



# INDIAN FOOD & BEVERAGES SECTORIAL SYSTEM OF INNOVATION (IFBSSI)

United Nations Industrial Development Organization (UNIDO) &  
Department of Science & Technology, Government of India

March 2023



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# INDIAN FOOD & BEVERAGES SECTORIAL SYSTEM OF INNOVATION (IFBSSI) - MEASUREMENT, ANALYSIS AND POLICY RECOMMENDATIONS

UNIDO-DST Survey Report

March 2023 Vienna, Austria



विज्ञान एवं प्रौद्योगिकी विभाग  
DEPARTMENT OF  
SCIENCE & TECHNOLOGY



UNITED NATIONS  
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## MESSAGE

I am pleased to extend my warmest congratulations to the Department of Science and Technology (DST) and the United Nations Industrial Development Organization (UNIDO) on the successful completion of the National Manufacturing Innovation Survey (NMIS) 2021-22. The results of the survey provide significant insight into the state of innovation in India's manufacturing sector. The Government of India has been steadfast in its commitment in promoting the competitiveness of Indian manufacturing and increasing its contribution to the GDP. In the past decade, key policies and programmes have been implemented to stimulate innovation, entrepreneurship and the adoption of new technologies. Additionally, large-scale incentive schemes have been introduced to foster growth and innovation in the manufacturing sector, positioning India as a global manufacturing hub.

The findings of the NMIS 2021-22 can add significant value to the Make in India programme objective, and, the more recent Production Linked Incentive (PLI) scheme. These initiatives aim to enhance manufacturing in various sectors, including electronics, pharmaceuticals, and automobiles, and have already demonstrated positive outcomes. The study's recommendations will undoubtedly strengthen our efforts to address the challenges and opportunities in manufacturing that require immediate attention.

I would once again like to applaud DST and UNIDO for their fruitful collaboration in bringing out NMIS reports and offering recommendations for continued growth and success of the Indian manufacturing sector.

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## FOREWORD

I am pleased to present the National Manufacturing Innovation Survey (NMIS) 2021-22 report on behalf of the Department of Science and Technology (DST), Government of India. The significance of this study lies in the government's prioritization of the manufacturing sector as a critical driver of economic growth and job creation in India, and the launch of several initiatives to catalyse innovation across the industry.

NMIS 2021-22, a follow up of first Indian innovation survey in 2011, is a focused effort to evaluate the state of innovation in India's manufacturing sector. In collaboration with the United Nations Industrial Development Organization (UNIDO), this survey provides a comprehensive understanding of the Indian manufacturing innovation landscape.

The NMIS 2021-22 findings offer valuable insights into the enabling characteristics and barriers to innovation faced by firms, and closely evaluated the performance of states and sectors in terms of producing new products and services. The detailed analysis of the survey results provides valuable insights into the innovation ecosystem in India. I anticipate this report to be of great interest to policymakers, researchers, and practitioners in the field of innovation and economic development.

Furthermore, the findings and recommendations of NMIS offer strong insights for strengthening the scope of the 5th National Science, Technology and Innovation Policy (STIP) (draft), to enable a holistic ecosystem for science, technology, and innovation that includes academia, industry, government, and civil society, with a stronger vision for manufacturing innovation to bolster the Make in India agenda.

I am confident that these reports will serve as an essential resource for all those interested in the state of innovation in India, providing valuable information that can contribute to the development of policies and initiatives that can foster a more innovative and dynamic manufacturing sector in the country.

(S. Chandrasekhar)



## Preface by Mr. Ciyong Zou, UNIDO Deputy to the Director General and Managing Director for publication of “the National Manufacturing Innovation Survey 2021-2022”



It is with great pleasure that I introduce the National Manufacturing Innovation Survey (NMIS) 2021-2022 report. Jointly conducted by the Department of Science and Technology (DST) of the Ministry of Science and Technology of India and the United Nations Industrial Development Organization (UNIDO), this report aims at comprehensively assessing the state of manufacturing innovation in India towards the achievement of the 2030 Agenda for Sustainable Development, especially Goal 9, and beyond.

As the only specialized agency of the United Nations mandated to promoting inclusive and sustainable industrial development, UNIDO recognizes the critical role that innovation plays in driving economic growth and job creation in the manufacturing sector. We are proud to partner with the DST in this endeavour to assess the state of innovation in India's manufacturing sector.

The NMIS 2021-2022 is a comprehensive study that provides a detailed understanding of the innovation landscape in India's manufacturing sector through a firm-level and systems analysis of innovation. The firm-level component of the survey examines the performance of firms across states, sectors, and firm sizes in terms of innovation processes, outputs, and barriers, and evaluates the innovation ecosystem that affects the innovation outcomes. The sectorial systems of innovation component provide insights into the collaborative processes between innovation stakeholders in specific industrial sectors, such as automotive, pharmaceutical, textiles, food and beverages, and information and communication technologies (ICT).

The findings of the NMIS 2021-2022 serve as a valuable resource to policymakers, researchers, and practitioners in the field of manufacturing, innovation, and economic development. The report highlights the enabling factors and barriers to innovation in the manufacturing sector and provides valuable insights for strengthening the ecosystem for science, technology, and innovation in India. The recommendations contained in this report will not only contribute to the development of national policies and initiatives but can also guide other countries in the region on ways to foster a more innovative and dynamic manufacturing sector.

I would like to express my sincere appreciation to the DST and the technical advisory committee for their valuable contributions to the NMIS 2021-2022. I also extend my gratitude to all the survey respondents who provided their insights and valuable information for this study serving as a public good. UNIDO is eager to continuing the long-standing collaboration with the Government of India in promoting inclusive and sustainable industrial development.

A handwritten signature in blue ink, appearing to read "Zou Ciyong", is located in the bottom right area of the page.

**Ciyong Zou**

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सत्यमेव जयते

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Dr. Akhilesh Gupta



## PREFACE

The National Manufacturing Innovation Survey (NMIS) 2021-22 is a significant step towards assessing manufacturing innovation in India. The objective of the survey was to evaluate the performance of states, sectors, and firm sizes in terms of innovation processes, outcomes, and barriers, as well as the innovation ecosystem that affects innovation outcomes. The NMIS 2021-22 offers a comprehensive understanding of manufacturing innovation in India from all perspectives.

The Department of Science and Technology (DST), in collaboration with the United Nations Industrial Development Organization (UNIDO), has developed the first Indian Manufacturing Innovation Index (IMII) for guiding decision-making in innovation policy with respect to manufacturing and related services. The significant difference in the IMII score captures the variations in manufacturing across the states.

The “Assessment of Firm-Level Innovation in Indian Manufacturing” report provides a comprehensive and in-depth analysis of innovation activities, outcomes, and barriers in manufacturing firms. Additionally, the NMIS 2021-22 survey produced five reports studying the sectorial systems of innovation within manufacturing sectors, namely, Automotive, Pharmaceutical, Textiles, Food & Beverages, and Information & Communication Technologies (ICT). These reports examine the collaborative processes between innovation stakeholders and the innovation systems available to specific industrial sectors.

The key findings from the study demonstrate that innovation is highly beneficial to manufacturing firms. Over a quarter of manufacturing firms in the country are innovative, and about eighty percent of these firms have used innovations successfully to increase turnover, open new market opportunities, and respond to market and cost pressures. However, the study also reveals that firms face a wide array of barriers to innovation, and innovation activities require perseverance and long-term commitment. Manufacturing firms demonstrate high risk-aversion and lack of entrepreneurial appetite to engage with innovation. Instead of competing for new products that are necessary to compete in the future, firms are still addressing the predominant and immediate demands in the market. These findings call for concerted efforts in strengthening manufacturing policies and bring attention to the need for an innovation strategy for the country, with particular attention to manufacturing.

I would like to express my sincere appreciation to all those who contributed to the creation of this report, including the UNIDO team and the technical advisory committee from DST. We sincerely hope that this report will be of great value as valuable resource and reference note.

(Akhilesh Gupta)



# Contents

List of Tables	10
List of Figures	10
List of Boxes	11
Acronyms	11
Conversion factor	16
Acknowledgements	17
Preface	18
Executive Summary	20
 <b>1. PROJECT CONTEXT</b>	 <b>22</b>
1.1 The National Manufacturing Innovation Survey 2021-22	23
1.2 Significance of the Sectoral Systems of Innovation Survey	24
1.3 Relevance of the 5 Manufacturing Sectors prioritised by the SSI Survey	25
1.4 SSI Survey to Strengthen Manufacturing Innovation as a GoI Policy Imperative	26
 <b>2. THEORETICAL FRAMEWORK</b>	 <b>27</b>
2.1 Underpinning Theoretical Framework	28
2.2 Sectorial System of Innovation (SSI) Approach	30
2.3 System failure	31
2.4 The Triple Helix (TH) Model	32
2.5 Towards an Analytical Framework	34
 <b>3. SURVEY METHODOLOGY</b>	 <b>38</b>
3.1 Sample Selection	39
3.2 Data Collection	40
3.3 The Data Acquisition Survey Instrument (DASI)	41
3.4 Survey Operationalisation	41
3.5 Secondary Data Collection	42
3.6 Stakeholder consultation	42
 <b>4. MANUFACTURING LANDSCAPE IN THE FOOD &amp; BEVERAGES SECTOR</b>	 <b>43</b>
4.1 Indian Food & Beverages Sector: Structure and Dynamics	44
4.2 Exports of Primary Processed Food grains and Cereals	44
4.3 Challenges and Barriers in the Indian Food Processing Industry	47



<b>4.4 The Technology-Shift in the Indian Food and Beverage Manufacturing Industry</b>	<b>48</b>
<b>5. POLICY LANDSCAPE</b>	<b>52</b>
5.1 Core Policies of the Food sector	53
5.2 Industry 4.0 Initiatives	59
5.3 Initiatives for the Future Workforce	61
<b>6. RESULTS AND ANALYSIS</b>	<b>63</b>
6.1 Descriptives	64
6.2 Linkages	67
6.2.1 Industry	68
6.2.2 Knowledge-Based Institutions	72
6.2.3 Government	74
6.2.4 Intermediary	77
6.2.5 Arbitrageurs and financial institutions	78
6.3 Barriers to Innovations	81
6.4 Success of Policy Instruments	86
6.4.1 Industry	88
6.4.2 Knowledge-Based Institutions	90
6.4.3 Intermediary	91
6.4.4 Arbitrageurs	91
6.4.5 Government	92
6.4.6 All Actors	93
<b>7. RECOMMENDATIONS</b>	<b>94</b>
<b>8. REFERENCES</b>	<b>100</b>
<b>9. ANNEXES</b>	<b>113</b>
9.1 Annex 1 – Sample size calculation	114
9.2 Annex 2 – NIC code classification	114

## List of Tables

<b>Table 1</b>	Overview of Firm-Level Survey and SSI Survey	23
<b>Table 2</b>	Examples of core actor, arbitrageur, and intermediary organizations by function	35
<b>Table 3</b>	Indian Food & Beverages SSI - Convenient sample, data collected and response rates	64
<b>Table 4</b>	Internal consistency of factor	81
<b>Table 5</b>	Kaiser-Meyer-Olkin (KMO)	82
<b>Table 6</b>	System-wide barriers to innovation	86
<b>Table 7</b>	Policy recommendations	96

## List of Figures

<b>Figure 1</b>	Triple Helix types	20
<b>Figure 2</b>	Triple Helix Model extension	32
<b>Figure 3</b>	Operational Methodology	41
<b>Figure 4</b>	State-wise distribution of mega food parks by implementation status	46
<b>Figure 5</b>	Project components of the Mega Food Park Model	47
<b>Figure 6</b>	Barriers in the Indian food processing industry	48
<b>Figure 7</b>	Actor distribution of respondents	64
<b>Figure 8</b>	Ownership structure of firms	64
<b>Figure 9</b>	Size classification	65
<b>Figure 10</b>	Industry - Affiliation	65
<b>Figure 11</b>	KBI - Affiliation	65
<b>Figure 12</b>	Intermediary - Affiliation	66
<b>Figure 13</b>	Arbitrageur - Affiliation	66
<b>Figure 14</b>	Government - Affiliation	66
<b>Figure 15</b>	Types of manufacturing	67
<b>Figure 16</b>	Ecosystem relationships	68
<b>Figure 17</b>	Main processing steps	69
<b>Figure 18</b>	Industry relationships	71
<b>Figure 19</b>	Knowledge-based institution relationships	73
<b>Figure 20</b>	Institutional architecture for PM-FME Scheme	75
<b>Figure 21</b>	Government relationships	76
<b>Figure 22</b>	Intermediary relationships	78
<b>Figure 23</b>	Arbitrageur and financial institution relationships	80
<b>Figure 24</b>	Policy taxonomy	88
<b>Figure 25</b>	Success of Policy Instruments - Industry	88
<b>Figure 26</b>	Success of Policy Instruments - Knowledge-based Institutions	90
<b>Figure 27</b>	Success of Policy Instruments - Intermediary	91
<b>Figure 28</b>	Success of Policy Instruments - Arbitrageur	91
<b>Figure 29</b>	Success of Policy Instruments - Government	92
<b>Figure 30</b>	Success of Policy Instruments - All Actors	93

## List of Box

<b>Box 1</b>	Amul - The white revolution in Gujarat.
<b>Box 2</b>	Licious - Use of AI/ML in supply and cold chain for D2C delivery of seafood and meat.

