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MODELLING DELIVERY PERFORMANCE PARAMETERS IN INDIAN FOOD PROCESSING SMES USING ISM

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Abstract: India is considered to be among the leading global food producers of the world. The supply chain involved in the sector is extremely long and complex and has a lot of participating intermediaries. Delays at various points result in delivery issues, which affects the efficiency and delivery performance of the overall supply chain. In this study, seventeen sub-parameters have been identified (after brainstorming sessions with experts from industry and academia) from the top five parameters obtained by implementing Analytic Hierarchy Process (AHP) in an earlier research work by the author. Further, the Interpretive Structural Modelling (ISM) model has been formed. As per the current F&V supply chain in India, the major delivery issues are related to demand management, transportation, logistics, outsourcing, and lead time management, considering the highly perishable nature of the products involved. The paper aims to investigate the relationship among the important sub-parameters of the F&V supply chain. The study involves responses from fifty people from different F&V SMEs across north India and the data is gathered using a five-point Likert scale. An ISM model is used to reveal interdependencies of delivery performance sub-parameters. MICMAC (Cross-Impact Matrix Multiplication Applied to Classification) analysis is also performed to find out the driving power and dependence power of the sub-parameters. The analysis determines the structural relation between sub-parameters, affecting the delivery performance in the F&V supply chain.

Keywords: *Indian fruits & vegetable supply chain, delivery issues, perishability, delivery performance, interpretive structural modelling, SME, MICMAC analysis.*

1. Introduction

As the world is advancing towards global trade, it is becoming more and more important to focus on a wide variety, good quality, improved service, on-time delivery, high reliability, and smooth supply chains of fruits & vegetables. Therefore, the competition between organizations is very intense and is affecting the life span, delivery performance, quality and costs, of perishable products (Laugen et al., 2005). To attain a competitive edge in an organization, it is crucial to be flexible with quality, speed, and cost (Mahajan et al., 2013). India tops the list of the world's largest producers of fruits & vegetables, spices, meat, millets, oil seeds, etc. and has a strong ranking among the top five producers of the world of over 80% agricultural produce, including crops like cotton, coffee, etc. (National Horticulture Board., 2013). India

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has a strong base and many positives in the fruits & vegetable production and marketing sector, but it has a lot of limitations also. Our country lacks an efficient and smooth fruit & vegetable supply chain. The perishable nature of the products involved is responsible for high marketing costs, price fluctuations, market glitches, and other similar issues (Rais et al., 2015).

Delivery performance is important to maintain the supply and demand ratio. Also, among all the issues in the supply chain in the F&V sector, the key issues are related to logistics, inventory, procurement, production costs, facilities, and IT support. India has a lack of modern warehouses, cold chain storage and management, packaging units/centres, value-addition units, and food testing laboratories (ASA and Associates Report., 2013).

An excessive number of stakeholders or intermediaries are there who are working in isolation. The infrastructure connecting the intermediaries is very weak. The estimation of demand is also poor and the producers or farmers are trying to sell everything they grow, in the market. The logistics management is also below par. The system integration of the whole supply chain should be well-designed and properly controlled via IT support. The retailers are unorganized and poorly communicated (Kalimuthu et al., 2012).

The present scenario of the Indian F&V supply chain is that the wastage rate is about 30-40% due to post-harvest issues. The reason behind this is an absence of a link between production units, research teams, and consumers which adds to delivery-related issues (Rais et al., 2015). Supply chain improvement is beneficial not only for the private sector but also generates derivatives that invigorate social, environmental, and financial development in the associated regions. An efficient supply chain will be free of delivery-related issues, post-harvest losses, and an excessive number of intermediaries. It will result in improved employability, reduction in transportation and storage costs, increased sales, better knowledge sharing among chain partners, better flow of information and capital, well-coordinated tracking of orders, transparent supply chain, better food quality and safety, & risk management (Sihariya et al., 2013).

According to the literature explored, there is a major information gap related to the cash & product flow in the market information & product demand information in global food loss/wastage due to the inefficient supply chain configuration (FAO report, 2011). The gaps identified in the literature review w.r.t supply chain inefficiencies, infrastructure-related issues, post-harvest losses, cold chain management issues, demand management issues, government policies and reforms in existing farm bills, food nutrition and quality-related issues, etc. gave direction to carry out the present research.

The objectives of the research are:

- Identify the sub-parameters affecting delivery performance in Indian F&V sector SMEs
- Establish the interrelationship among the identified sub-parameters

- Develop a structural model using the ISM technique to analyse the driving and dependence power of the parameters affecting the delivery performance of the F&V sector in the Indian market scenario. The problem complexity and the degree of interconnection among the sub-parameters can be found. This will help the sector experts & managers to take action on mitigating the issues. To carry out MICMAC analysis, implemented to classify sub-parameters based on their criticality.

Figure 1 depicts a Food processing and distribution chain, which has several levels. Farmers/growers/producers are at the initial level, then the second level consists of Mandi agents, then come suppliers of food preservatives, edible colours, plastic or aluminium packaging, then come distributor level which holds the credit of further distribution of packaged crates, baskets, or cartons to the next level i.e. wholesalers. After wholesalers, retailers are there which can be either organized or unorganized. After the retailer level, the final level consists of the customers or consumers (Negi, 2015). In our study of delivery performance parameters, we focus on the farmer level to retailer level.

