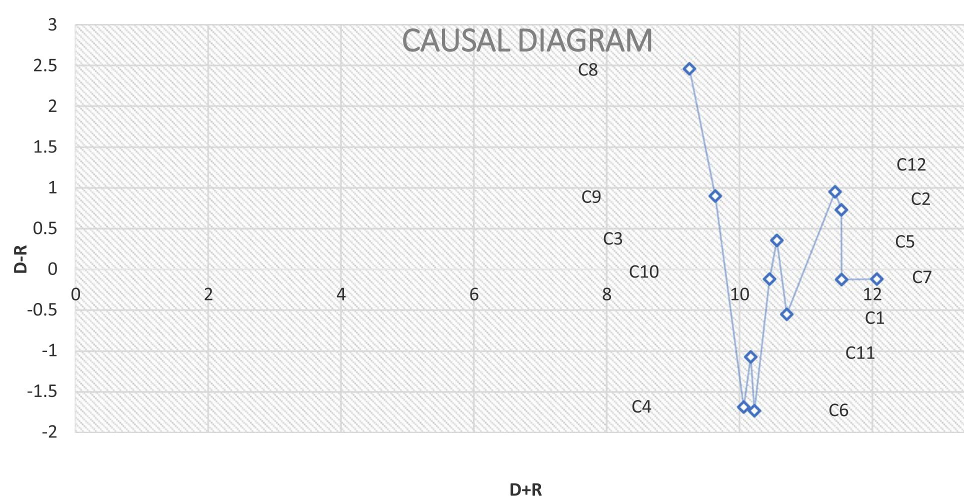


Fig. 3 Causal Diagram to visually represent cause and effect barrier parameters

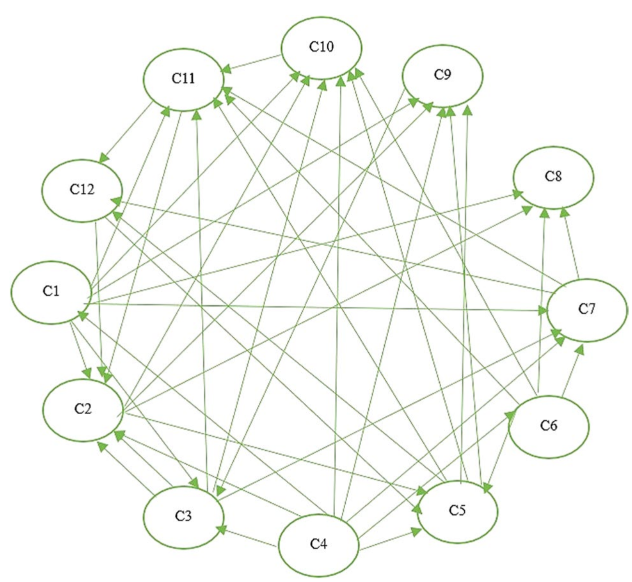
The matrix table is used to calculate the initial threshold value, which is (0.07049). An arrow is generated exclusively from values that exceed the threshold values. In this manner, an arrow is drawn for each element of the matrix whose value exceeds the threshold value.

5 Discussion

The introduction of Industry 4.0 has brought about technological advancements that have improved the industry's operational capabilities, making them more effective and optimized. Despite the rapid pace of development, most industries have embraced the new industrial revolution. However, the food industry is still facing challenges in implementing digitalization in their processes and management techniques. This study aims to identify the potential obstacles related to the digitalization of food industries in the Indian market, where the process is impeded by various factors that must be minimized to ensure optimal industrial operations. The extrinsic research focuses on analyzing literature findings to compile a list of significant challenges that can assist in determining the digital transformation priorities of small and medium-sized food enterprises (SMEs) in India. It concludes that the key factors responsible for the slow growth of digitalization in this sector are agility, information management, dynamic information, organizational barriers, data management, and technology/human errors. The research also aims to provide solutions to overcome the barriers associated with digitalization. Marinelli et al. [49], Rupeika-Apoga and Petrovska [50], and Marczewska [51] investigated the difficulties associated with the adoption of digital technology in small and medium-sized enterprises (SMEs). In order to successfully navigate the digital environment, small and medium-sized enterprises (SMEs) must strategically enhance their organizations and incorporate technology policies as crucial components of their business models.

Prior to the pandemic, the management, faced with low profits and limited production capacity, consistently favored conventional processes and manufacturing methods in order to effectively manage costs over an extended period. Another significant obstacle to implementing digital transformation was found to be the absence of financial assistance. The COVID-19 pandemic has caused significant disruptions in various industries, prompting the need for digital transformation of operational functions as a strategy to recover from similar disruptions. However, accomplishing this transformation necessitates the assimilation of digital tool implementation into current systems. Small and medium-sized enterprises (SMEs) engage in collaboration with larger corporations, depending on their smaller partners to handle outsourced production. After the COVID-19 pandemic, small and medium-sized enterprises (SMEs) encounter difficulties in improving production efficiency and reducing obstacles in the industry. SMEs, which constitute a fundamental pillar of the Indonesian economy, contributed 60.5% to the GDP in 2022. Therefore, it is imperative for them to adapt to the prevailing changes. SMEs must promptly adapt to the digital transformation in order to effectively address customer demands [52].