## Acronyms

<b>4IR</b>	Fourth Industrial Revolution
<b>ADP</b>	Advanced Digital Production
<b>AFSTI</b>	Association of Food Scientist & Technologist of India
<b>AI</b>	Association of Food Scientist & Technologist of India
<b>AIF</b>	Alternative Investment Fund
<b>AIFPA</b>	All India Food Processors' Association
<b>APC</b>	Agro-Processing Cluster
<b>APEDA</b>	Agricultural Processed Food Products Export Development Authority
<b>AR</b>	Augmented Reality
<b>ARB</b>	Arbitrageur
<b>ASI</b>	Annual Survey of Industries
<b>B2B</b>	Business-to-Business
<b>BI</b>	Business Intelligence
<b>BIRAC</b>	Biotechnology Industry Research Assistance Council
<b>BIS</b>	Bureau of Indian Standards
<b>BTS</b>	Bartlett's Test of Sphericity
<b>BRC</b>	British Retail Consortium
<b>CAGR</b>	Compound annual growth rate
<b>CALS</b>	College of Agriculture and Life Sciences
<b>CAP</b>	Creator Accelerator Program
<b>CASMB</b>	Chamber for Advancement of Small and Medium Businesses
<b>CEFPPC</b>	Creation/Expansion of Food Processing & Preservation Capacities
<b>CEO</b>	Chief Executive Officer
<b>CFTRI</b>	Central Food Technological Research Institute
<b>CII</b>	Confederation of Indian Industry
<b>CIIE</b>	Centre for Innovation, Incubation and Entrepreneurship
<b>CISTA</b>	Confederation of Indian Small Tea Growers' Association
<b>CMIE</b>	Centre for Monitoring Indian Economy
<b>CMP</b>	Clean Milk Production
<b>CoE</b>	Centre of Excellence
<b>COFIT</b>	Consortium of Food Industry & Trade
<b>COVID-19</b>	Coronavirus Disease 2019
<b>CPI</b>	Consumer Price Index
<b>CSIR</b>	Council of Scientific and Industrial Research
<b>DAHD</b>	Department of Animal Husbandry and Dairying
<b>DASI</b>	Data Acquisition Survey Instrument

<b>DASI-V4</b>	Data Acquisition Survey Instrument Version 4
<b>DBT</b>	Department of Biotechnology
<b>DFP</b>	Designated Food Parks
<b>DGFT</b>	Directorate General of Foreign Trade
<b>DISK</b>	Data Information Statistics and Knowledge
<b>DLC</b>	District Level Committee
<b>DSIR</b>	Department of Scientific and Industrial Research
<b>DST</b>	Department of Science and Technology
<b>DUI</b>	Doing, Using, and Interacting
<b>DCAAI</b>	Development Council for Automobiles and Allied Industries
<b>DESE</b>	Department of Energy Science and Engineering
<b>DHI</b>	Department of Heavy Industries
<b>DISK</b>	Data Information Statistics and Knowledge
<b>DME</b>	Dimethyl Ether
<b>DoTE</b>	Directorate of Technical Education
<b>DPIIT</b>	Department for Promotion of Industry and Internal Trade
<b>DSEU</b>	Delhi Skill and Entrepreneurship University
<b>DSIR</b>	Department of Scientific and Industrial Research
<b>DST</b>	Department of Science and Technology
<b>DTSI</b>	Digital Twin Spark Ignition
<b>DUI</b>	Doing, Using and Interacting
<b>EIA-PTH</b>	Export Inspection Agency - Pilot Test House
<b>EIC</b>	Export Inspection Council
<b>EMPEA</b>	Emerging Market Private Equity Association
<b>ERP</b>	Enterprise Resource Planning
<b>ESG</b>	Environmental, Social and Governance
<b>ETP</b>	Effluent Treatment Plant
<b>EXIM</b>	Export-Import Bank of India
<b>FACE</b>	Food and Agriculture Centre of Excellence
<b>FAPCCI</b>	Federation of Andhra Pradesh Chambers of Commerce and Industry
<b>FBO</b>	Food Business Operators
<b>FC</b>	Finance Commission
<b>FCI</b>	Food Corporation of India
<b>FDI</b>	Foreign Direct Investment
<b>FI</b>	Financial Institution
<b>FICCI</b>	Federation of Indian Chambers of Commerce & Industry
<b>FICSI</b>	Food Industry Capacity & Skill Initiative
<b>FIFA</b>	Fisheries and Aquaculture Infrastructure Development Fund
<b>FITT</b>	Foundation for Innovation and Technology Transfer
<b>FOSTAC</b>	Food Safety Training and Certification
<b>FPO</b>	Farmer Producer Organizations
<b>FSMS</b>	Food Safety Management System
<b>FSSAI</b>	Food Safety and Standards Authority of India
<b>FSSC</b>	Food Safety System Certification Scheme
<b>FTL</b>	Food Testing Laboratory

<b>GDP</b>	Gross Domestic Product
<b>GEM</b>	Government e Marketplace
<b>GFSP</b>	Global Food Safety Partnership
<b>GHP</b>	Good Hygienic Practices
<b>GIS</b>	Geographic Information System
<b>GMP</b>	Good Manufacturing Practice
<b>GoI</b>	Government of India
<b>GOV</b>	Government
<b>GPS</b>	Global Positioning System
<b>GVA</b>	Gross Value Added
<b>GVC</b>	Global Value Chain
<b>HACCP</b>	Hazard Analysis Critical Control Points
<b>HEFA</b>	Higher Education Financing Agency
<b>IBA</b>	Indian Banks' Association
<b>IBEF</b>	India Brand Equity Foundation
<b>ICAR</b>	Indian Council of Agricultural Research
<b>ICRIER</b>	Indian Council for Research on International Economic Relations
<b>ICRISAT</b>	International Crops Research Institute for the Semi-Arid Tropics
<b>ICT</b>	Information and Communication Technology
<b>IDDP</b>	Intensive Dairy Development Programme
<b>IEC</b>	Importer - Exporter Code
<b>IFBSSI</b>	Indian Food & Beverages Sectorial System of Innovation
<b>IIFPT</b>	Indian Institute of Food Processing Technology
<b>IIM</b>	Indian Institute of Management
<b>IIoT</b>	Industrial Internet of Things
<b>IIT-D</b>	Indian Institute of Technology - Delhi
<b>IMEC</b>	Inter-Ministerial Committee
<b>IND</b>	Industry
<b>INR</b>	Indian Rupees
<b>INT</b>	Intermediary
<b>IoT</b>	Internet of Things
<b>IP</b>	Intellectual Property
<b>IPR</b>	Intellectual Property Rights
<b>IQ</b>	Intelligence Quotient
<b>IQF</b>	Individual Quick Freezing
<b>IRCTC</b>	Indian Railway Catering and Tourism Corporation
<b>ISO</b>	International Organization for Standardization
<b>ISTC</b>	Institutions Supporting Technical Change
<b>IT</b>	Information Technology
<b>ITC</b>	India Tobacco Company
<b>ITC-FSAN</b>	International Training Centre Food Safety & Applied Nutrition
<b>ITPO</b>	Indian Trade Promotion Organisation
<b>JICA</b>	Japan International Cooperation Agency
<b>KBI</b>	Knowledge-based Institution
<b>K-DISC</b>	Kerala Development Innovation Strategic Council

<b>KMO</b>	Kaiser-Meyer-Olkin
<b>KPMG</b>	Klynveld Peat Marwick Goerdeler
<b>MCCI</b>	Madras Chamber of Commerce and Industry
<b>MCCIA</b>	Mahratta Chamber of Commerce, Industries and Agriculture
<b>MDoNER</b>	Ministry of Development of North Eastern Region
<b>MEITY</b>	Ministry of Electronics and Information Technology
<b>ML</b>	Machine Learning
<b>MoAFW</b>	Ministry of Agriculture & Farmers' Welfare
<b>MoFPI</b>	Ministry of Food Processing Industries
<b>MoU</b>	Memorandum of Understanding
<b>MPEDA</b>	Marine Product Exports Development Authority
<b>MSME</b>	Medium, Small and Micro Enterprises
<b>MSSVF</b>	Maharashtra State Social Venture Fund
<b>NABARD</b>	National Bank for Agriculture and Rural Development
<b>NABL</b>	National Accreditation Board for Testing and Calibration Laboratories
<b>NAFARI</b>	National Agriculture & Food Analysis & Research Institute
<b>NBFC</b>	Non-Banking Financial Institutions
<b>NCMR</b>	National Research Centre on Meat
<b>NDDB</b>	National Dairy Development Board
<b>NER</b>	North Eastern Region
<b>NIC</b>	National Industrial Classification
<b>NIFTEM</b>	National Institute of Food Technology Entrepreneurship and Management
<b>NIN</b>	National Institute of Nutrition
<b>NIS</b>	National Innovation System
<b>NIScPR</b>	National Institute of Science Communication and Policy Research
<b>NITI</b>	National Institution for Transforming India
<b>NMEO-OP</b>	National Mission on Edible Oils - Oil Palm
<b>NMFP</b>	National Mission on Food Processing
<b>NMIS</b>	National Manufacturing Innovation Survey
<b>NPDD</b>	National Programme for Dairy Development
<b>NPMU</b>	National Programme Management Unit
<b>OBM</b>	Own Brand Manufacturing
<b>ODOP</b>	One District One Product
<b>OECD</b>	Organization for Economic Co-Operation and Development
<b>PBFIA</b>	Plant Based Foods Industry Association
<b>PEC</b>	Project Executive Committee
<b>PHDCCI</b>	Progress, Harmony and Development Chamber of Commerce and Industry
<b>PIB</b>	Press Information Bureau
<b>PLI</b>	Production Linked Incentive
<b>PLISFPI</b>	Production linked Incentive Scheme for Food Processing Industry
<b>PMFME</b>	Pradhan Mantri Formalization of Micro Food Processing Enterprises
<b>PMKSY</b>	Pradhan Mantri Kisan Sampada Yojana
<b>PMMSY</b>	Pradhan Mantri Matsya Sampada Yojana
<b>PPP</b>	Public-Private Partnership
<b>PSL</b>	Priority Sector Lending

<b>QCI</b>	Quality Control of India
<b>QP</b>	Qualification Packs
<b>R&amp;D</b>	Research & Development
<b>RFID</b>	Radio Frequency Identification
<b>RI</b>	Research Institution
<b>RL</b>	Reinforcement Learning
<b>RP</b>	Resource Person
<b>RPA</b>	Robotic Process Automation
<b>S&amp;T</b>	Science & Technology
<b>SAMARTH</b>	Smart Advanced Manufacturing and Rapid Transformation Hub
<b>SAMPADA</b>	Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters
<b>SAP</b>	Systems, Applications & Products
<b>SBI</b>	State Bank of India
<b>SC</b>	Scheduled Caste
<b>SDCFPO</b>	Supporting Dairy Cooperatives and Farmer Producer Organizations
<b>SHG</b>	Self Help Group
<b>SI</b>	System of Innovation
<b>SIDBI</b>	Small Industries Development Bank of India
<b>SIQ</b>	Strengthening Infrastructure for Quality
<b>SLAC</b>	State Level Approval Committee
<b>SME</b>	Small and Micro Enterprises
<b>SMP</b>	Skimmed Milk Powder
<b>SPMU</b>	State Programme Implementation Unit
<b>SSC</b>	Sector Skill Council
<b>SSI</b>	Sectorial System of Innovation
<b>ST</b>	Scheduled Tribe
<b>STEP</b>	Science and Technology Entrepreneurship Park
<b>STI</b>	Science, Technology, and Innovation
<b>TDPS</b>	Tea Development and Promotion Scheme
<b>TH</b>	Triple Helix
<b>TIFAC</b>	Technology Information Forecasting and Assessment Council
<b>TOP</b>	Tomato, Onion and Potato
<b>TOTAL</b>	To All Fruits & Vegetables
<b>TPCI</b>	Trade Promotion Council of India
<b>TRIZ</b>	Theory of Inventive Problem Solving
<b>TVE</b>	Total Variance Explained
<b>UDAAN</b>	Ude Desh Ka Aam Naagrik
<b>UNIDO</b>	United Nations Industrial Development Organization
<b>US</b>	United States
<b>USD</b>	United States Dollar
<b>USFDA</b>	United States Food and Drugs Administration
<b>UT</b>	Union Territory
<b>VC</b>	Venture Capitalist



<b>WALMI</b>	Water and Land Management Institute
<b>WEF</b>	World Economic Forum
<b>WIPO</b>	World Intellectual Property Organization
<b>WMP</b>	Whole Milk Powder

## Conversion factor

1 Crore = 10 millions

1 Lakh = 100,000

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## Preface

India's aspiration to become a global economic powerhouse, with the goal of crafting a US\$ 5 trillion economy by 2026-27, will require reinventing the country's manufacturing and innovation performance. In order to deliver rapid industrial growth that is sustained over the next few decades, India needs to strategically focus on building a robust industrial sector with a next generation, intelligent manufacturing base. As domestic manufacturing companies need to become an integral part of global supply chains, India can leverage its strong Information Technology (IT) sector and drive supply chain efficiencies and productivity growth through deploying it at scale. By harnessing these soft power advantages, a manufacturing revolution can be triggered, allowing India to become a global manufacturing superpower.

Creating an industrial revolution of this scale would require the Indian government to formulate a comprehensive vision for industrial development and execute it through the implementation of coherent and effective policy. The unprecedented disruptions of societies and economies caused by the COVID-19 pandemic have highlighted the need to take immediate action. In recent years, the Government of India (GoI) has launched special initiatives like Production Linked Incentive (PLI) schemes to strengthen India's industrial capabilities and technological innovation in 14 key sectors, while creating and nurturing global champions capable of producing for the world. The PLI scheme is a time bound initiative with a clear mandate of focusing on critical sectors such as food processing that can attract maximum investments and be scaled rapidly to provide maximum returns in terms of higher productivity, employment and exports. Such schemes are also designed to identify and support the adoption of the Fourth Industrial Revolution (4IR) technologies that are opening new avenues of opportunity for advancing economic competitiveness, creating shared prosperity, safeguarding the environment, and strengthening knowledge and institutions. However, Niti Aayog has identified the lack of convergence in government initiatives as one of the key challenges in the Indian food processing sector. Inter-ministerial coordination is required to develop effective procurement linkages, food processing facilities, retail chains and export activities. This is also needed to facilitate synergies between various initiatives such as the "Rashtriya Krishi Vikas Yojana" of the Ministry of Agriculture, and "Pradhan Mantri Kisan SAMPADA Yojana" of the Ministry of Food Processing Industries (MoFPI). The aim is for interorganizational relationships to evolve gradually from coordination to collaboration to knowledge creation and application.

With knowledge emerging as a critical resource, its better management and flow among people, enterprises and institutions is key to the innovative process. A System of Innovation (SI) represents the strength and quality of the systematically organised interactions and linkages between the stakeholders of the ecosystem, namely government, knowledge-based institutions, industry, intermediaries (institutions supporting technical change, industry associations and incubators), and arbitrageurs (venture capital, angel investors, and financial institutions). The mapping and visualisation of the dynamics of an innovation system are crucial to formulating evidence-based policy for the effective use of resources.