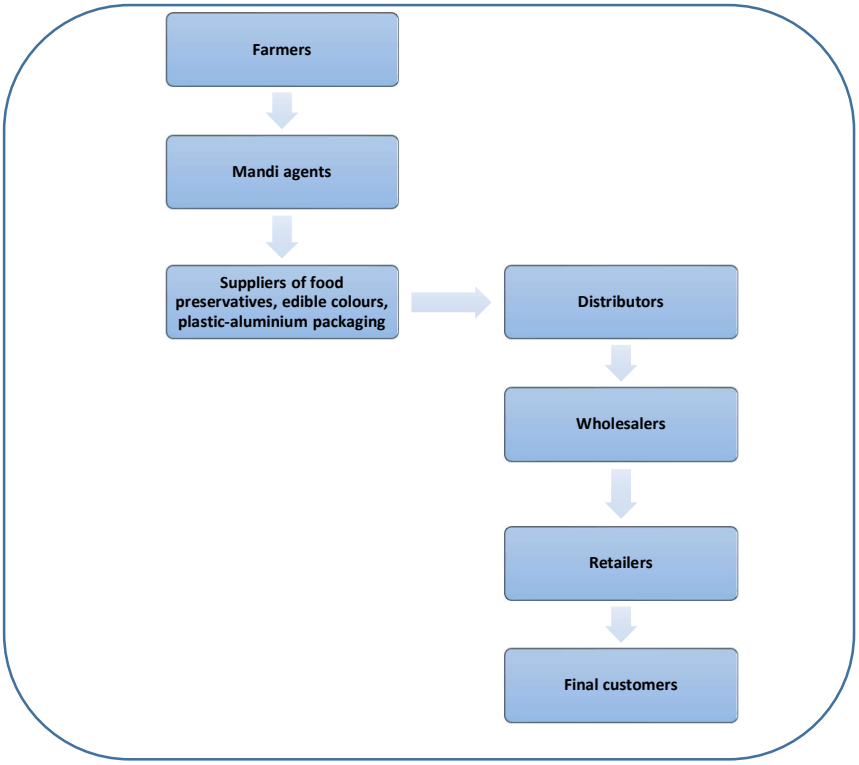

Figure 1 *A Food Processing and Distribution Supply Chain*

2. THEORETICAL FOUNDATION

A. Delivery Performance Sub Parameters

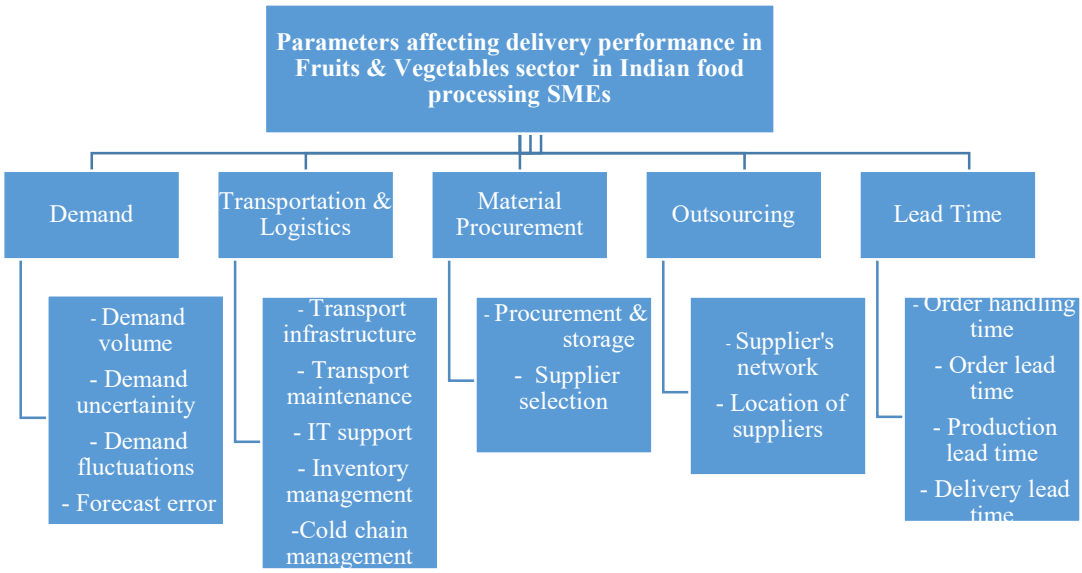

Figure 2 *Delivery performance parameters and sub-parameters found in each category for the Fruits & vegetable sector in Indian Food Processing SMEs*

The sub-parameters for delivery performance are described below (in brief).

Demand volume

It is considered as the volume of fruits and vegetables ordered by the supply chain role players from one level to another (start to end), in exchange for money. This defines the supply volume also and determines the price (actual) in the market (Hsiao et al., 2010).

Demand uncertainty

This is the point where the Fruits & vegetable industry is unable to predict consumer demand accurately. This initiates many issues in managing the orders and maintaining the stocks in the inventory and ultimately ends in affecting the delivery performance. (Agarwal, 2017), (Hsiao et al., 2010)

Demand fluctuations

Purchasing interest increases or decreases because of straight or incidental influences. The factors that lead to demand fluctuation include seasonal variation, availability of supplies, and pricing issues. It is a crucial part of demand complexity and represents the characteristics of the demands of customers (Hsiao et al., 2010)

Forecast error

It is the difference between the actual value of sales and the predicted value of sales at particular time series. Due to poor forecasting, the imbalance between supply and demand ratios arises (Rais et al., 2015). This results in poor delivery performance due to the unavailability of fruits

and/or vegetables and a boost in prices. Demand risks arise due to forecast errors (Chopra et al., 2004).

Cold chain management

It is related to cold storage and cold chain facilities used to transport F&V to different parts of the country while maintaining food quality and nutrition. India needs a better cold chain infrastructure and management which is more affordable, reliable, and developed to maximize the contribution of agri-business to the national economy by improving delivery times and food safety (Rais et al., 2015). Cold chain facilities reduce costs, maintain the quality of the products and ensure timely delivery of the produce (Agarwal, 2017).

Transport infrastructure

It includes railways, roads, ports, & airports, which are used for transporting the F & V supplies from one place to another depending upon the distance to be travelled. The inclusion of appropriate infrastructure reduces costs, maintains product quality and ensures timely delivery of the output or produce (Agarwal, 2017). In India, due to unsafe modes of transportation like rickshaws, vans, and trucks, where no control is there over temperature & humidity, the wastage rate is very high, and transportation time is also high which in turn increases delivery time (IIFT Report).

Transport maintenance

Often, fleet vehicles, trucks, buses, trains, trailers, etc. need repairing, and minor servicing, after a breakdown. The number of hours/days/weeks taken in transport maintenance for either the repair or arranging a backup decides the order deliveries and hence, affects delivery performance.

Information technological support

F&V supply chains in India lack data capturing & processing, order tracking, order tracing, and synchronous freight transport transmit times for compression of time throughout the supply chain and maintaining the supply-demand ratio (Sihariya et al., 2013). The use of IT support gives transparency to the process of the whole supply chain by improving visibility and accountability. For better coordination among the channel partners, the internet and mobile communication should be used to enable a flow of information & financial transfer (Rais et al., 2015).

Inventory management

The inventory system decides the time of delivery by maintaining an optimum stock of fruits & vegetables. Fluctuating inventories, insufficient stocks, etc. can cause a delay in deliveries. Inventory can be found as raw materials, semi-finished commodities, or finished inventory at any point in a supply chain. A firm loses between 25% and 40% of the value of its inventories when they are stored for a predetermined period. Inventory mismanagement can result in lost

sales and dissatisfied customers; as a result, effective stock management is crucial for the operation of the supply chain and aids the company in maintaining a competitive edge (Axsäter, 2006; Li, 1992).

In the case of perishable supply chains such as that of F&V, the major issues faced under inventory management are spoiled products due to over-stocking; expired products due to over-stocking cannot be processed again for human consumption (Rais et al., 2015).