Fig. 4 Loop Diagram for the barriers



6 Research implications

The study contributes to theory, practice as well as policy formation. The list of challenges divided into two distinct segments within the cause-and-effect barrier group helps to validate the challenges experienced within SMEs.

The study identified five high-priority challenges associated with digital transformation namely Internet connectivity (C8), Organizational barriers (C12), Skilled labor (C9), Dynamic information (C2), and Finances (C3). Two SMEs, operating in the food processing and food manufacturing sectors, were visited to validate the findings. Validating the results with employees and other stakeholders of these two enterprises revealed that internet connectivity was the most significant challenge, although it had a marginally easy solution. This challenge became evident during the first and second waves of COVID-19. However, top management perceived internet connectivity as an unreasonable barrier to digital transformation. The scale of operations was also affected by unskilled laborers working in the limited but digitized production shop floor. They need to undergo training and acquire the necessary skills before any technology upgrade.

Food-based businesses played a crucial role during the COVID-19 pandemic, and supply chain members worldwide recognized the power of digital technologies. Meanwhile, managers of Indian food-based SMEs became aware of the limitations of these technologies in serving customers and driving future business growth. In the post-pandemic era, these firms are actively seeking to identify and address the challenges that can enhance their productivity and quality standards. This study sheds light on the challenges faced by such SMEs, enabling a conscious evolution of digital transformation in the future. Managers can improve internet connectivity for process automation and facilitate data management, which are the two key challenges identified in the research. This will catalyze the process of digital transformation. Furthermore, organizational support can help accelerate the digitalization process, bringing Indian food SMEs in line with other thriving sectors.

The implementation of digital technologies has the potential to enhance transparency and food safety, facilitate access to agricultural information and services, and improve management of the food supply chain. In the midst of the pandemic, food SME suppliers served as external production facilities for larger corporations. However, their limited utilization of resources for digital technologies impeded their capacity to increase production beyond the facility's physical constraints. The significant contribution of small and medium-sized enterprises (SMEs) to India's thriving food industry is the source of its prosperity. This category comprises enterprises that include producers, warehouses, agriculturists, transporters, and food processors. By bringing together a variety of stakeholders, the implementation of technologies that enable digital transformation improves the effectiveness of food supply operations through collaboration. Strategic decisions involving industrial digital transformation may result in increased revenue, decreased expenses, and enhanced operational efficiency. By promptly adjusting, organizations can secure a competitive edge and position themselves for triumph in an ever more digital environment.

7 Conclusion

This article evaluates the crucial components of digital transformation applications in the context of the food supply chain, with the aim of achieving successful and sustainable development in Indian small and medium-sized firms (SMEs) in the business domain.The COVID-19 pandemic has disrupted various industries, and digital transformation of operational functions is seen as a means to recover from similar disruptions. However, achieving this transformation requires the integration of Industry 4.0 elements into existing systems. SMEs collaborate with larger firms, relying on their smaller counterparts for outsourced production. Post-COVID-19, SMEs face challenges related to optimizing production rates and minimizing industry bottlenecks. To address these barriers, the DEMATEL technique is used to identify and prioritize them. The questionnaire was developed to obtaine the information from the various stakeholders. This research highlights the efforts of SMEs to become self-reliant, aiming to minimize issues and optimize production. It provides a clear direction for channeling digital transformation, contrasting vague and skeptical judgments. The study concludes that internet connectivity is a crucial driver in the technology advancement process, as supported by previous studies. This is particularly relevant as many Indian SMEs are located in rural areas with limited or no internet connectivity. Another significant challenge is the high influential value of organizational barriers, stemming from the organization's resistance to adopting new technologies and political complexities, which perpetuate a traditional work environment. Consequently, transformation efforts are neglected, and outdated operational practices persist, disregarding the benefits of digital transformation for the industry. These challenges require attention to streamline and optimize workflow processes, ultimately reducing bottlenecks and maintaining optimal production rates. The current research limited to 20.21% response rate of, due to the non availability of the respondents. The response rate further can be improved for greater insight. Also,The current research focuses on minimizing the influence of barriers that hinder the slow transformation of SMEs into a self-sustaining industry capable of operating with maximum production and minimal issues.

Author contributions S.G. and S.J. wrote the main manuscript text, figures and tables. All authors reviewed the manuscript.

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Data availability Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate Approval was obtained from the ethics committee of Amity University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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