Consequently, the growth of the Indian food and beverages sector will not only depend on the utilisation of the 4IR technologies and knowledge production, but also on the availability of sufficient policy and regulatory support for the sector. Clear and targeted policy is needed to enable the effective allocation of resources. UNIDO acknowledges the importance of evidence in optimally deploying policy instruments and targeting available resources (economic incentives and institutions) so that the Indian automotive sector can achieve a competitive advantage and the development of a well-functioning SI will aid this as a driver for long-term socio-economic development.

The "Indian Food & Beverages Sectorial System of Innovation (IFBSSI) Report" maps and analyses the challenges, potential, and opportunities arising from the innovation system. The analysis is based on data gathered as part of the "National Manufacturing Innovation Survey" conducted by UNIDO in 2021-22. The measurement through this survey enables the provision of evidence to guide policy. Therefore, the IFBSSI Report is a source of policy insight for supporting the Government of India to elaborate an evidence-based industrial policy that articulates the role of science, technology, and innovation throughout the economy. Moreover, the policy analysis, implications arising from the analysis and the policy recommendations presented in the report offer a range of evidence-based policy choices to facilitate policy decisions related to the role of sectorial system actors in the draft "National Food Processing Policy 2019". The mandate of UNIDO – as one of the specialised agencies of the United Nations system – to provide its member states with capacity-building and policy advisory services is manifest in this report.

The chapters in this report are the result of UNIDO's services in capacity-building, policy analysis, and empirical research on the Indian food and beverages sector. It aims to enhance the understanding of the role of the core actors, their interactions, and perspectives, thus providing a solid basis for strategic planning, policy, and the management of policy actions in order to achieve national targets and goals effectively.

## Executive Summary

This report, titled the “Indian Food & Beverages Sectorial System of Innovation (IFBSSI) – Measurement, Analysis, and Policy Recommendations” surveys innovation and innovativeness in the food and beverages sector in India and maps the functioning of innovation and the associated collaborative processes between innovation stakeholders. The survey and analysis were undertaken within the framework of the “National Manufacturing Innovation Survey 2021-22” (NMIS 2021), co-designed with and funded by the Department of Science and Technology, (GoI).

The report has been compiled for the GoI to inform innovation policy and improve innovation practices within the sector. Furthermore, it aims to facilitate coherent delivery of innovation policy and the establishment of a long-term policy monitoring and management capability for the sector.

Although there are many significant challenges identified, the policy analysis, implications arising from the analyses, and the policy recommendations to address these implications provide an unprecedented menu of evidence-based development priorities and policy choices to address the challenges. The approach outlined in this report is comprehensive and holistic for mapping and measuring the Indian Food and Beverages Sectorial System of Innovation (IFBSSI). It provides an accurate visualisation of the connectivity between the core actors of the IFBSSI, the significant barriers to innovation and innovativeness, and the relative success of current policies in overcoming these barriers. After all, it is not the number of assets India has when considering innovation and innovativeness, but rather how well and coherently they are connected and

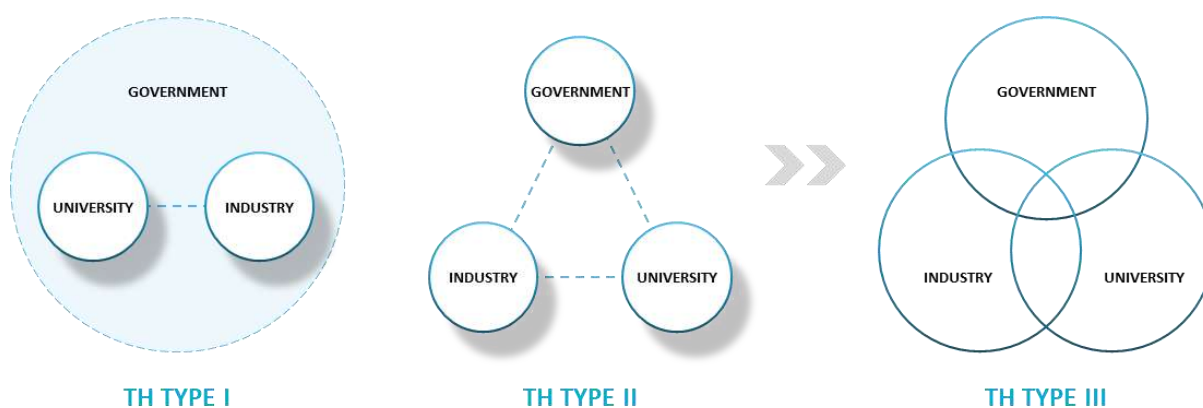
managed and if they are achieving innovative products and business processes and subsequent economic value.

It is imperative that policymakers view the analysis, implications, and recommendations in light of India’s economic performance in an emerging economy and in the context of the COVID-19 pandemic, which hit all sectors across the globe.

The analysis of the GoI policy documents; the mapping and measurement of the IFBSSI in terms of analysing linkages between (and within) actor groups, barriers to innovation; and the success of policy instruments disclose the significant key policy analysis findings, the major implications from the analysis, and the recommendations that stem from them.

In the specific case of the food and beverages sector, our assessment is that the IFBSSI falls into the category of a Triple Helix (TH) Type I transitioning to Triple Helix Type II, as per the traditional framing of the TH model. TH-Type I can be considered to be statist, and the three spheres of the actors are strongly institutionally defined, however, they work in isolation leading to the local technological knowledge also being kept isolated. TH Type II refers to mechanisms of communication between the actors that are strongly influenced by the market and technological innovations. In this case, the point of control is at the interfaces and consequently new codes of communication are developed. Within the TH Type II the role of the government is primarily to limit cases of market failure. It can be considered a ‘laissez-faire’ model of interaction in which actors are expected to act competitively rather than cooperatively in their relations with each other.

**FIGURE 1: Triple Helix types**



- Consequently, there is the need to foster linkages between crucial actors of the IFBSSI, particularly for the use and application of joint research, skills orientation and development, and access to finance.
- Based on this observation, the inter and intra interactions that need attention are:
- Fostering more joint research between industry actors.
- Promoting joint research between industry and the knowledgebase.
- Fostering of knowledge sharing between industry and the knowledge base through secondments with the objective of aligning curricula in line with the requirements of industry.
- Closer relationships between industry and the knowledgebase for the absorption of skilled human capital.
- Closer linkages between industry and financial institutions for the purposes of knowledge transfer and ultimately better access to finance.
- Boosting joint research between knowledge-based institutions, being inclusive of T2 and T3 institutions; and
- Strengthening linkages between knowledge-based institutions and arbitrageurs in order to facilitate ideation to market.

Secondly, the analysis highlights that relationships between actors in the IFBSSI are imbalanced in that there is an unequal level of exchange between two actors, hindering the flow of knowledge and information crucial to the innovation process. This is mainly due to a suboptimal understanding of each actor's role within an effective system of innovation and the terms and conditions unfavourable to meaningful participation. Consequently, 'Market Dynamics and Structure' 'Industry 4.0', 'ICT', and 'Human Capital and Organization' emerge as the underlying barriers to innovation within the IFBSSI.



The market shows its importance in driving innovation through demanding customers and innovative customers, as well as distinct 'rules of the game'. The variables associated with this barrier are 'Lack of innovative customers', 'Lack of clear national innovation strategy', 'Lack of demanding customers', 'Lack of explicit policy support (government)', 'Lack of traditional infrastructure' and 'Excessive perceived economic risk'. Market dynamism and structure can be described by rapid changes in technologies, changes in market structure, the instability of market demand, intense fluctuations in supply of materials, and the probability of market shocks, as well as the related infrastructure and institutions. Volatility and unpredictability characterises market dynamism and therefore a high level of market dynamics restricts the

ability to distinguish the market boundaries, develop clear successful business models, and identify market participants such as competitors, customers, and suppliers and their respective needs. Consequently, this manifests as external uncertainty thus making it more difficult to predict future market situations, plan and organise their resources, and respond with their own knowledge and related processes. Within the Indian context, while India has favourable supply-side dynamics on the back of agriculture base, the food and beverages sector faces challenges such as rising food prices which is expected to impact demand if not controlled. Product development and innovation focus is lacking. However, changing consumer preferences are expected to drive innovation.



From the perspective of 'Industry 4.0', the associated variables are: 'Lack of understanding of I4.0 technologies', 'Cost of I4.0 technologies', 'Lack of access to I4.0 technologies', and 'Lack of infrastructure for I4.0'. In real terms the challenges in the adoption of I4.0 in the Indian food and beverages sector are multi-faceted. Firstly, The Internet of Things (IoT) which is the technology for linking manufacturing and supply chain is still relatively novel. It requires a level of collaboration and trust between diverse businesses at the production, processing, wholesale, and retail levels, some of which are very traditional in their outlook and sharing that much information does not come naturally. This kind of transparency also requires improvements in Internet security. Secondly, capital cost is a factor, particularly as many food and beverage companies function with technology and equipment that was installed, with significant capital outlay, well before the IoT became a reality. Replacing it may not be an immediate possibility. Thirdly, there is the aspect of a skilled workforce that is capable of running their transformed facilities.

The first step towards successful 4IR implementation for the Indian food and beverages sector is a clear understanding of I4.0 technologies and articulation of the value, goals and needs of 4IR technology among many firms.

The IFBSSI Report demonstrates the value of comprehensive survey and the critical importance of mapping and measurement to guide the discussion for evidence-based and collaborative policymaking, execution, monitoring and impact evaluation. A periodic repeat of systematic mapping and measurement of the IFBSSI in two to three years is strongly advised and can help to ascertain the effects of policy choices, implementation, resource application, and hence innovation and innovativeness in the Indian economy.





# 1. Project Context

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## Project Context

The “National Manufacturing Innovation Survey (NMIS) 2021-22” is a follow-up to the Department of Science and Technology’s (DST) (GoI) first “National Innovation Survey” held in 2011. The 2011 survey results showed that most of the innovations in Indian firms were in the form of introducing new machines, or improvements to existing products and processes (DST, 2014). The study found these firms at par or ahead of their competitors regarding improved ranges of products (better quality and standards), besides improving production capacity and reducing environmental impacts. Such firms were largely privately owned small companies and relied on domestic financial institutions. While these innovative firms struggled with cost factor and availability of skilled manpower, more than 50% did not employ scientists or engineers but reported that access to knowledge and information was a critical barrier.

The decade that followed the 2011 National Innovation Survey saw the launch of key policy initiatives, especially the “Make in India”, “Startup India” and the “Aatmanirbhar Bharat Abhiyan”, among others, positioned to strengthen and boost the country’s manufacturing sector outputs where innovation and entrepreneurship programmes were prioritised. The scope of indigenous innovations and innovation ecosystems thus received greater impetus in this period. In 2019 the DST followed up with the planning of the second nationwide innovation survey and partnered with the United Nations Industrial Development Organization (UNIDO), with greater attention to manufacturing and associated services spread across large, medium, small and micro enterprises. It emphasised the

role and separately studied the impact of this ecosystem and its actors on innovations in specific sectors.

### 1.1 The National Manufacturing Innovation Survey 2021-22

The National Manufacturing Innovation Survey (NMIS) 2021-22 was designed as a 2-pronged survey where the DST-UNIDO collaboration adopted a 360-degree approach to measuring innovation performance at the level of manufacturing firms, and assessing innovation processes, its barriers and support measures at the ecosystem level of industrial sectors. To this end, the survey was designed with two specific components – the Firm-Level Survey and the Sectorial System of Innovation (SSI) Survey.

The objective of the Firm-Level Survey was to capture insights regarding activities impacting innovations in a firm, across a broad spectrum of product and business process innovations and understand the various factors enabling and/or limiting innovation activities. On the other hand, the SSI Survey aimed to measure the innovation system available to specific industrial sectors to examine how manufacturing firms accessed information, knowledge, technologies, practices, and human and financial resources, and what linkages connect the innovating firm to other actors in the innovation system (laboratories, universities, policy departments, regulators, competitors, suppliers, and customers). Thus, with an overarching scope to strengthen, improve and diversify India’s manufacturing with targeted and evidence-based innovation policy, the NMIS 2021-22 Survey was launched in February 2021.

**TABLE 1: Overview of Firm-level survey and SSI survey**

The Firm-Level Survey assessed the following: (Broad overview)	The SSI Survey assessed the following: (Broad overview)
<ul style="list-style-type: none"> <li>Types of innovations in manufacturing firms               <ul style="list-style-type: none"> <li>Product innovation</li> <li>Business process innovations in (e.g., operation, product/business process development, marketing &amp; sales, procurement, distribution &amp; logistics, administration, and management)</li> </ul> </li> <li>Innovation activities</li> <li>Sources of information, collaborations, resources</li> <li>Factors hampering innovation activities.</li> <li>Impacts of digitalisation, infrastructure, IP</li> <li>Impact of COVID-19 pandemic</li> </ul>	<ul style="list-style-type: none"> <li>Innovation actors (firms and non-firm actors) for their networks (density, distribution, directionality, symmetry of intra- and inter-linkages of actors)</li> <li>The role and impact of actors and institutions on innovation activities in firms</li> <li>Impact of policy instruments (fiscal, monetary, regulatory, standards and others)</li> <li>Barriers to innovation</li> </ul>

With a stratified random sample representing micro, small, medium and large manufacturing companies, the Firm-Level Survey targeted 10,139 firms across 58 manufacturing sectors (as per the national industrial classification 2008<sup>1</sup>) across the 36 states and union territories in the country. The SSI Survey targeted the innovation systems of 5 key manufacturing sectors critical to the Indian economy, prioritised by their gross value-added (GVA) and their presence across the country, impacting state level and national policies and strategies. These 5 sectors are: Food and Beverages, Textiles and Apparel, Automotive, Pharmaceuticals, and, Information and Communication Technologies (ICT). A stratified random sample close to 7,851 firms and 1,000 non-firm actors were targeted under the SSI Survey across India. The outcomes of the Firm-Level Survey are separately reported, while this report features the SSI Survey objectives and findings.