Procurement & storage

Low temperature helps in storing and preserving the F&V by reducing the activities of microorganisms like yeast, bacteria, molds, etc. which are the spoilage agents (Sihariya et al., 2013). The climatic changes often decide the procurement, storage, growth and cropping of certain fruits & vegetables, and lead to low production, reduction in average yields, and crop failures. All of these factors influence the sustainability, production, and import/export scenarios of fruits & vegetables, which lead to delivery issues by affecting delivery performance.

Supplier selection

The supplier selection is based on various criteria, such as performance history, packaging ability, communication system, price, technical capabilities, amount of past business, geographical location of the supplier, financial position, labour relations record, procedural compliance, etc. A supplier is an important unit in the supply chain and their failure can cause major issues, e.g. delivery delays, product quality, lost demand, product reputation, etc. Any wrong decision regarding supplier selection can maximize supply risks. Therefore, it is crucial to reduce supply chain downstream risks. Upstream risks in supply chains for perishable foods are supplier dependability, supply quality, and supplier capability (Norrman and Jansson, 2004; Tummala and Schoenherr, 2011), (Lockamy, 2011).

Supplier's network

The supplier's network plays a vital role to support the delivery, in case of any breakdown in one supplier's unit due to unforeseen circumstances it helps to create a backup. It helps to keep in competitive advantage and thus results in the reduction of cost and process improvement (Lockamy, 2011). The selection of multiple suppliers is a superior approach to reducing operational risks and disruptions.

Location of supplier

The location of the supplier ensures minimum transportation and travel time depending upon the geographical location of the supplier. Local suppliers give more flexibility, and greater control, reduce supply chain costs and help the environment and thus provide a guiding condition for delivery improvement (Lockamy, 2011).

Delivery lead time
It is the time from the receipt of a customer order to the final delivery of the product. It allows a delivery time to the customer, depending upon the shipping status of fruits & vegetable stocks.

Order lead time
It means the minimum amount of time between the dates on which the supplier receives a Purchase Order and the date for the delivery of the fruits & vegetables to the shipping location designated by the retailer or customer, as mentioned in a such Purchase order. The order lead time affects the delivery time.

Order handling time
The amount of time that has passed from the time the customer placed the purchase and the seller delivers the order to the delivery service. The standard handling period might range from 1-2 business days and is deterministic. However, order handling time can range from 1 to 30 working days. It affects delivery performance by delaying the cycle with a higher order handling time.

Production lead time
It is the period of time between placing a retailer or consumer order and having the order filled and finished. Since it guarantees merchants and customers receive products immediately, a shorter production lead time is usually preferred to a lengthy production lead time.

The reason behind choosing Food processing SMEs
The traditional and minimal processing technologies showcase ample opportunities for transformation and vertical diversification in the F&V sector. However, a few SMEs can utilize and make the most of these opportunities. Most SMEs are lacking the capacity to compete and operate in the global market due to poor quality of inputs and/or supplies, poor access to IT support, scale issues, low production efficiency, limited R&D approach, high marketing costs, lack of knowledge, expertise, technology, and last but not the least, incapability to act in accordance with international standards for processed products (Rolle, 2005).

B. Review in Indian Fruits & Vegetable sector

The concept of 'delivery performance improvement' encloses many areas such as demand management, procurement, transportation and logistics, outsourcing, and lead time management. It also includes on-time deliveries and a reduction in overall wastage. An effort has been made to recognise and comprehend the prior work in this direction in this section. A study of publications over the past 20 years which were published in reputable journals like Scopus, Science Direct, Emerald Insight, etc. was conducted to evaluate the current problems

and difficulties. The articles under examination were published between 2000 and 2020 in peer-reviewed publications and were published in the English language.

Table 1 General review of the Indian Food processing industry and F&V sector

AUTHOR(S), YEAR	*METHODOLOGY*	*MAJOR FINDINGS*
Rajesh Kr. Singh et al. (2019) Applications of information and communication technology for sustainable growth of SMEs in Indian food industry	The food supply chain, ICT, resource management, SME development in India, and sustainable growth are just a few of the significant results that are presented.	Issues impacting supply chain management in Indian SMEs
Siya Ram Meena et al. (2019) Strategic analysis of the Indian agri-food supply chain	Explained agri-food supply chain, SWOT analysis, and strategy development; used AHP, Fuzzy AHP techniques	Parameter selection & AHP implementation in Agri-food supply chain in India
Rahul S Mor et al. (2018) A structured literature review of the supply chain practices in food processing industry	Covered structured by literature review, food processing industry, supply chain, logistics & transportation, & coordination	Logistics and transportation issues affecting the Indian food processing industry
Radha Mani et al. (2018) Food processing ingredients: India's food processing sector poised for growth	Given a study on distribution channels, major food processing sectors, marketing, importers, and sales of packaged food	Role of distribution channels in food processing sectors in India
Farm Sector Policy Department NABARD, Mumbai (2018) Sector Paper on Food Processing	Developed a descriptive framework on overall industry status, performed sub-sector analysis, a brief about agencies involved in food processing / Export / R&D, detailed review on food processing industries and technological development and investment opportunities	Status of IT development in food processing industries

Aashish. C. I et al. (2018) A study on the food processing industry and its quality conscious effect	Dealt with a scenario building on industrial youngsters, diet food & income of employees	Significance of food quality and nutrition on the consumers
H. Grillo et al. (2017) Mathematical modelling of the order-promising process for fruit supply chains considering the perishability and subtypes of products	A mathematical model of the fruit order-promising process was proposed, and the concepts of perishability, lack of uniformity in the product, and availability to promise were all investigated.	Perishable supply chain management concept
Shivani Agarwal (2017) Issues in supply chain planning of fruits and vegetables in Agri-food supply chain: A review of certain aspects	Fruits, vegetables, the role of farmers, and farmer cooperatives were discussed along with agri-supply chain management.	Issues identified in the agri-food supply chain such as demand fluctuation, poor infrastructure, cold chain management issues, vertical coordination, post-harvest losses, etc.
Surya Prakash et al. (2017) Risk analysis and mitigation for perishable food supply chain: A case of dairy industry	Risk reduction techniques in the dairy business, a look at supply chain management, the use of interpretative structural modelling, a look at the supply chain for perishable foods, and risk reduction	Risk analysis and management in the perishable food supply chain
Kalidas Kalimuthu (2016) Supply Chain Management of Selected Vegetables in Kerala	A thorough review of consumers, intermediaries, producers, supply chain management, and vegetables	Challenges w.r.t customers, too many stakeholders, growers in the vegetable supply chain
Dr. Madan Lal Singla (2016) Food processing industry in India: an evaluation	The report pinpointed the issues impeding India's food processing industry's expansion. Numerous encouraging aspects that supported the industry's potential for expansion were also a major focus of the study.	Possible advancements can be done in the Indian food processing sector