## 1.2 Significance of the Sectoral Systems of Innovation Survey

The SSI Survey postulates that for a firm to be effective in the innovation process, a conducive environment that consists of an effective support infrastructure of actors is critical. Connectivity between them that is fluid and dynamic will be pivotal in aiding access to the requisite, knowledge, skills, and resources. Hence, the survey aimed to map the innovation capability of manufacturing firms to such actors and institutions of sector-specific systems of innovation and also regional systems of innovation, and national systems of innovations. To this end, the interactions (or linkages) and the density of these linkages to various ecosystem actors were studied to achieve a clear understanding of these relationships in empirical terms to assess the flow of communications and information and assets between knowledge-based institutions, research and development agencies, industry bodies, government agencies, financial institutions, startup incubators, institutions supporting technical change, and arbitrageurs.

The survey particularly took cognisance of the innovation and manufacturing mandate of NITI Aayog, the apex policy advisory body to the GoI<sup>2</sup>. In its strategic recommendation for improving India's manufacturing sector outcomes, NITI Aayog strongly recommended the need for promoting latest technology advancements and predicted a defining role for Industry 4.0 intervention in shaping the sector and

achieving an ambitious double-digit growth (NITI Aayog, 2018). Further, the agency has also been assessing the nation's priorities and strategies for consolidating and strengthening science and technology (S&T) initiatives to amplify technology development and commercialisation. Since the 1990s, the Government of India has deployed technology incubators as an important policy tool for S&T entrepreneurship (Surana et al., 2018). The DST has been at the forefront of designing and establishing science and technology entrepreneurship parks, incubation systems, and technology business incubators to build close linkages between universities, academia, R&D institutions and the industry, including MSMEs, and also to generate employment<sup>3</sup>. These initiatives led to strong technology-based entrepreneurship and startups in the country, and set motion to various policy frameworks and initiatives, such that most incubation programmes in the country today leverage support offered under various ministries, who also have a manufacturing stake. The public sector enterprise model for biotechnology-based startups by the Department for Biotechnology (DBT) has been highly successful in converting research into products and attracting investments and has impacted the pharma and life-sciences landscape in the country. Similarly, for strengthening IT and digital startup linkages with markets, the Ministry of Electronics and Information Technology (MeitY) has been offering risk capital and low-cost loans. With their broader mandate, the Ministry of MSME and the Department for Promotion of Industry and Internal Trade (DPIIT) have designed and implemented several startup programmes, and importantly brought SME collaborations to sector-specific incubators, thus offering a stronger market access to entrepreneurs.

India's technology and innovation agenda took a strong leap over the last decade when the Government of India launched a series of high-powered initiatives to amplify and catalyse the pace of innovation and entrepreneurship with greater emphasis on the startup ecosystem. The "Startup India" mission was put in place to tackle the complex, lengthy regulatory processes for startups and introduced tax incentives and high-risk funding to startups<sup>4</sup>. The "Atal Innovation Mission" brought sector-specific attention to the startup agenda for innovation and entrepreneurship incubation infrastructure across the country and widened

<sup>1</sup> National Industrial Classification (NIC) 2008 is an essential statistical standard for developing and maintaining a comparable database according to economic activities [https://www.ncs.gov.in/Documents/NIC\\_Sector.pdf](https://www.ncs.gov.in/Documents/NIC_Sector.pdf)

<sup>2</sup> About NITI Aayog: <https://www.niti.gov.in/objectives-and-features>

<sup>3</sup> Science & Technology Entrepreneurship Park (STEP): <https://www.nstedb.com/institutional/step.htm>

<sup>4</sup> The Startup India initiative (under DPIIT) was launched to improve the innovation ecosystem and handhold, fund and incentivise startups and improve industry-academia partnerships through incubation services: <https://www.startupindia.gov.in/content/dam/invest-india/Templates/public/Action%20Plan.pdf>

its scope to schools and other academic institutes<sup>5</sup>. Further, the “Invest India” programme was launched to catalyse investments in manufacturing, technologies, incentivising innovations and other areas of trade and commerce<sup>6</sup>. The increased access to risk capital in technologies in this period have played a key role, such that Bain (2022) reports that VC investments in India pegged at US\$ 38.5 billion in 2021 and have positioned India as the third largest startup ecosystem in the world<sup>7</sup>.

The SSI Survey was positioned to examine how such policy and institutional arrangements (innovation/incubation programmes established in various technology and higher education institutes) across the country have impacted the collaboration of firms with academia, startups and investors for commercialising innovations, thereby addressing various transaction-related problems endemic to lab-to-market journeys. Studies show that traditional R&D institutions in the country, however, continue to prioritise “blue-sky research” over “application-oriented research” and on the other hand, several recent studies have brought attention to the challenges faced by India’s public-funded labs in commercialising their research outputs. While technology interventions have direct impact on productivity, accessing capital in manufacturing technology-based projects continue to be a challenge, owing to the longer gestation period before they yield returns. As Nandagopal et al., (2013) point out, Indian firms continue to be traditionally risk-averse, and are inclined to invest in non-technology-based sectors like retail, banking, infrastructure, entertainment, among others. The SSI Survey made crucial inclusion of the role of arbitrageurs, such as the venture capitalists and knowledge brokers, as these actors have increasingly been decisive in the innovation process in bringing internal and external knowledge and high-risk investments that result in new business models and new types of companies.

### 1.3 Relevance of the 5 Manufacturing Sectors Prioritised by the SSI Survey

With the goal of significantly increasing the manufacturing sector contribution to the GDP from 16.5%, the “Make in India” mission is a major policy initiative launched in 2014

aimed to make India a high-tech manufacturing hub<sup>8</sup>. The mission now targets 27 manufacturing sectors that has key significance to the economy and the 5 manufacturing sectors identified for the SSI Survey have significant priority in the Make in India mission.

India’s food processing is globally one of the largest, with a significant number of registered factories across the country attributing to the direct employment of 1.9 million people, with 8.9% MVA (food and beverage along with tobacco) (UNIDO IAP, 2023). Despite being a major trader and exporter of agriculture products, India’s export processed food is less than 10% owing to critical impediments across supply chain infrastructure, production and processing, inefficient capacity utilisation, quality and safety challenges, and slow product and technology interventions (RBI, 2020). Similarly, the other large sector in the survey, the textiles and apparel sector, has a prominent manufacturing presence in many states and provides direct employment to more than 45 million people and contributes close to 7% of MVA<sup>9</sup>. In 2021-22 the Indian textiles and apparel industry was valued at US\$ 152 billion and accounted for a 4% share of the global textile markets. Yet the highly fragmented sector is also labour and raw material intensive and is mired with productivity challenges that tend to undermine value chains and their backward linkages. For instance, more than 80% of the 50 million spindles and 842,000 rotors deployed by textile mills are found to be outdated or inefficient<sup>10</sup>.

The SSI Survey aimed to also gather learnings from actor collaborations, institutional best practices, challenges, technology leapfrogging trajectories and other aspects of systems of innovation in three high performing sectors, such as the automotive, pharmaceutical and ICT sectors. With a 20.1% contribution to the manufacturing GDP, the automotive sector is a top driver of macroeconomic growth and technological development in the country (UNIDO IAP, 2023). With robust performances, the ICT and pharmaceutical sectors are the world’s key players. India’s pharmaceutical sector is the third largest in volume, driven by export markets and the expansion of Indian healthcare that has resulted in innovative products, processes and services, thereby positioning India as the pharmacy of the world<sup>11</sup>.

<sup>5</sup> The Atal Innovation Mission driven by NITI Aayog established numerous innovation and entrepreneurship centres in schools, universities, research institutions, private and MSME sectors: <https://www.aim.gov.in/overview.php>

<sup>6</sup> Invest India: [Investment Promotion and Facilitation Agency | Invest India](https://www.investindia.gov.in/)

<sup>7</sup> Economic Survey: India becomes third-largest startup ecosystem in the world. Mint: <https://www.livemint.com>

<sup>8</sup> The Make in India Mission: <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1738170>

<sup>9</sup> Textile Industry in India - Garment & Apparels Market in India: [www.investindia.gov.in/sector/textiles-apparel](https://www.investindia.gov.in/sector/textiles-apparel)

<sup>10</sup> India should continue investing in modern, efficient spinning technology to remain globally competitive: <https://www.indiantextilemagazine.in/india-should-continue-investing-in-modern-efficient-spinning-technology-to-remain-globally-competitive/>

<sup>11</sup> India has become pharmacy of the world: <https://www.moneycontrol.com/news/india/india-recognised-as-pharmacy-of-the-world-fm-9759651.html>

## 1.4 SSI Survey to Strengthen Manufacturing Innovation as a GoI Policy Imperative

The Make in India ambitions were further boosted in 2020-21 with the launch of the Production Linked Incentive (PLI) scheme across 14 key manufacturing sectors, to incentivise import substitution by domestic production in strategic growth sectors<sup>12</sup>. Invariably, the domestic manufacturing ecosystem and supply chains are critical to the success of the PLI scheme. Similarly, the “Gati Shakti” programme was launched in 2021 to improve infrastructure and connectivity for faster and more efficient movement of goods and services, and impact manufacturing and business operations at large<sup>13</sup>. Besides technological leapfrogging, world-class innovation capabilities, skills and investments, the Government of India’s efforts in improving the investment environment has been critical. The country saw FDI inflow catch great momentum between 2014-22 and by 2019 India was recognised as one of the most attractive emerging markets for investments<sup>14</sup>. However, the FDI share in Indian industries seems to continue to largely benefit non-manufacturing sectors such as software businesses. Nevertheless, the hardware, pharma-biotech and electrical equipment sectors, among others, with strong product sophistication and better production capabilities, attract strong foreign direct investment (FDI) inflow, especially with their digital capabilities in manufacturing and product offerings<sup>15</sup>. The global shifts in advanced digital manufacturing with self-correcting intelligence has been a game changer since the pandemic and has reflected in investment interests as well.

The SSI Survey has attempted to capture the dynamics of communication, stocks and flows of knowledge and organization by introducing the notion of an intersection of exchange relations that feed back into institutional arrangements. The aim has been to understand how co-evolution between the layers of institutional arrangements and evolutionary functions can be conceptualised, in relation to the division of innovative labour among both institutions and functions. This is particularly important when crafting policy for the effective use of resources. Thus, by generating evidence of the barriers and challenges to technological learning, innovation and development, and technological up-gradation of Indian industries the survey findings shall be used for devising policies, programmes, and partnerships to strengthen innovation outcomes and benefits.

The project was supported by the UNIDO Facility for International Cooperation for Inclusive & Sustainable Industrial Development (FIC-ISID), a joint initiative of the DPIIT and UNIDO, with the aim to catalyse inclusivity and sustainability in manufacturing industry development. Five major business membership organizations, respectively the India SME Forum (ISF), the Federation of Telangana Chambers of Commerce and Industry (FTCCI), the Federation of Andhra Pradesh Chambers of Commerce and Industry (FAPCCI), the Madras Chamber of Commerce and Industry (MCCI), and the PHD Chamber of Commerce and Industry (PHDCCI) were key partners in data-collection across India’s 28 states and 8 union territories. The survey completed the data collection in early May 2022.

<sup>12</sup> The PLI Scheme: <https://www.investindia.gov.in/production-linked-incentives-schemes-india>

<sup>13</sup> Gati Shakti: <https://dpiit.gov.in/logistics-division>

<sup>14</sup> Emerging Markets Private Equity Association 2019 Survey: <https://www.globalprivatecapital.org/app/uploads/2019/05/2019-lp-survey-final-web.pdf>

<sup>15</sup> FDI in India 2021: <https://www.makeinindia.com/policy/foreign-direct-investment>





2.

## Theoretical Framework

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# Theoretical Framework

Innovation is increasingly viewed as the salient ingredient in the sustainable growth of the modern economy. An economy must continuously absorb new knowledge and develop new skills and capabilities to avoid erosion of competitiveness and facilitate economic growth and diversification. Historically, countries that fostered innovation by developing interconnected innovation systems have proven to be more capable of generating new knowledge and translating it into business opportunities and thus wealth creation (Freeman, 1987; Nelson and Rosenberg, 1993; Lundvall, 1992, 2016; Chaminade et al., 2018). An innovation system refers to a set of institutions that contribute to the development, diffusion and application of scientific and technological knowledge (Dosi, 1988). Studies have shown that well-functioning innovation systems are essential to catch up with advanced economies (Kim, 1992, 1997; Kim and Nelson, 2000; Fagerberg and Srholec, 2008; Malerba and Nelson, 2013; Fagerberg et al., 2017; Shekar, K. C., & Joseph, K. J., 2022).

Innovation systems are framed at different scales, including national, sectoral and local/regional (Chaminade, 2018). The framing of an innovation system involves different types of network and interactions depending on the driving interest, practices, behaviours and the working environment in general. The considerations for building these networks may vary depending on the context and scale of the operations/activities happening among the actors. These networks will evolve based on the behaviour and routine among the actors and their organizational context (Hall, Mytelka, and Oyeyinka 1997; Jacob 2016). However, knowledge and learning remain the central points to the networks (Moschitz et al., 2015). The establishment of such networks for building a system involves breaking barriers and reconstructing channels for knowledge flow. This is done by setting interactive processes, sharing best practices and learning from prior experience, while overcoming failures and filling gaps. The form and the performance of learning approaches may vary from one sector to another, depending on different patterns such as the roles, habits, mode of operation, competencies, demand, among others (Mytelka and Smith, 2002). This suggests a systemic way of establishing a framework that allows interactions among the different groups and contributes to the use of knowledge for the collective/mutual interest of the actors.

Since innovation is a collective action that involves a multitude of actors who co-operate and compete in networks and who are stimulated and constrained by

institutional settings in different sectors, we use the concept of 'Sectorial Innovation Systems'. The rationale for using this framework can be further justified on the ground that it encompasses all the relevant aspects that might possibly influence innovation and economic growth and is suitable to analyse the inter-related character of innovation processes. In this backdrop, this chapter presents the theoretical underpinnings for the approach used in mapping and measuring the Indian Textiles and Apparel Sectorial System of Innovation (ITASSI). It introduces the concept of the Sectorial System of Innovation (SSI), as well as reviews the elements that constitute its early conceptualisation, through a review of the evolution of seminal literature. Based on this, the chapter outlines the traditional Triple Helix Model of government-university-industry (Etzkowitz and Leydesdorff, 2000) interactions as well as its extension.

## 2.1 Theoretical Underpinnings

The Organization and development of innovation have gained much attention from different perspectives. The traditional notion of innovation as an end provides a narrow view of innovation and the potential it has on societal development in different dimensions. Whereas the consideration of innovation as a process that engages a chain of activities that can lead to different types of innovations that then have diverse socio-economic impacts is more prevalent today. An innovation system considers innovation as a process and considers how the actors interact among themselves to undertake innovation activities. They consider the inputs to innovations and the channels leading to the expected outputs. This does not mean the use of the linear model of input-output that has been used for some time as a way of linking science to innovation. Rather, it considers the complexity of the processes and the interactions among actors involving learning activities and the use and transfer of knowledge (Etzkowitz and Leydesdorff, 2000). The available literature on innovation capabilities in the Indian industrial sector is mostly based on STI indicators that focus more on R&D activities and the creation of access to codified knowledge (Basant, 1997; Basant and Fikkert; 1996; Kartak, 1985; Kumar and Siddharthan, 2013; Shekar, K. C., & Paily, G., 2019). For instance, Basant and Fikkert, (1996) examines the effects of domestic and foreign technology purchases as well as R&D activities in enhancing the productivity of firms in India. The study shows that between 1974-75 and 1981-82, domestic and international R&D spillovers and



foreign technology purchases are highly statistically significant as compared to own R&D expenditures. Even though technological strategies greatly contribute to the productivity growth of Indian enterprises it is not directly reflected in export performance, which is also considered as an important indicator of a firm becoming more innovative (Lall and Kumar, 1981). It is highly evident in high technology sectors rather than medium and low technology sectors (Kumar and Siddharthan, 1994). A sector-specific study conducted by Bhaduri and Ray (2004) examines the technological capability of exporting firms in the electrical and electronic equipment industry. Firms in this industry mainly depend on know-how rather than know-why capabilities. In addition to these approaches, innovation systems research focuses on interactive learning, interdependence and non-linearity wherein institutions play the central role (Joseph, K. J., 2009; Shekar, K. C., & Joseph, K. J., 2022). The innovation system perspective has become a widely used analytical tool for academic research, policy formulation and implementation which aim at effective relationships among the agents and increase the innovation efficiency (Dosi et al., 2006). Therefore, the innovation system, which has by now emerged as the most popular approach in innovation studies, involves a more holistic framework to study the inter-related character of innovation processes as it focuses on the interdependencies among the various agents, organizations and institutions while underlining the need for R&D (Freeman, 1987; Dosi et al., 1988; Lundvall, 1992; Nelson, 1993; Edquist, 1997; Shekar, K. C., & Joseph, K. J., 2022).

Since the late 1980s, innovation system concepts have been developed and presented primarily by innovation researchers as a response to the shortcomings of neoclassical attempts to explain innovation and technological progress (Edquist, 1997). According to Christopher Freeman, "...systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, import, modify, and diffuse new technologies" (Freeman, 1987). The innovation system, with a focus on technology and information flows between people, businesses, and institutions, and was created as a tool to understand the innovation process (Lundvall, 1985). Innovation systems help identify how to stimulate innovation and what inhibits its development and have become a viable method for researchers and policymakers to study the innovation process, especially in emerging and developing economies (Weber and Truffer, 2017; Shekar, K. C., & Joseph, K. J., 2022).

Different types of innovation systems have emerged since the identification of the concept of innovation systems such as the National Innovation System (NIS) (Lundvall, 1992;

Freeman, 1987; Edquist, 1997; Lundvall, 2007; Nelson, 1993), Regional Innovation System (RIS) (Saxenian 1994; Cooke & Uranga, 1997), Sectoral System of Innovation (SSI) (Malerba, 2002; Breschi and Malerba, 1997) and technological systems (e.g., Carlsson and Stankiewicz, 1991), also known as a technological innovation system (Bergek et al., 2008; Hekkert et al., 2007). The NIS as the common analytical framework for innovation to economic growth. This considers a country as a unit of analysis. It provides the macro indicators in regard to interactions among actors, organization structures, institutions and learning processes as well as the facilitation. It considers interactions among actors as key for innovations. Actors can be firms' organizations and non-firms' organizations (universities, R&D organizations) (Chaminade et al., 2018; Shekar, K. C., & Paily, G., 2019). The categories of organizations may generally be grouped as knowledge producers and knowledge users. Whereas the system is based on these categories and the interactions among them, institutions are very important in the innovation systems. In this context, institutions are considered as a set of routines, behaviour, regulatory tools, and policies (Edquist, 2005; Freeman, 1995). The set of organizations, institutions, knowledge, interactions, and learning make up an innovation system and this system can be analysed at a lower level as a sectorial innovation system. Types of activities, actors, and products; and how these are interconnected determines the sector.

Geographical factors define national and regional innovation systems, whereas sectorial and technological innovation systems are defined by the knowledge base that supports a particular sector or technology (Carlsson, 2016). In the sectoral system of innovation, innovative activities within a particular sector, a set of new and established products and the set of agents involved in the creation, production and sale of those products are examined. SSI surpasses specific technological and geographical boundaries, with sectors being positioned sometimes in small regional clusters, yet sometimes covering global networks, as, for example, within multinational corporations (Stenzel, 2007).

In recent years, advances in innovation theory have gradually moved closer to a fully systemic, dynamic, and non-linear process that involves a range of interacting actors. This process emphasises the significance of knowledge flows between actors; expectations about future technology, market, and policy developments; political and regulatory risk; and the institutional structures that affect incentives and barriers. Thus, while conceptual and methodological specifics vary, these more recent innovation systems emphasise the role of multiple agencies and distributed learning mechanisms in technological



change. Rather than all-powerful firms or unidirectional knowledge flows, the focus is on inter-organizational networks and feedback (Winskel and Moran, 2008). The system perspectives still acknowledge the existence of stages of technology development, but they attempt to put these in a broader context.

There are various channels of university-industry interactions that facilitate innovation development. Joseph and Vinoj (2009) provide empirical evidence that in spite of the low level of university-industry interactions in the country, firms that collaborate with universities achieve a high level of innovative activities.

In particular, the role of institutions at all levels in establishing and maintaining the “rules of the game” is a central theme since institutions may constrain choices, driving innovation along certain - possibly suboptimal - paths while often throwing up barriers to more radical change (Foxon, 2003). The importance of feedback between different parts of the system – both positive and negative - is also emphasised, as are the links between technological and institutional change. A well-functioning system vastly improves the chances for a technology to be developed and diffused (Negro et al., 2008; Shekar, K. C., & Paily, G., 2019; Shekar, K. C., & Joseph, K. J., 2022).

Hence, the guiding principle of innovation studies is that if we can discover what activities and contexts foster or hamper innovation (i.e., how innovation systems function) we will be able to intentionally shape the innovation processes (Hekkert et al., 2007).

## 2.2 Sectorial System of Innovation (SSI) Approach

The notion of sectorial system draws from evolutionary theory, the innovation system approach and the analysis of the dynamics and transformation of industries. According to the SSI approach, a sector is seen as a set of activities which are associated with broad product groups, are addressed to an existing or emerging demand, share a common knowledge base, and are affected by a system of actors and institutions (Malerba, 2002). Malerba (2002) defines SSI as a “set of products and the set of agents carrying out market and non-market interactions for the creation, production, and sale of those products”. SSI focuses then on the sector rather than on any geography. A sectorial systems framework focuses on three main dimensions (for a broader discussion see Malerba, 2004 and Malerba and Adams, 2019) that are typically distinguished as: a) knowledge and technological domains; b) actors and networks; and c) institutions (Malerba and Adams, 2019).

- a. **Knowledge and technological domains.** A sector is characterised by a specific knowledge base and technologies. Knowledge plays a central role in the sectorial systems approach. Knowledge is highly idiosyncratic at the firm level, does not diffuse automatically and freely among firms (Nelson and Winter, 1982), and must be absorbed by firms through the capabilities which they have accumulated over time (Cohen and Levinthal, 1990). Knowledge - especially technological knowledge- involves varying degrees of specificity, tacitness, complexity, complementarity, and independence (Winter 1987; Cowan, David, Foray 2000; Dosi and Nelson, 2010). From a dynamic perspective, it is essential to understand how knowledge and technology are created, how they are distributed and exchanged between firms, and how such processes can redefine industry boundaries.
- b. **Institutions.** The cognitive frameworks, actions and interactions of agents are influenced by institutions, which include norms, common habits, established practices, rules, laws, and standards. Institutions may be binding and more or less formal (such as patent laws or specific regulations versus traditions and conventions). Many institutions have national dimensions (such as patent laws or regulations concerning the environment), while others are specific to sectors (such as standards) and may cut across national boundaries (such as international conventions, or established practices).
- c. **Actors and networks.** A sector is composed of heterogeneous agents that include firms (e.g., innovating and producing firms, suppliers and users), non-firm organizations (e.g., universities, financial organizations, industry associations) and individuals (e.g., consumers, entrepreneurs, professionals and scientists). These heterogeneous agents are characterised by specific learning processes, competencies, beliefs, objectives and behaviour. They interact through processes of communication, exchange, competition, control, and cooperation. Thus, in a sectorial systems framework, innovation is a process that involves systematic interactions among a wide variety of actors for the generation and exchange of knowledge relevant to innovation and its commercialisation. Actors are individuals and/or organizations that “interact through processes of communication, exchange, cooperation, competition, and governance, and various institutions shape their interactions (norms, common habits, established practices, rules, laws, standards, etc.)” (Malerba, 2002). Under this framework, many actors generate,

and exchange knowledge related to innovation and its commercialisation. The sectorial innovation system undergoes changes and transformations through a co-evolution of its various elements (Nevzorova, 2021).

There are several limitations of the SSI approach. Firstly, interactions between various agents in the SSI are shaped by institutions at both sectoral and national levels. Therefore, delineating between national and sectoral boundaries is not easy. Furthermore, distinguishing the characteristics of these institutions (norms, routines, common habits, established practices, rules, laws, standards) at both levels is a challenge. Second, SSIs are also influenced by institutions at a global level. In some cases, the relevant geographical boundaries are global as well as sectoral and in such cases it is not easy to distinguish the boundary between them. Thirdly, the relationship between national institutions and sectoral systems could differ. That is, the same institution may play different roles in different countries, and thus may affect the same sectoral system differently in different countries. Finally, the nature of relationships and networks differ across sectoral systems and therefore it can be difficult and complex to compare them to each other (Baskaran, and Muchie, 2019).

No withstanding this, each of these components of a sectorial system has its own characteristics and its own set of dynamics which are important to disentangle to understand how innovation takes place. But each of these elements is also part of a broader system in which the interaction among the parts drives innovation and change.

Sectorial systems studies also expanded to the analysis of emerging and developing countries, as in Malerba and Mani (2009), Malerba and Nelson (2011), Luz and Salles-Filho (2011) and Muchie and Baskaran (2017), in which the cases of several sectorial systems in Asia, Latin America and Africa are examined. More recently catch-up by emerging and new leading countries in different sectorial systems has been examined by Lee and Malerba (2017 and 2020) and has been associated with opening of windows of opportunities and responses by firms and sectorial systems in catching-up countries and incumbent countries (see in this respect Giachetti and Marchi 2017, Morrison and Rabellotti 2017, Kang and Song 2017 and Lee and Ki 2017). The sectorial systems framework has also been adopted to examine China's catching-up in a variety of "green sectors" (Lema et al., 2020), such as solar photovoltaics (Binz et al., 2020), wind energy (Dai et al., 2020), biomass (Hansen & Hansen, 2020), and hydro energy (Zhou et al., 2020). In these sectors, the windows of opportunity for latecomers are primarily driven by institutional changes that favour

clean and renewable energy and by demand conditions (Lema et al., 2020).

The existing literature (e.g., Bhagavan, 1985; Desai, 1985; Prameswaran, 2004) on India's manufacturing sector deal with Science, Technology and Innovation (STI) aspects of innovation strategies such as research and development activities and creating access to explicit codified knowledge, and technical efficiency, etc. The innovation system combining a strong version of the STI mode with a Doing, Using and Interacting (DUI) mode can provide a better picture of innovative behavior of the firms (Jenson et al., 2007; Shekar, K. C., & Joseph, K. J., 2022).

## 2.3 System failure

As previously highlighted, the basic conceptual underpinnings of the SI approach are, first, that innovation does not take place in isolation and interaction is central to the process; second, that institutions are crucial to economic behavior and performance (Smith, 1996); and third, that evolutionary processes play an important role, they generate variety, select across that variety, and produce feedback from the selection process to variation creation (Hauknes and Nordgren, 1999).

In all these basic elements, systemic imperfections can occur if the combination of mechanisms is not functioning efficiently. This can translate into various types of system failure:

- Infrastructure failure, where there is a lack of formal institutions/institutional mechanisms as well as soft institutions, social norms, trust, values that hinder innovation.
- Institutional failure, where there is lack of networking/linkages among the different actors in the whole ecosystem.
- Network failure/Capability failure, which underscores the absence of the necessary capabilities of the actors to move up the value chain, adapt to new and changing circumstances etc.
- Directionality failure, where there is a lack of shared vision, collective coordination, regulation, targeted funding regarding the goal and direction of the transformation process.
- Demand articulation failure, caused by improper anticipation and learning about user needs, shaping innovation based on user needs, lack of instruments for supporting user-led and open innovation, novel innovations/solutions not finding enough space in public procurement.

- Policy coordination failure, due to a lack of multi-level policy coordination, horizontal and vertical coordination, across and within different systemic levels; between regional and national or between technological and sectoral systems, etc.
- Reflexivity failure, as a result of an insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance (Woolthuis, et al., 2005).

The systemic failures as presented above cannot be addressed directly, or by one actor alone. If policy makers want to use the framework, they will have to address groups of actors to make changes in the innovation system possible. Consequently, as opposed to the market failure approach for driving policy, a systems approach to innovation is seen as more robust (Bergek et al., 2010).