Saurav Negi et al. (2015) Issues and challenges in the supply chain of fruits & vegetables sector in India: a review	Numerous problems and obstacles that hinder India's fruits and vegetable industry have been highlighted. The supply chain models for the Indian market for fruits and vegetables have been discussed.	Critical findings of the existing obstacles in the Indian fruits & vegetable sector
Rais M et al. (2015) Scope of supply chain management in fruits and vegetables in India	An overview of fruits and vegetables, India as a global market, food wastage, supply chain management, cold storage. The factors affecting Indian fruits and vegetable supply chain management are pursued.	Major parameter finding such as cold chain management issues, post-harvest losses, transportation issues, logistics issues, etc.
Bag. S et al. (2015) Modelling barriers of sustainable supply chain network design using interpretive structural modelling: an insight from food processing sector in India	Proposed an ISM model for sustainable supply chain network design. Discussion on quantitative models, review, barriers, food sector, ISM, and Indian food processing sector.	Barriers in the Indian food processing sector
Saurav Negi et al. (2014) Supply Chain Efficiency: An Insight from Fruits and Vegetables Sector in India	Discussion of agriculture, supply chain effectiveness, logistics, fruits and vegetables, and post-harvest losses	Post-harvest losses, logistics issues, supply chain inefficiency issues
Atanu Chaudhuri et al. (2014) Supply Uncertainty in Food Processing Supply Chain: Sources and Coping Strategies	A review on supply uncertainty in the food processing supply chain; Explained about food Industry; Suggested coping strategies.	Parameter finding on supply uncertainty in the Indian food industry
Bikram K. Bahinipati (2014) The Procurement Perspectives of Fruits and	Review of the food sector, information exchange, supply chain planning, and cooperative methods.	Role of information sharing in the food industry supply chains

Vegetables Supply Chain Planning		
Sihariya, G. et al. (2013) Supply Chain Management of Fruits and Vegetables in India	identify various issues involved in managing the supply chain in fruits and vegetables and identify and analyze different strategies that can be applied to optimize the supply chain in fruits and vegetables. This paper aims to analyze the business models of vegetable retailers in organized retailing To manage the supply chain for fruits and vegetables, the study identifies several problems and examines alternative supply chain optimization techniques. Analysis of vegetable traders' business models in retail chains.	gjhgjgjhg Impact of organized and unorganized retail sectors, fruits & vegetable supply chain management and optimization
Surendra P. Singha et al. (2012) The Food Processing Industry in India: Challenges and Opportunities	A review of the food processing industry in India in terms of constraints and commodities.	Critical issues in the food processing industry in India
Piali Halder and Simayan Pati (2012) A Need for Paradigm Shift to Improve Supply Chain Management of Fruits & Vegetables in India	Thorough research on the impact of price shocks, and exchange rate volatility in fruits and vegetables supply chain management in India.	Impact of perishability on demand fluctuation and market shifts
Surendra P. Singha, Fisseha Tegegneb and Enefiok Ekenemc (2012) The Food Processing Industry in India:	Various challenges and opportunities are discussed in the Indian Food processing industry based on constraints & commodities.	Issues identified in Indian food processing sector

Challenges and Opportunities		
Hsiao. H. I et al. (2009) A classification of logistic outsourcing levels and their impact on service performance: Evidence from food processing industry	Various classifications of logistic outsourcing levels are suggested. The impact of these levels on service performance is explored in food processing industry scenarios.	Outsourcing & logistics issues impact the performance of the food processing industry.
Sriraman Parthasarathy (2008) Indian Food Processing Industry – A Snapshot	A review study on the Indian food processing industry. Discussion on green revolution, Indian food processing sector, bulk investments and modern food processing technologies.	Traditional versus modern food processing technologies, issues in the Indian food processing industry
Ministry of Food Processing Industries Government of India (2005) Vision, Strategy and Action Plan for Food Processing Industries in India	Problems of surplus, rapid growth, status, constraints of food processing, the role of industry and consumer association, food product distribution, food safety & hygiene, action plan for future endeavours	Supplier networks, demand frequency, food quality, food safety, and food nutrition-related issues are identified.

The Indian food processing industry entails activities that are intricate in design and comprise several factors in decision-making to establish the entire network (Bag et al., 2015).

3. Methodology

The research methodology employed is empirical and consists of three phases.

- The first phase consisted of gathering a list of parameters on which delivery performance actually or majorly depends, post-reviewing of research articles, journal papers, review articles, & technical papers related to the F&V sector in India.
- The second phase consisted of creating a complete relationship check among the selected delivery parameters and segmentation of key parameters into sub-parameters based on expert opinion and questionnaire data. Later, the implementation of the Analytic Hierarchy Process (AHP) on chosen nine key parameters was carried out to find out the most critical parameters depending upon the criteria weights of the respective parameters.

- All through the third and final phase, a detailed ISM technique has been implemented to find out the interrelationships between selected sub-parameters (corresponding to the identified critical parameters) and then, an ISM model has been formed. It is later followed by MICMAC analysis to classify the sub-parameters by their driving and dependence power.

The results obtained after AHP implementation were checked and verified through existing literature and expert reviews, and then the top five performance criteria (demand, transportation & logistics, material procurement, outsourcing, & lead-time), based on major delivery issues in F&V supply chain, were chosen and bifurcated into seventeen more detailed sub-criteria or sub-parameters for ISM study. The list of the top AHP parameters categorized into their sub-parameters is shown in Table 2.

Table 2 Top Five AHP identified parameters

AHP Parameters (Top Five)	Sub-parameters for ISM implementation
Demand	Demand volume
	Demand uncertainty
	Demand fluctuations
	Forecast error
Transportation & logistics	Transport infrastructure
	Transport maintenance
	Information technological support
	Inventory management
	Cold chain management
Material Procurement	Procurement & storage
	Supplier selection
Outsourcing	Location of Supplier
	Supplier's Network
Lead time	Order Lead Time
	Order Handling Time
	Production Lead Time
	Delivery Lead Time

The total number of sub-parameters which are considered for the implementation of the ISM technique is seventeen.