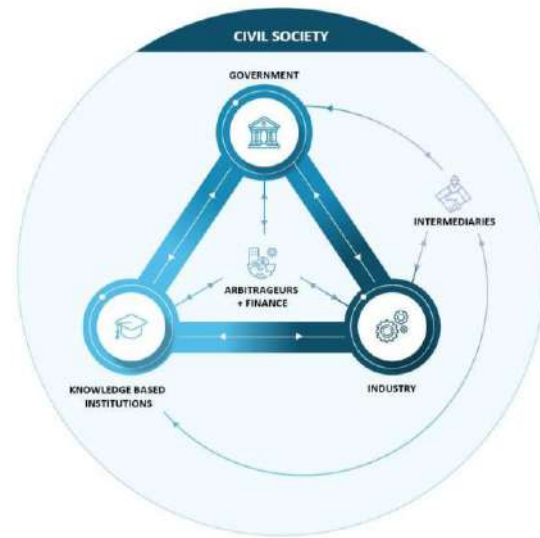
By using the systems framework as a tool for analysis, policy makers can identify: (1) where systemic failures occur; and (2) which actors should be addressed to make change possible. Most problems in the innovation system will not be uni-dimensional but will consist of a complex mixture of causes and effects and involve several actors. By using the framework, priorities can be given to the most stringent obstacles for innovation and thus also serve as a guideline to implement innovation policy.

## 2.4 The Triple Helix (TH) Model

Besides the systems approach, there are other tools that have the potential to offer similar facilitation for innovation at the sectorial level. The Triple Helix Model is advocated to be a powerful tool for linking universities to the rest. This can also be seen as a tool for operationalising the IS concept. However, this might require setting up a proper framework at a low scale to set the foundation for the running of the system, which is expected to be inclusive and socially embedded in the context of developing countries.

This interaction between government, universities and firms is addressed in the Triple Helix Model proposed by Etzkowitz and Leydesdorff (1997). This model is a descriptive construct of the components, interaction channels and functions or benefits of an effective NIS (Ranga and Etzkowitz, 2013; Santana, 2016).

**FIGURE 2: Triple Helix Model extension**



Etzkowitz (2002) states that interaction channels are necessary when firms and government are related with universities in knowledge-based economies. From a business perspective, the most important channels of transfer of knowledge are open science, property rights, human resources, projects of collaborative research and development (R&D) and networking among actors (Cohen et al., 2002; Hanel & St.-Pierre, 2006; Arza, 2010; Bekkers & Freitas, 2008; Ruiz, Corrales and Orozco, 2017).

The triple helix is effective in understanding the dynamics of innovation at the sectorial, regional, national or international level, as it provides a well-elaborated framework for understanding central inquiries in innovation processes, including a) What the key actors are and b) What the mechanisms of interactions are (Cai and Amaral, 2021). Traditionally, the literature on the Triple Helix Model has focused on the relationships between universities and knowledge-based institutions (KBIs), firms, governments, and hybrid organizations at the intersection of these three helices (Etzkowitz and Leydesdorff, 1995; Leydesdorff, 2001). Etzkowitz and Leydesdorff developed the Triple Helix Model to explain the dynamic interactions between academia, industry, and government that foster entrepreneurship, innovation, and economic growth in a knowledge-based economy (Etzkowitz & Leydesdorff, 2000).

According to the literature, the scope and intensity of the interactions between the three actors are reflected in varying institutional arrangements, referred to as Triple Helix Type I, II, and III (TH-Type I, II and III) (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2003, 2008; Ranga and Etzkowitz, 2013).

In the TH- Type I, the three helices are strongly defined, with relatively weak interactions. Institutionally, “the nation state encompasses academia and industry and directs the relations between them” (Etzkowitz and Leydesdorff, 2000: p. 111). New knowledge is produced only within universities and research centres. Hence, TH-Type I is largely viewed as a failed development model with not enough room for ‘bottom up’ initiatives, where “innovation was discouraged rather than encouraged” (Etzkowitz and Leydesdorff, 2000, pg.112). To achieve statist reform “the first step [...] is the loosening of top-down control and the creation of civil society where one is lacking” (Etzkowitz, 2003a, pg.304). Otherwise, there is minimal direct connection to the needs of society, which in turn discourages the introduction and diffusion of innovations in the economy (Martin and Etzkowitz, 2000).

Triple Helix Type II is characterised by decreasing direct control of the state on the functions of Type I with a shift of focus on fixing market failures. The mechanisms of communication between the actors are strongly influenced by and deeply grounded in market mechanisms and innovations (Nelson and Winter, 1982; Bartels, et al., 2012). The point of control is at the interfaces (Leydesdorff, 1997) and consequently, new codes of communication are developed (Leydesdorff and Etzkowitz, 1998b). Research is also carried out outside universities and research centres. As research becomes increasingly multidisciplinary and applied, societal needs have a direct influence on it (Etzkowitz and Leydesdorff, 2000; Martin and Etzkowitz, 2000; Ranga and Etzkowitz, 2013).

TH-Type II can be considered a ‘laissez-faire’ model of interaction “in which people are expected to act competitively rather than cooperatively in their relations with each other” (Etzkowitz, 2003, pg.305). To summarise and compare TH-Types I and II, “statist societies emphasise the coordinating role of government while laissez-faire societies focus on the productive force of industry as the prime mover of economic and social development” (Etzkowitz, 2008, pg.13).

Furthermore, in TH-Type III, the three actors assume each other’s roles in the institutional spheres as well as the performance of their traditional functions. With the emergence of TH-Type III, a complex network of organizational ties has developed, both formal and informal, among the overlapping spheres of operations.

The transformation of universities is of particular relevance. After having incorporated research as an additional mission beyond teaching, universities recognise their role in the pursuit of economic and social development (Etzkowitz and Leydesdorff, 2000; Webster, 2000; Ranga and Etzkowitz, 2013; Etzkowitz, 2008, 2017). Hence, universities take on entrepreneurial tasks such as marketing knowledge, increased technology transfers and the creation of spin-offs and startups, as a result of both internal and external influences (Etzkowitz, 2017; Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000). These entrepreneurial activities are assumed with regional and national objectives in mind, as well as financial improvements to the university and the faculty (Etzkowitz, et al., 2000). In doing so, universities cease to be ivory towers, disconnected and isolated from society, but interact closely with industry and government (Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000). In addition to the above, “firms develop an academic dimension, sharing knowledge among each other and training employees at ever higher skill levels” (Leydesdorff and Etzkowitz, 1998, pg.98), as well as increasing collaboration with knowledge-based institutions (KBIs). Improved university-industry collaboration is visualised through: i) an increased patenting output, particularly as they are a “repository of information about how the socially organised production of scientific knowledge is interfaced with the economy” (Leydesdorff, 2004); ii) the increase in university revenues from licensing (Perkmann and Walsh, 2007); iii) a greater proportion of industry funds making up university income (Hall, 2004); and iv) the diffusion of technology transfer offices, industry collaboration support offices and science parks (Siegel et al., 2003, in Perkmann and Walsh, 2007, pg. 4). Governments therefore create incentives through “informed trade-offs between investments in industrial policies, S&T policies, and/or delicate and balanced interventions at the structural level” (Leydesdorff, 2005). Phrased differently, there is a shift in the traditional role of policy from the facilitation of basic science to its ‘bridging function’. In a nutshell, the Triple Helix Type III assumes that the three spheres - universities, industry, and government - overlap, and their boundaries become more permeable. A complex network of organizational ties develops individuals and ideas move around the three helices, and synergies are maximised (Etzkowitz, 2002). Actors evolve and assume each other’s roles, with new hybrid organizations emerging at the interfaces, for example incubators, accelerators, science parks, technology transfer offices, venture capital firms, angel networks, and seed capital funds (Etzkowitz, 2000; Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2002; Ranga and Etzkowitz, 2013).

The Triple Helix Model has also been applied to the context of developing economies. Case studies document how innovation and learning processes differ in developing economies, what factors constrain the adoption of more integrated Triple Helix models, and how actors and mechanisms cope with these factors (Sarpong et al., 2017). In this regard, it has been noted that while the components of the triple helix do not change, the intensity and quality of their interactions are often weaker than in developed economies (Dzisah and Etzkowitz, 2008). Generally, in order to address such challenges effectively, through tailored and targeted policy interventions, there is the clear need for system level measurement.

## 2.5 Towards an Analytical Framework

Our framework for analysis of the ITASSI is grounded in the literature, but it extends the traditional model in two main ways and is referred to as Triple Helix (TH-Type IV) Type IV<sup>16,17</sup>. The TH-Type IV has the additional features of arbitrageurs (banks, financial institutions, venture capital and angel investors) and intermediary organizations (industry associations, institutions supporting technical change and incubators), as well as diffused ICT in the context of the fourth industrial revolution.

Arbitrageurs can be defined as venture capitalists, angel investors/ networks and knowledge brokers. They are essential for the innovation process as it requires internal and external knowledge for the development of new ideas, business models and types of companies. As such, knowledge brokers and venture capitalists fulfil this requirement through the provision of links, knowledge sources and even technical knowledge so that firms can improve their performance, in terms of survival rate, as well as accelerate and increase the effectiveness of their innovation processes (Zook, 2003; Baygan and Freudenberg, 2000). Their resource allocation role is based on the assessment of advantages in information asymmetries (Williamson, 1969, 1971, 1973) (Bartels, et al., 2012, pg.7). However, information asymmetry and uncertainty can lead to transaction problems. "Countries seeking to encourage the emergence and growth of entrepreneurial firms need to devise ways that reduce

transaction problems" (Li and Zahra, 2012, pg.95). It can be said that a combination of both formal institutions and (informal) cultural values can provide the proper incentives to reduce transaction problems. Arbitrageurs are therefore of vital importance as the innovation process requires internal and external intermediation (financial, knowledge, transacting and investment), and as such, complement the traditional Triple Helix Model.

Intermediaries are recognised as actors that place themselves in the middle of relationships between other actors, or actors that facilitate the process of interacting in exchange relationships. Four roles of intermediaries include: (a) consultant, providing information and advice in the recognition, acquisition and utilisation of the relevant intellectual property and technological capabilities; (b) broker, brokering a transaction between two or more parties; (c) mediator, acting as an independent third party who assists two organizations achieve a mutually beneficial collaboration and (d) resource provider, acting as an agent who secures access to funding and other material support for the innovation outcomes of such collaborations (Chunhavuthiyanon & Intarakumnerd, 2014; Chappin et al., 2008).

Nakwa et al., (2012) highlight the importance of intermediaries in transforming pre-existing inter-firm networks into more robust, dynamic, and sustainable system-oriented networks. In addition, Nakwa et al., (2012) indicate that "intermediaries play a sponsoring role at the policy level by channeling resources to industry; a brokering role at the strategic level by linking triple helix actors; and a boundary spanning role at the operational level by providing services that facilitate knowledge circulation".

Intermediary organizations are pertinent in facilitating the flow of knowledge, technology, and skills among the actors of the SI. Within this actor group, institutions supporting technical change (ISTC) promote knowledge generation, technology development and commercialisation; facilitators like industry associations establish and reinforce the links between system actors through networking; enablers such as industrial parks and incubators support with infrastructure, framework conditions, capabilities and related resources and funders (Letaba, 2019).

<sup>16</sup> Leydesdorff claims no ex-ante or necessary limitation to three helices for the explanation of complex developments, but instead propose that an N-tuple or an alphabet of (20+) helices can be envisioned. However, in scholarly discourse and for methodological reasons, one may wish to extend models step by step and as needed to gain explanatory power. (Leydesdorff, 2012).

<sup>17</sup> Civil society - comprising the activities of non-state organizations, institutions, and movements - has in recent years emerged as the major force for change in the realms of politics, public policy, and society both globally and locally. It is also recognized as an actor in the in the quadruple helix (Roman et al., 2020). Yet, despite the crucial importance of this political phenomenon to the principle and practice of democracy, it eludes definition and systematic understanding (Anheier 2004). The benefits of incorporating civil society within systems measurement, and hence policy craft include: i) the provision of bottom-up insights, particularly as civil society represents demand-side perspectives, such as innovation users and consumers; ii) supports the creation of social innovations, and legitimation and justification for innovations; iii) promotes commitment to and ownership of a development agenda. However, despite the aforementioned benefits civil society comprises a heterogeneous group of actors who must themselves be approached differently and therefor measurement is a challenge. It would be important to note that participation of civil society should be included for the policy selection and implementation process.



Table 2 below shows core actors, arbitrageurs and intermediary organizations by the function they perform in the Indian food and beverages sector. These functions span across the innovation value chain, namely: knowledge

generation and transfer; technology development, acquisition, and transfer; product development; testing service; commercialisation; and business development.

**TABLE 2: Examples of core actor, arbitrageur and intermediary organizations by function**

Function	Knowledge based institutions	Government	Intermediaries	Arbitrageurs (VCs, Angel Investors, NBFCs)
<b>Technology Development</b>	<ul style="list-style-type: none"> <li>CFTRI</li> <li>NIFTEM</li> <li>CSIR Labs</li> <li>Agricultural Universities (most relevant names?)</li> <li>Various start-ups who are actually developing the tech.</li> <li>WALMI</li> <li>ICRISAT</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Food Processing</li> <li>Ministry of Animal Husbandry</li> <li>Ministry of Agriculture</li> <li>FSSAI</li> <li>APEDA</li> <li>DST</li> <li>BIRAC</li> <li>Ministry of Fertilizer</li> <li>Ministry of Fisheries</li> </ul>	<ul style="list-style-type: none"> <li>Tea Board</li> <li>Coffee Board</li> <li>Indian Packaging institution FCI</li> </ul>	
<b>Technology Transfer</b>	<ul style="list-style-type: none"> <li>Science Park</li> <li>University-enterprise joint research centre</li> <li>University-owned enterprise centre</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Food Processing</li> <li>Ministry of Agriculture</li> <li>DST</li> <li>BIRAC</li> </ul>	<ul style="list-style-type: none"> <li>TIFAC</li> <li>FCI</li> </ul>	
<b>Technology Acquisition</b>	<ul style="list-style-type: none"> <li>-</li> </ul>	<ul style="list-style-type: none"> <li>FCI</li> </ul>		
<b>R&amp;D</b>	<ul style="list-style-type: none"> <li>National Agriculture &amp; Food Analysis &amp; Research Institute (NAFARI), Pune</li> <li>ICRISAT</li> <li>WALMI</li> <li>Central Rice Research Institute</li> <li>Indian Institute of Spice Research</li> <li>National Research Centre on Meat</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Food Processing</li> <li>Ministry of Health and Family Welfare</li> <li>BIRAC</li> <li>DST</li> <li>FICSI</li> <li>NIN</li> </ul>	<ul style="list-style-type: none"> <li>All India Food Processors Association</li> <li>Indian Chambers of Food and Agriculture</li> <li>Agricultural Economics Research Association (India)</li> <li>FICCI</li> </ul>	
<b>Knowledge Transfer</b>	<ul style="list-style-type: none"> <li>National Agriculture &amp; Food Analysis &amp; Research Institute (NAFARI), Pune</li> <li>National Research Centre for Grapes</li> <li>Central Rice Research Institute</li> <li>Indian Institute of Spice Research</li> <li>National Research Centre on Meat</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Food Processing</li> <li>State Food Departments</li> </ul>	<ul style="list-style-type: none"> <li>All India Food Processors Association</li> <li>Federation of Indian Export Organizations</li> <li>The Indian Salt Manufacturers' Association</li> </ul>	
<b>IP Protection</b>	<ul style="list-style-type: none"> <li>CFTRI</li> <li>NIFTEM</li> </ul>	<ul style="list-style-type: none"> <li>Patent offices</li> <li>WIPO</li> <li>Controller General of Patents, Designs &amp; Trademarks</li> </ul>		
<b>Infrastructure Development</b>	<ul style="list-style-type: none"> <li>FCI</li> <li>Food Parks</li> </ul>	<ul style="list-style-type: none"> <li>Ministry of Food Processing</li> <li>Ministry of Health and Family Welfare</li> <li>State Departments</li> </ul>	<ul style="list-style-type: none"> <li>APEDA</li> </ul>	

<b>Product Development</b>	<ul style="list-style-type: none"> <li>• CFTRI</li> <li>• NIFTEM</li> </ul>	<ul style="list-style-type: none"> <li>• National research &amp; development corporation</li> <li>• Ministry of Health and Family Welfare</li> </ul>		
<b>Human Capital Development</b>	<ul style="list-style-type: none"> <li>• CFTRI</li> <li>• NIFTEM</li> <li>• State-Level Universities</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> </ul>	
<b>Business Development</b>	<ul style="list-style-type: none"> <li>• Science Park</li> <li>• Incubator (examples?)</li> <li>• Industrial Park (examples?)</li> </ul>	<ul style="list-style-type: none"> <li>• National engineering research centre</li> <li>• Incubator (examples?)</li> <li>• Industrial Park (example?)</li> </ul>	<ul style="list-style-type: none"> <li>• Incubator</li> <li>• Industrial parks (example)</li> <li>• -</li> <li>• -</li> </ul>	
<b>Funding</b>	<ul style="list-style-type: none"> <li>• University-enterprise joint research centre</li> </ul>	<ul style="list-style-type: none"> <li>• Ministry of Food Processing</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> </ul>	
<b>Fund raising</b>	<ul style="list-style-type: none"> <li>• -</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> </ul>	
<b>Agenda setting</b>	<ul style="list-style-type: none"> <li>• Ministry of Food Processing</li> </ul>	<ul style="list-style-type: none"> <li>• Ministry of Food Processing</li> </ul>	<ul style="list-style-type: none"> <li>• All India Food Processors Association</li> <li>• Federation of Indian Export Organization</li> <li>• FICCI</li> </ul>	
<b>Testing &amp; certification services</b>	<ul style="list-style-type: none"> <li>• University-enterprise joint research centre (example?)</li> <li>• Universities (NIFTEM)</li> <li>• FICCI Lab</li> <li>• INFoLNET</li> </ul>	<ul style="list-style-type: none"> <li>• Standardisation Testing and Quality Certification Directorate</li> <li>• BRC Global Standard Certification</li> <li>• ISO</li> <li>• BIS</li> <li>• QCI</li> <li>• APEDA</li> <li>• EIC</li> <li>• NABL</li> <li>• FSSAI</li> </ul>	<ul style="list-style-type: none"> <li>• BRC</li> <li>• USFDA</li> <li>• Halal Certification</li> <li>• FOSTAC Training partners</li> <li>• GFSP</li> <li>• ITC-FSAN</li> <li>• EIA-PTH</li> </ul>	

Source: Letaba, Petrus (2019)

Compared to the Triple Helix Type III, our augmented version of the model also gives prominence to the fourth industrial revolution (4IR) and digital transformation through ICTs. Through the spread of digital information and ICT, a new technological wave and a new corresponding mode of development has emerged (Perez, 1983; Freeman and Louça, 2001; Mowery, 2009). Innovation activities shape and use ICTs with lagged but often large effects on productivity and innovation in both developed and developing economies (Paunov and Rollo, 2016; Hjort and Poulsen, 2017). The channels through which ICTs affect firms' productivity and innovation are multiple, and often difficult to disentangle. For example, ICTs can facilitate access to information and knowledge, fostering learning and knowledge flows, or ease communication among firms and SSI actors, thereby promoting collaborative projects. To make the most of these new technologies, countries have put in place several policies. However, often their design does not take full account of the local environment in which actors operate, suggesting a potentially large role for evidence-based policymaking in this area (Koria et al., 2014).

Today, ICTs are at the centre of what many believe to be the Fourth Industrial Revolution (4IR) (World Bank, 2016). Each of the actors in the Triple Helix Type IV has a specific role to play in the context of the 4IR. Using analytics and data, the 4IR allows firms to identify new opportunities, expand their businesses and tap into new markets. 4IR technologies enable firms to increase their productivity, provide better customer experience, and optimise resources.

Universities have a great role to play to make the 4IR a reality, particularly through fostering the development of future skills as well as acting as test beds for new technologies. The role of the government in the context of the 4IR is to facilitate the adoption of emerging technologies through support infrastructure and regulations (Kucirkova, 2019).

The adoption of the 4IR and digital transformation requires investments which could be satisfied with the help of arbitrageurs such as venture capital (Deloitte, 2018a). Innovative technologies are becoming more prevalent and venture capitalists are making even greater investments in them. Venture capital investments in 4IR-focused startups



have steadily increased, both in terms of size and number of deals. Globally, venture capital investments in this arena grew from approximately US\$ 600 million in 2014 to US\$ 2.3 billion in 2016, representing a 40% CAGR (Deloitte, 2018).

However, venture capitalists need to be mindful of conservative and risk-averse investment strategies that fail to consider a broad range of promising investments bias towards companies in specific narrowly defined industries. VCs should not conflate “risk averse” with prudent (Forbes, 2021). Regular communication between arbitrageurs and especially with industry and other actors such as KBIs, government and intermediaries can help VCs understand the dynamics of the sector and invest accordingly.

Due to the rapid changes in technologies linked to digital transformation and the 4IR, firms require the support of intermediaries as knowledge brokers. Intermediaries can ensure that knowledge spillover processes are more inclusive for firms and thereby contribute to developing their absorptive capacities. In addition, intermediaries have a vital role in building efficient technology transfer systems between actors of the system of innovation (Karlsen et al, 2022).

In light of the above, utilising the Triple Helix Type IV for measuring the Indian Food and Beverages Sectorial System of Innovation (IFBSSI) provides an evidence-based framework for identifying barriers and priorities, leading to the articulation of policies and targeted short, medium and long-term interventions.



# 3.

## Survey Methodology

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# Survey Methodology

The Indian Food & Beverages Sectorial System of Innovation (IFBSSI) Survey has been to obtain a holistic view of the SSI as basis for evidence-based innovation policy for the food and beverages sector, one out of the five sectors surveyed under the sectorial system of innovation component of the National Manufacturing Innovation Survey 2021-22.

Essentially, two basic forms of data collection exist, those with and those without an interviewer, or, phrased differently: interviews and self-administered questionnaires (De Leeuw, 2009 in Dillman ed). Interview surveys can either be administered in person or over the telephone. There is a great deal of variation in the use of these methods across countries, due to technical reasons, lack of infrastructure, or cultural norms (Dillman, 1978; Dillman, 1998). Self-administered questionnaires take on many forms and can be used in group or individual settings. A well-known example of a self-administered questionnaire is the mail survey, and its computerized equivalent, the Internet survey, which is the current norm (Raziano, et al., 2001; De Leeuw et al., 2003). Often a combination approach is used, particularly when there is the need to ask sensitive questions. All the taxonomical approaches mentioned are respondent orientated, and the method choice is complex and based on a delicate balance between the quality of the data acquired, time and costs.

The Internet-based approach was chosen in line with the reasoning of Koria, et al. (2012), that i) "... maximising the use of the budget, internet surveys can cover a much larger sample size than the conventional mail survey (Berrens, et al., 2003); ii) the time dimension associated with conducting web-based surveys is much lower in comparison to other forms (Cobanoglu et al., 2001); iii) the quality of retrieved data is higher in terms of non-response and the ability to include conditionality in a discreet manner (Olsen, 2009); iv) a higher reliability of data is achieved due to the reduced need for data entry (Ballantyne, 2004; and Muffo, et al., 2003)." (Koria, et al., 2012., pg.8); and v) the emergence of the COVID-19 pandemic restrictions during the implementation phase of the project which limited face-to face interaction.

## 3.1 Sample Selection

As per the "Theoretical Framework" chapter, the IFBSSI survey focuses on five core actor groups, namely: government (GOV), knowledge-based institutions (KBI);

arbitrageurs (ARB); intermediaries (INT) and industry (IND). The executive policy community, essentially the government (GOV), is represented by high-level officials (national and state level) in the relevant public institutions that are directly or indirectly responsible for innovation in the food & beverages sector. Knowledge-based institutions (KBIs) are represented by the heads of university faculties/ departments from the disciplines of engineering, technology and innovation, think-tanks, as well as both public and private research institutes (RIs). Arbitrageurs (ARB) comprise the venture capital, angel investors, and banks or other financial institutions and are represented by their respective heads or senior management. Intermediaries constitute industry associations and institutions supporting technical change such as regulatory bodies and are represented at the managerial level. The industrial community is represented by the CEOs of firms from the food & beverages sector.

### Procedure:

Non-firm actors, namely GOV, KBI, ARB and INT were sampled on a convenience basis. A frame was prepared for the food and beverages sector with around 200 relevant non-firm actors within GOV (20), KBI (30), ARB (50) and INT (100) which was treated as the universe and the sample. Sampling for firms (IND) were conducted through stratified random sampling across 28 states and 8 union territories, the five sectors, including the food & beverages sector from the National Industrial Classification (NIC) 10 and 11 (2008) and their respective firm sizes measured through a combination of turnover, investment in plant and machinery or equipment or employment.

The sampling frame for firm actors has been obtained from the "Annual Survey of Industries" (ASI) 2018-19 frame, the Centre for Monitoring Indian Economy's (CMIE) Prowess IQ database (2018-19) and the Department of Science and Technology's (DST) directory (2018-19) with a total of 37,444 firms from the food & beverages sector. After sampling, 4,206 firms were to be surveyed in the food and beverages sector.

The target population is broken down into similarly structured subgroups or strata, which are as homogeneous as possible, and form mutually exclusive groups. Appropriate stratification will normally give results with smaller sampling errors than a non-stratified sample of the same size and will make it possible to ensure that there are enough units in the respective domains to produce results

of acceptable quality. Wherever possible, turnover and investment in plant and machinery or equipment<sup>18,19</sup> as per

the 2020 MSME definition are used to calculate firm size as listed below.

**FIGURE: - Firm size classification**

Turnover	≤ 5 cr	Large	Medium	Small	Micro
	≤ 50 cr	Large	Medium	Small	Small
	≤ 250 cr	Large	Medium	Medium	Medium
	> 250 cr	Large	Large	Large	Large
Firm size classification		> 50 cr	≤ 50 cr	≤ 10 cr	≤ 1 cr
		Investment in plant and machinery or equipment			

The Government of India notification mentions that: If an enterprise crosses the ceiling limits specified for its present category in either of the two criteria of investment or turnover, it will cease to exist in that category and be placed in the next higher category but no enterprise shall be placed in the lower category unless it goes below the ceiling limits specified for its present category in both the criteria of investment as well as turnover.

In some cases, employment data was used as a proxy for firm size and the firms were reclassified post the survey.

- Large – 200 + employees (Kapoor., 2016, p.11)<sup>20</sup>
- Medium – 50 to 199 employees
- Small – 20 to 49 employees
- Micro – 0 to 19 employees (Kapoor., 2018, p.12)

#### Limitations:

- The data collection was impacted due to the covid crisis as businesses were closed. This has affected the survey response rate to some extent with an overall response rate of 64.25%, a firm response rate of 64.50% and non-firm response rate of 59%.
- Absence of a baseline for evaluating the performance of sectorial system of innovations in India as there are no prior surveys conducted along the same lines.
- The classification of firms into large, medium, small and micro is only a rough estimate given the universe is a

combination of 3 databases with the absence of similar parameters to measure firm size.

## 3.2 Data Collection

Due to the technical nature of the data to be collected it is imperative that the quality and integrity of information is ensured. Consequently, the outlined approach was utilised to maintain a level of rigour in the selection of enumerators from the Indian knowledge-based and technical institutions, as compared to standard data collection firms. The merits of the approach are outlined below:

#### Selection of enumerators and retention

Criteria: Given the highly technical nature of the information collected it is imperative that the selected enumerators were able to:

- Comprehend the specifics of innovation and systems of innovation.
- Effectively communicate innovation constructs to the target respondent.
- Guide the discussion as and when required, based on some degree of understanding and exposure to innovation in the sector, which will also enable them to support data analysis and reporting.
- Demonstrate experience in data collection and therefore be able to extract nuanced information.

<sup>18</sup> The expression “plant and machinery or equipment” of the enterprise, shall have the same meaning as assigned to the plant and machinery in the Income Tax Rules, 1962 framed under the Income Tax Act, 1961 and shall include all tangible assets (other than land and building, furniture and fittings). Available at: [https://msme.gov.in/sites/default/files/IndianGazette\\_0.pdf](https://msme.gov.in/sites/default/files/IndianGazette_0.pdf)

<sup>19</sup> Data on turnover and investment in plant and machinery or equipment is inflation-adjusted using CPI with base year 2015. Investment in plant and machinery or equipment values are adjusted for depreciation by taking their net values.