3.1 ISM-based model

The investigation was carried out using the ISM technique, widely used to identify and analyse the parameters and their interrelationships in terms of their driving and dependence power values. ISM is a powerful and proven tool to inflict order and a particular direction on the complex relationships among parameters of any system of interest (Sage, 1977) and concludes into a systematic & comprehensive model. The ISM model portrays the structural form of any complex issue of a field of study in a well-organized and well-designed pattern using graphical presentation and words (Mandal & Deshmukh, 1994; Jharkharia & Shankar, 2004)

3.2 Findings of sub-parameters from the literature review

This step consists of finding the different sub-parameters affecting delivery performance in the Indian Food processing sector, especially F&V supply chains in SMEs in North India, based on direct conversation, telephonic conversation, emails, questionnaires, and personal observation. The questions were related to the issues in the F&V sector in India, delivery of the F&V supplies, the role of different selected parameters in the whole delivery cycle, the impact of the chosen delivery parameters on F&V SMEs, and possible mitigation strategies. As a result, 25 sub-parameters were found to be influencing delivery performance substantially. A brainstorming session was arranged to comprise experts from the food industry and academics. The first round resulted in the reduction of sub-parameters to 22. The second round made it 20 and the third round brought it to 17.

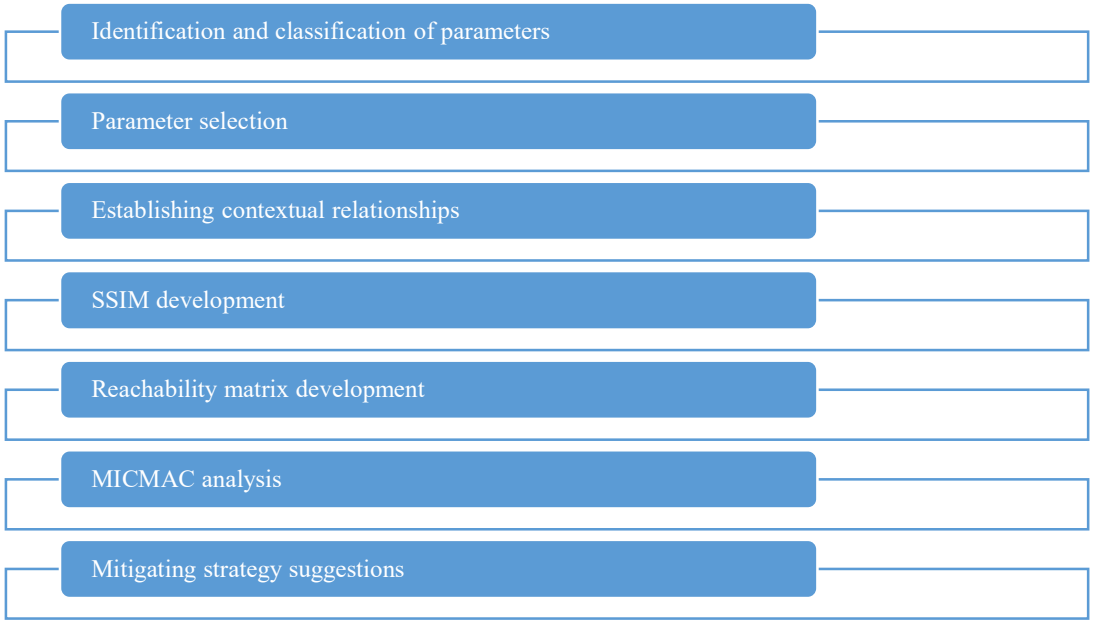

Figure 3 *Steps and stages for implementation of ISM*

3.3 ISM implementation for the Fruits & Vegetables Sector in Indian Food processing SMEs

The steps involved in Interpretive Structural Modelling are as follows:

1. Sub-parameters affecting the Fruits & Vegetable sector in Indian Food Processing SMEs are listed; in this research, factors affecting delivery performance in the F&V sector have been identified from previous research work.
2. From the sub-parameters identified in step 1, the contextual relationship among them is examined.
3. A structural self-interaction matrix (SSIM) is developed for sub-parameters, which indicates a pairwise relationship among sub-parameters of the system.
4. A reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of contextual relationships is a basic assumption made in ISM. It states that if parameter A is related to parameter B and parameter B is related to parameter C, then parameter A necessarily is related to parameter C.
5. The reachability matrix obtained in step 4 is partitioned into different levels.
6. Based on the contextual relationships in the reachability matrix, a digraph is drawn, and the transitivity links are removed.
7. The resultant digraph is converted into an Interpretive Structural Model by replacing subparameter nodes with statements.
8. The ISM model developed in step 7 is reviewed to check for conceptual inconsistency and any necessary modifications are made.

4. ISM implementation: Data analysis and findings

The ISM technique focuses on the opinions given by experts (based on different management techniques, brainstorming, nominal technique, etc.) that help in developing the contextual relationship among the sub-parameters. This step involves the examination of contextual relationships between sub-parameters w.r.t the pairs of sub-parameters. A questionnaire was developed to investigate the relations between 17 sub-parameters. The questionnaire was sent to people working as supervisors, store managers, managers, retailers, etc. in the food processing industry. The questionnaire was tested for the validity of content and reliability. The questionnaire format had three sections; the first one was about the characterization of a firm; the second section was about the academic profile of the expert; the third section was related to delivery improvement parameters in the form of a tabular sheet to be filled by experts using different suggested symbols of interpretation. Later, the data was taken again based on the relative impact on a five-point Likert scale and the other response taken was of the parameter influenced by which other parameter. The internal consistency was checked using Cronbach's alpha.

4.1 Developing the structural self-interaction matrix

The structural self-interaction matrix (SSIM) was developed as per the interpretations mentioned below. The symbols used are V, A, X, & O to denote the direction of relationships between sub-parameters (i & j).
V: i lead to j but j does not lead to i
A: i do not lead to j but j leads to i

X: i lead to j and j leads to i
O: i and j are unrelated to each other.

Table 3 Structural self-interaction matrix for sub-parameters for the F&V sector in Indian Food Processing SMEs

S.N.	*Sub-parameters*	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
1	Supplier's network	V	O	O	O	V	O	V	O	O	V	V	V	V	V	V	O	X
2	Transport maintenance	V	O	O	O	V	O	O	O	O	V	O	V	V	V	V	X	
3	Demand fluctuations	V	O	O	O	O	V	O	O	O	V	O	O	O	X	X		
4	Supplier selection	O	V	O	O	O	V	V	O	V	V	V	V	V	X			
5	Delivery lead time	V	O	V	O	V	O	O	O	A	X	X	O	X				
6	Procurement & storage	V	O	V	O	V	A	O	O	O	V	O	X					
7	Inventory management	O	O	V	V	V	O	V	V	V	X	X						
8	Location of supplier	A	A	V	X	V	A	O	O	O	X							
9	Transport infrastructure	V	A	A	X	O	V	V	V	X								
10	Demand volume	O	A	A	O	O	O	A	X									
11	Demand uncertainty	V	O	A	A	A	A	X										
12	Order lead time	V	O	O	O	V	X											
13	Forecast error	O	X	X	X	X												
14	IT Support	X	A	X	X													
15	Production lead time	V	O	X														
16	Order handling time	V	X															
17	Cold chain management	X																

4.2 Develop a reachability matrix

The conversion of SSIM into a binary matrix is done as per the rules mentioned in Table 4, which results in the final reachability matrix (Table 5) by replacing V, A, X, and O with 1 & 0, and using the transitivity rule which says that if "A" is related to "B" and "B" is related to "C", then it concludes that "A" is related to "C" (Warfield, 1974; Watson, 1978; Sushil, 2012).

Table 4 Rules for Transformation

If the (i,j) entry in the SSIM is	*Entry in the Initial reachability matrix*	
	(i,j)	(j,i)
V	1	0
A	0	1
X	1	1
O	0	0

Table 5 Final reachability matrix for Sub parameters for the F&V sector in Indian Food Processing SMEs

S.N.	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*	*Driving power*
1	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*1*	*16*
2	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*16*
3	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*15*
4	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*15*
5	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
6	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
7	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
8	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
9	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
10	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
11	*1*	*0*	*0*	*1*	*0*	*0*	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*5*
12	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
13	*1*	*1*	*1*	*1*	*1*	*0*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*9*
14	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
15	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
16	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*
17	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*13*

Dependence power	***16***	***15***	***15***	***16***	***15***	***14***	***16***	***17***	***15***	***16***	***14***	***14***	***14***	***4***	***4***	***1***	***1***

4.3 Level partitioning

The final reachability matrix obtained in Table 5 is further partitioned into different levels. Post first iteration (), the subparameter (s) classified to level 1 is/are discarded and the partitioning process is repeated on the remaining subparameters to determine level 2. These iterations are continued until the level of each subparameter has been determined. The results for iterations 1 to 6 are summarized in Table 6.

Table 6 Levels of delivery performance sub-parameters after level partitioning

Sub parameter	*Reachability*	*Antecedent*	*Intersection*	*Level*
1	1	1	1	**6**
2	2	2	2	**6**
3	3,4	1,2,3,4	3,4	**5**
4	3,4	1,2,3,4	3,4	**5**
5	5,6,7,12	1,2,3,4,5,6,7,8,9,12,14,15,16,17	5,6,7,12	**4**
6	5,6,7,12	1,2,3,4,5,6,7,8,9,12,14,15,16,17	5,6,7,12	**4**
7	5,6,7,12	1,2,3,4,5,6,7,8,9,12,14,15,16,17	5,6,7,12	**4**
8	5,6,7,8,9,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17	5,6,7,8,9,11,12,13,14,15,16,17	**2**
9	5,6,7,9,12,13,15,16	1,2,3,4,5,6,7,8,9,12,13,14,15,16,17	5,6,7,9,12,13,15,16	**3**
11	8,11,14,17	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17	8,11,14,17	**2**
12	5,6,7,12	1,2,3,4,5,6,7,8,9,12,14,15,16,17	5,6,7,12	**4**
13	9,13,15,16	1,2,3,4,5,6,7,8,9,12,13,14,15,16,17	9,13,15,16	**3**

14	5,6,7,8,9,11,12,13,14,15,16,17	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17	5,6,7,8,9,11,12,13,14,15,16,17	**2**
15	5,6,7,9,12,13,15,16	1,2,3,4,5,6,7,8,9,12,13,14,15,16,17	5,6,7,9,12,13,15,16	**3**
16	5,6,7,9,12,13,15,16	1,2,3,4,5,6,7,8,9,12,13,14,15,16,17	5,6,7,9,12,13,15,16	**3**
17	5,6,7,8,9,11,12,13,14,15,16,17	15,16,17	5,6,7,8,9,11,12,13,14,15,16,17	**2**

Table 7 Table shows the driving power and dependence power of sub-parameters for the F&V sector in Indian Food Processing SMEs

S.N.	*Sub parameter*	*Dependence Power (X)*	*Driving power (Y)*
1	Supplier's network	1	16
2	Transport maintenance	1	16
3	Demand fluctuations	4	15
4	Supplier selection	4	15
5	Delivery lead time	14	13
6	Procurement & storage	14	13
7	Inventory management	14	13
8	Location of supplier	16	13
9	Transport infrastructure	15	13
10	Demand volume	17	1
11	Demand uncertainty	16	5
12	Order lead time	14	13
13	Forecast error	15	9
14	IT Support	16	13
15	Production lead time	15	13
16	Order handling time	15	13
17	Cold chain management	16	13

4.4 Formation of ISM-based Model

After having the final reachability matrix and level partitions, the structural model is formed employing lines and arrows. The analysis yields a hierarchy called ISM hierarchy in which demand volume is at level 1 (the top level or most critical level); cold chain management, IT support, demand uncertainty, and location of the supplier are at level 2; transport infrastructure,

forecast error, production lead time, order handling time are at level 3; delivery lead time, procurement & storage, inventory management, order lead time are at level 4, demand fluctuations & supplier selection are at level 5; supplier's network & transport maintenance are at level 6 (lowest level).

The resulting ISM model is shown in Figure 4.

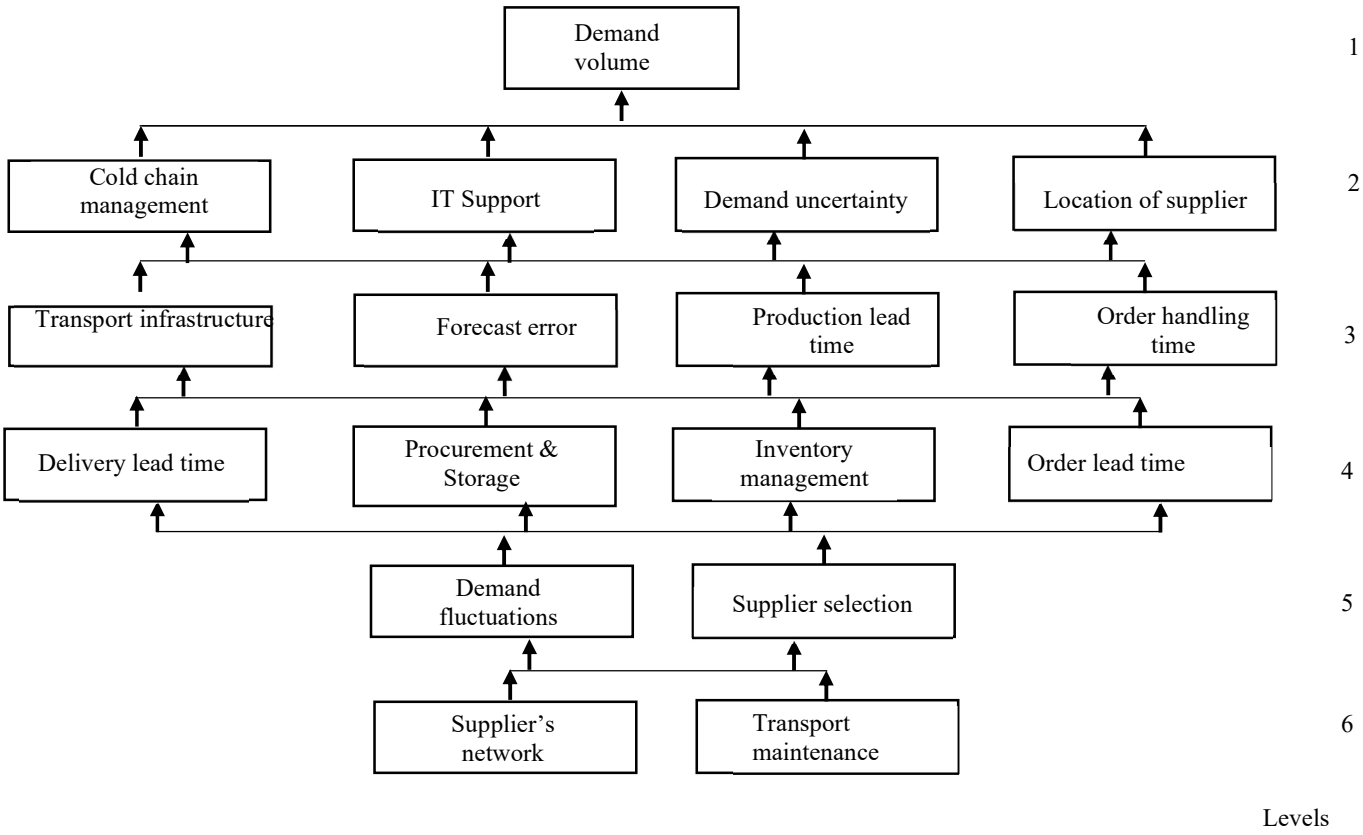

Figure 4 *Hierarchy of Parameters in delivery improvement in the F&V Sector of Indian Food Processing SMEs*

4.5 MICMAC Analysis

The MICMAC analysis, which relies on the multiplication characteristics of matrices, is a helpful procedure for figuring out the driving and dependency powers of all the selected parameters. The driving and dependent powers of all the chosen factors are shown in Table 7. Fig. 5 shows the chart of driving power and dependent power created after classification. The graph demonstrates that Category 1 poses no threat (Autonomous variables). Demand volume and demand uncertainty are elements of Category 2 (dependency variables), which are known as dependence elements because of their substantial reliance and limited driving powers. In Category 3 (Linkage variables) the variables have a strong driving power as well as strong

dependence power, here, we have delivery lead time, procurement & storage, inventory management, order lead time, transport infrastructure, production lead time, order handling time, location of the supplier, IT support, and cold chain management. Similarly, in Category 4 (which shows independent driving variables) the variables have a strong driving power but weak dependence power, here, the supplier's network, transport maintenance, demand fluctuations, and supplier selection are there.

The relationship between sub parameters is not always equal, some relations may be strong, esp. better & strong. To overcome this problem of ISM, MICMAC analysis is used.

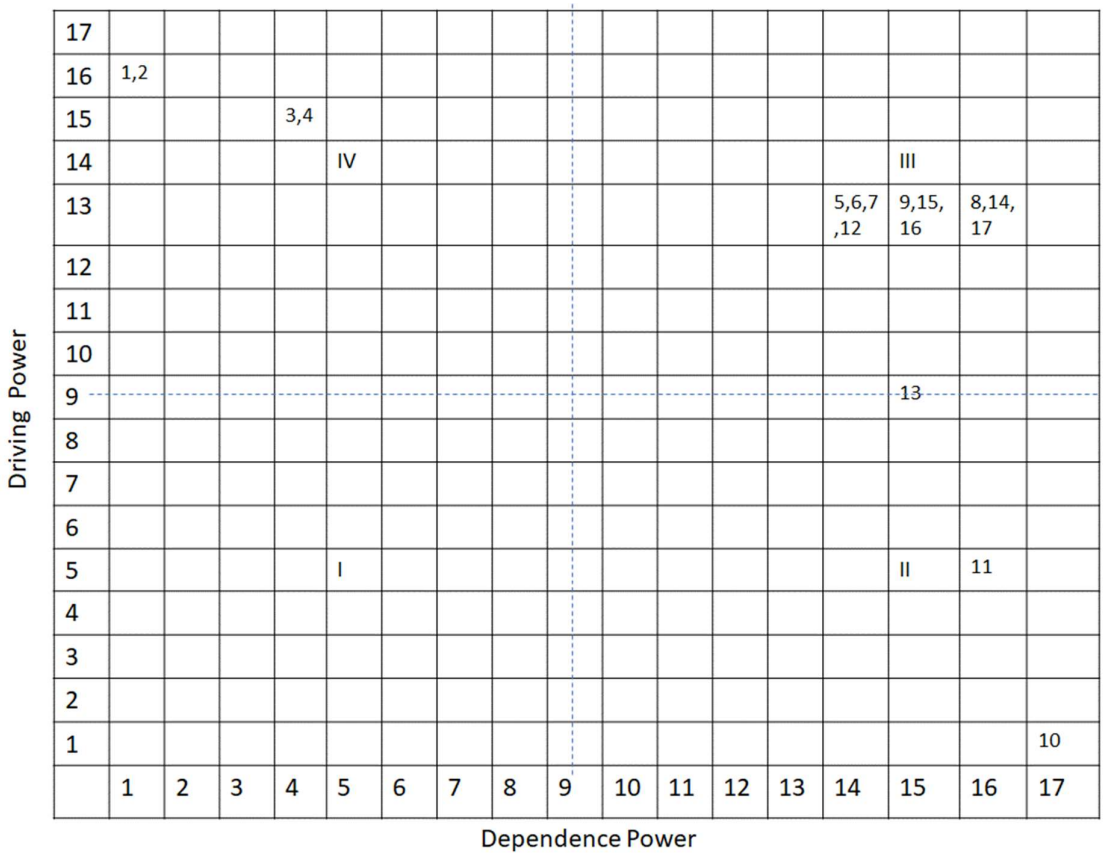

Fig. 5: The driving power and driven power chart of Parameters in delivery improvement in the F&V Sector of Indian Food Processing SMEs

5. DISCUSSION

The vision behind having an F&V supply chain with high delivery performance has been quite clear in recent years; however, there is a shortage of research studies, case studies, and review reports of SMEs turning this vision into reality, in India. It is important to transform the key delivery parameters into strategy models based on quality, time, speed, profitability,

productivity, efficiency & robustness. These parameters should be deployed or checked or managed by the managers or practitioners to prove the significance of these parameters in a supply chain of F&V.

The ISM model (Figure 4) helps to establish a hierarchy of parameters and gives a strategy for successful delivery improvement that increases an F&V supply chain's efficiency. The driver dependence diagram aids in classifying various F&V supply chain factors.

The sub-parameters marked at levels 1 & 2 are considered mainly as they have strong driving power and strong dependence power. The MICMAC analysis performed here proved a useful analysis by evaluating driving power & dependence power for the determination of affecting sub-parameters and their levels. The high-level ranking indicates that their impact will be less in overall decision-making. Based on MICMAC analysis and sub-parameters hierarchy in the Indian F&V supply chain, it can be concluded that sub-parameters at levels 1 & 2 which include demand volume, IT support, demand uncertainty, & location of the supplier most relevant in the context of fruits and vegetables supply chain. Ultimately, an ISM model has been delivered for delivery performance improvement of the supply chain in the Indian F&V sector.

For modelling of the delivery performance sub-parameters to improve on-time delivery in the F&V sector in India, the priority order post ISM implementation is as follows:

1. Demand volume
2. (a) Cold chain management
   (b) IT support
   (c) Demand uncertainty
   (d) Location of supplier
3. (a) Transport infrastructure
   (b) Forecast error
   (c) Production lead-time
   (d) Order handling time
4. (a) Delivery lead-time
   (b) Procurement & storage
   (c) Inventory management
   (d) Order lead-time
5. (a) Demand fluctuations
   (b) Supplier selection
6. (a) Supplier’s network
   (b) Transport maintenance

Parameters at level 1 (Demand volume) and level 2 (Cold chain management, IT support, demand uncertainty & location of supplier) are dependent parameters influenced by parameters

lying at lower levels and are expected to directly impact delivery performance. Cold chain management inadequacy or inefficiency may hamper the delivery timings/dates/performance. The increase in the number of cold chain facilities for multiple commodities near major production belts of F&V production will resolve the issue to a great extent. IT support has an important role in order tracking, tracing, managing and generating invoices, paybacks, replenishment of stocks, lead time management, due date calculation, maintaining store data, vendor data, supplier data, etc. Installation of IT support and holding awareness sessions, seminars or workshops for spreading knowledge about marketing & modern technologies are important practices. Demand uncertainty is caused when the F&V production system is not in a position to predict the demand of internal or external customers or stakeholders which leads to high variance in the demand & supply ratio. The location of the supplier plays an important role in managing delivery delays; the delivery time is directly proportional to the distance of the supplier from the F&V production belt or a food processing unit.

Parameters at levels 3 & 4 are linkage parameters. Level 3 of the ISM model has four sub-parameters. Firstly, the development of appropriate infrastructure reduces cost and maintains the quality of fresh F&V and ensures timely delivery of the stocks (Agarwal, 2017). Forecast error acts as a measure of forecast accuracy, accurate forecasting helps in strengthened financial planning by having accurate sales record or demand data forecasting, volume-wise, product wise and/or service type-wise. Production lead time holds a critical position in delivery performance parameters, a shorter production lead time is better than a longer one to serve the customers quickly and it ensures a growing customer base. Lastly, order handling time is also a strong criterion for delivery improvement. Usually, the order handling time should be kept as low as possible to improve the delivery service.

On level 4, we have delivery lead time, procurement & storage, inventory management, and order lead time. All of these sub-parameters are very important parameters in the improvement of delivery performance in F&V supply chains in India as they have a major role in delivery stage performance, operation, & execution. To keep the price stable and the quality consistent, an efficient inventory management strategy must include segmenting fresh fruit and vegetables (F&V), consumers, the supply chain, and distribution channels (Agarwal, 2017). The delivery lead time is the time from the receipt of a client request to the conveyance of the item and the lead time is the amount of the stock deferral, which is the way long the shipment takes to arrive at your stock, in addition to the reordering delay. Procurement & storage deals with the type of procurement (via direct sourcing route, marketplace, contract farming, etc.) and the type of storage (at room temperature, dry & cool storage, refrigeration, etc. Furthermore, order lead time is the least measure of time (laid out in the material assertion of work) between the date on which a buy request is gotten by a provider and the date for the conveyance of the item/supply to the transportation area assigned by client, as gone ahead in such buy request or purchase order.

Parameters at levels 5 & 6 are independent parameters. The farmer or consumer has no control over the supplier's network and supplier selection in India, and they are treated as external factors. Therefore, the farmer should take decisions about a mutually valuable partnership with suppliers. Supplier selection is based on various criteria such as price, reliability, value for money, responsiveness, quality, and flexibility. A small but trustworthy supplier base serves the purpose. Transport maintenance can be taken care of on a weekly/monthly basis as it is an internal factor and can be controlled. Demand fluctuations describe customers' demand characteristics (Hsiao et al., 2010), & can only be anticipated as a response to uncontrolled seasonal events.

The interesting result of MICMAC analysis is that there are no autonomous delivery performance parameters identified in this work. The linkage parameters will be sensitive to changes in independent parameters. The independent & linkage parameters impact other parameters in the system & are therefore expected to have a more significant effect on the entire supply chain. The dependent parameters will be influenced by changes in the independent & linkage parameters & will directly impact the delivery performance.

5. CONCLUSION

It is anticipated that the resurgence of the horticulture industry would create several opportunities for players with strong connections to the farming value chain. The sector that handles food is anticipated to benefit the most from this relationship. The study provides insight into some serious issues involved in the Indian F&V supply chain in north Indian SMEs. The work has identified relevant sub-parameters influencing delivery performance for a perishable supply chain as that of the one followed by the F&V sector. An ISM model is used to reveal interdependencies of delivery performance sub-parameters; the model shows six different levels of influence. Dependent parameters at the top level directly impact delivery performance & are sensitive to changes in linkage & independent parameters lying at lower levels in the model hierarchy. Any changes in the independent parameters can propagate influence on the parameters lying at higher levels in the hierarchy & should therefore be managed most carefully when attempting to improve the supply chain efficiency. The limitations of this study are the experts' subjectivity in decision-making; empirical testing of the proposed research methodology through different industries is still not explored fully, which can be achieved via surveys, research work, etc.

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