<sup>20</sup> Small firms are defined as those having less than 50 employees, medium firms have 50-199 employees and large firms are defined as those having 200 or more workers.

- Communicate in the relevant regional language of the focus state; and
- Summarise the findings and participate in further analysis of the data to support the UNIDO team.

Enumerators were trained on systems of innovation, technical aspects related to the food sector and data collection techniques with the Lime Survey® interface. In order to ensure data quality, the Lime Survey® enables real time tracking of enumerators to the respondent level through the back end. It also signals when surveys have been partially completed. The fact that an online interface is being used means that there is zero transcription error, that is, once the response to a question is given it is automatically updated to the database. In addition, spot checks from the response data are randomly taken to ensure data quality at the level of each individual enumerator is being maintained.

### 3.3 The Data Acquisition Survey Instrument (DASI)

The Data Acquisition Survey Instrument (DASI) for the IFBSSI Survey was created using an interactive multi-step process, and currently stands at its fourth iteration. The provenance of the earlier iterations of the tool can be found in the Ghana, Kenya and Cabo Verde National System of Innovation Survey Reports (Bartels and Koria, 2012, 2015; Koria, 2019). The current iteration, DASI-V4, saw the introduction of new actor-specific questions to support measurement at the sectorial level and to provide better insights at the actor level. This enhancement of the DASI allows for greater accuracy and impact of the policy recommendations in the short-, medium-, and long-term.

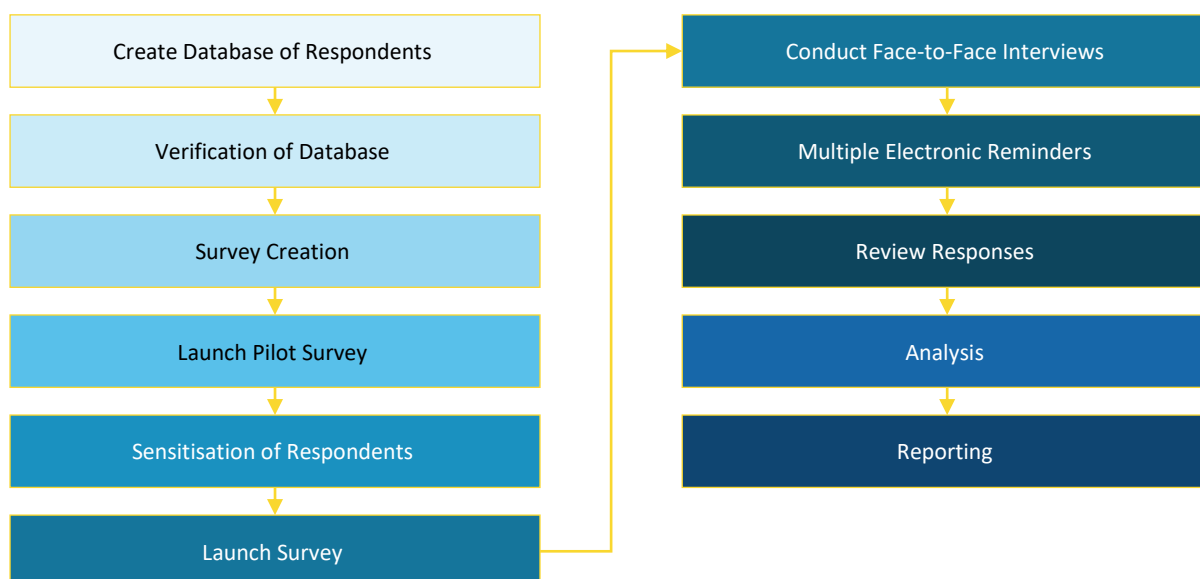
### 3.4 Survey Operationalisation

The launch of the survey was accomplished by using a combination of both the free open-source software tool Lime Survey® as well as, where possible, face-to-face interviews. The Lime Survey® tool is an advanced online survey system. The outputs from the verification protocol were uploaded into the Lime Survey® system and individual tokens were assigned to each target respondent. This restricted survey access solely to the targeted qualified individual respondent, therefore greatly enhancing the fidelity, reliability and validity of the results obtained.

As previously mentioned, the IFBSSI Survey was launched remotely once the initial critical mass of target respondent contacts had been gathered. The survey was remotely and non-intrusively managed via the Lime Survey® interface. Electronic reminders were sent out to the target respondents who had only partially completed or not responded at all. This process was facilitated by the structure of the Lime Survey® back-end, as the system logs the exact date and time at which the survey was accessed and to what degree it was completed.

For those who had not accessed the survey for a long period, a follow up was made telephonically to monitor any potential technical difficulties. Once responses were completed, they were automatically uploaded into the survey response database. On completion of data collection, the survey responses were analysed with the planned statistical analysis in mind. Figure 3 shows the steps associated with the data collection process.

**FIGURE 3: Operational Methodology**



### 3.5 Secondary Data Collection

In addition to the primary data collection undertaken it is crucial to gain a view of what is being presented in the form of secondary sources at the sectorial level, particularly those from the government. The secondary sources that were analysed comprised qualitative material consisting of policy documents, government budget statements, development strategies and action plans at the national and sectorial levels. The purpose of analysing these documents was to gain an understanding of the policy direction that the Government of India is taking with respect to innovation in the food and beverages sector. Phrased differently, is there convergence or divergence between what is presented within policy documentation from the actual results obtained? The results of the analysis

are presented in the “Results and Analysis” chapter of this report.

### 3.6 Stakeholder consultation

In order to garner preliminary insights into the results obtained from the survey, a stakeholder consultation was undertaken. Results were presented and discussed with sector experts and practitioners in order to understand whether or not the observations were meaningful. The platform provided an opportunity to orient the report writing through linking the findings to specific case examples as well as highlighting any supporting secondary research that may have been conducted at the national level. The process was important for the identification of any potential outliers in the results.



A close-up photograph of a food processing facility. In the foreground, a worker's hand wearing a blue nitrile glove is sorting through a large pile of fresh raspberries on a light-colored wooden or plastic surface. Another worker's hand, also in a blue glove, is visible in the lower left, reaching towards the fruit. In the background, another worker in a blue uniform and blue gloves is partially visible, working on a similar surface. The scene is brightly lit, and the raspberries are a vibrant red color. The overall atmosphere is one of a clean, industrial food production environment.

4.

## Manufacturing Landscape in the Food & Beverages Sector

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# Manufacturing Landscape in the Food & Beverages Sector

## 4.1 Indian Food & Beverages Sector: Structure and Dynamics

The Indian food processing industry is a sunrise sector, with a food ecosystem offering huge opportunities for investments in the food retail sector through favourable economic policies and attractive fiscal incentives. Its output is expected to reach US\$ 535 billion by FY 2025-26. Currently, it has a 10.4% share in exports and a 11.6% share in employment, with the unregistered food processing sector employing 5.1 million people<sup>21</sup>. The sector had foreign direct investment (FDI) equity inflows of US\$ 709.72 million during financial year (FY) 2021-22, and the total FDI received from April 2000 to June 2022 was US\$ 11.34 billion. The exports of agricultural and processed food products rose by 30% in the first quarter of the current FY 2022-23 in comparison to the same quarter in FY 2021-22. India's food processing market is estimated to grow to US\$ 470 billion by 2025<sup>22</sup> as Tier-II and Tier-III cities will replicate the trends seen in metropolitan cities, by consuming more processed food.

The major sectors comprising the food processing sector are grains, sugar, edible oils, beverages, and dairy products (Coinmen Consultants, 2019). India is the world's largest producer of spices, milk, food grains, fruits, vegetables, and pulses. It is the largest producer, consumer, and processor of cashew nuts. "Pradhan Mantri Kisan Sampada Yojana" (PMKSY) is one of the Government of India's flagship schemes with an allocation of INR 6,000 crore. So far, 41 mega food parks, 356 cold chain projects, 68 agro-processing clusters, 320 proposals under creation/expansion of food processing and preservation capacities (CEFPPC), 61 backward/ forward linkages projects and 6 Operation Green projects across the country have been approved (Invest India, 2022). The key sub-segments of the food processing industry are fruits and vegetables, poultry and meat processing, fisheries, food retail, and the dairy industry (Invest India, 2022). The total horticultural production in FY 2021-22 is estimated to be 341.67 tonnes. India ranks 1<sup>st</sup> in milk production and

contributes a share of 23% of global milk production, growing at a compound annual growth rate (CAGR) of 6.2% to reach 209.96 metric tonnes in FY 2020-21. India ranks 3<sup>rd</sup> in global egg production with a per capita availability of 91 eggs per annum in FY 2020-21 (Economic Survey, 2021-22). The fisheries sector grew at an impressive growth rate of 14.3% from FY 2019-20 to FY 2020-21. Fish production has achieved an all-time high of 16.19 million metric tonnes during 2021-22<sup>23</sup>. The marine products exports touched an all-time high of US\$ 7740 million during FY 2021-22. Despite the heavy odds that confront this sector it has observed a 30% growth over the previous financial year. The United States, China and Japan are key export destinations comprising 63% of global exports (MPEDA, 22).

## 4.2 Exports of Primary Processed Food grains and Cereals

India's quest for expanding the footprint of cereals as primary processed foods exports through exploring new opportunities in countries or markets has started to yield results. The sharp spike in exports of mainly rice (basmati and non-basmati), wheat and other cereals in 2020-21 is attributed to synergies and collaboration between various stakeholders – farmers, millers, exporters, and government agencies – in boosting exports. The total volume of exported rice was only 188 metric tonnes and 197 metric tonnes in 2018-19 and 2019-20 respectively while the volume shipment rose to 153 thousand tonnes in 2020-21. Wheat exports did not take place in 2018-19 but rose to 148 thousand tonnes in 2020-21. Only 4 metric tonnes of grain were exported in 2019-20, however, exports of other cereals (excluding rice and wheat) were shipped in substantial quantity to newer destinations (Sudan, Poland, Bolivia, Colombia, Congo Democratic Republic and Ghana) in 2020-21; India did not export cereals other than rice and wheat to these six countries in 2018-19. Only 102 metric tonnes of cereals other than rice and wheat were exported in 2019-20, which rose to 521 metric tonnes in 2020-21 (Press Information Bureau, 2021<sup>24</sup>). As per the 4<sup>th</sup> Advance Estimates, the estimated production of rice is 130.29 million tonnes, wheat is 106.84 million tonnes, and nutri

<sup>21</sup> National Sample Survey Report, 73rd Round, Jul 2015-Jun 2016.

<sup>22</sup> Sourced from: <https://www.investindia.gov.in/sector/food-processing>

<sup>23</sup> Sourced from: <https://pib.gov.in/PressReleaseSelfFramePage.aspx?PRID=1858281>

<sup>24</sup> "India expands its cereals exports footprints through shipping rice, wheat and other cereals to newer destinations: Overall exports of cereals have seen a sharp spike in 2020-21", Press Information Bureau, Release ID: 1729115 date d21st June 2021. Available at: <https://pib.gov.in/PressReleasePage.aspx?PRID=1729115>

/coarse cereals is 50.90 million tonnes for 2021-22. During the same year, India exported 11 million metric tonnes to become the second largest sugar exporter in the world, earning about INR 40,000 crore worth of foreign exchange for the country. India also ranks 8<sup>th</sup> globally in meat production which has increased from 6.69 metric tonnes in 2014-15 to 8.80 metric tonnes in 2020-21 (Invest India<sup>25</sup>).

India is the world's largest producer of milk, pulses and jute, and second largest producer of rice, wheat, sugarcane, groundnut, vegetables, fruit and cotton.<sup>26</sup> However, food is being wasted at harvest point and during transportation so the wastage level in perishables is currently very high. There is an impetus by the government to bring advanced technologies into the supply chain to reduce wastage in the value chain. For this purpose, private sector participation is promoted in the manufacturing segment of the food processing industry. Foreign direct investment of up to 100% is allowed subject to government approval. A 2,000 crore INR fund was allotted for the mega food project/s in India. A 100% tax exemption is extended to such mega food parks for a period of five years from their initial operation. In addition to a reduction in basic customs duty from 10% to 5%, there is a reduction of excise duty on refrigerated containers from 12.5% to 6 %<sup>27</sup>. There is also a service tax exemption on the pre-conditioning, pre-cooling, ripening, waxing and retail packing, and labelling of fruits and

vegetables besides the transportation of food grains including rice and pulses, flour, milk and salt by rail, vessels, or road<sup>28</sup>.

To facilitate imports and exports, a single window customs clearance has been implemented, whereby 6 partner government agencies have been integrated allowing the seamless exchange of information. A food map identifying surplus and deficit areas of various agricultural produce has been developed and made available by the Ministry of Food Processing Industries that will aid investors in identifying the availability of raw materials in various regions.

The past initiatives of the government have included addressing challenges in the supply chain, cold chain, logistics, and storage through promoting greater and more effective participation by private players. In this context, the development of forward and backward linkages, the approval of mega food park projects and addressing financing challenges have been the focus. Currently, there are 22 mega food parks in India, the number already completed, implemented or under consideration are shown in Figure 4 below. Those with a black square are fully operational, a green circle denotes final approval and a yellow signifies in-principal approval. There are six state government food parks (shown with red circles), and 11 private player operated mega food parks (shown with sky blue circles).

<sup>25</sup> Sensharma, Sandipan. Invest India Snapshot on Food Processing Industry. Available at: <https://www.investindia.gov.in/sector/food-processing>

<sup>26</sup> Sourced from: <https://www.fao.org/india/fao-in-india/india-at-a-glance/en/#:~:text=India%20is%20the%20world's%20largest,%2C%20vegetables%2C%20fruit%20and%20cotton.>

<sup>27</sup> Sourced from: <https://pib.gov.in/newsite/PrintRelease.aspx?relid=156058>

<sup>28</sup> Sourced from: <https://www.cbic.gov.in/resources//htdocs-servicetax/mega-exemption-notfn.pdf>

**FIGURE 4: State-wise distribution of mega food parks by implementation status**



Figure 5<sup>29</sup> shows the project components of the mega food park model. It includes farmers' groups, self-help groups and individual farmers. There are field collection and primary collection centres that conduct specific activities in addition to central processing centres (CPCs). The land

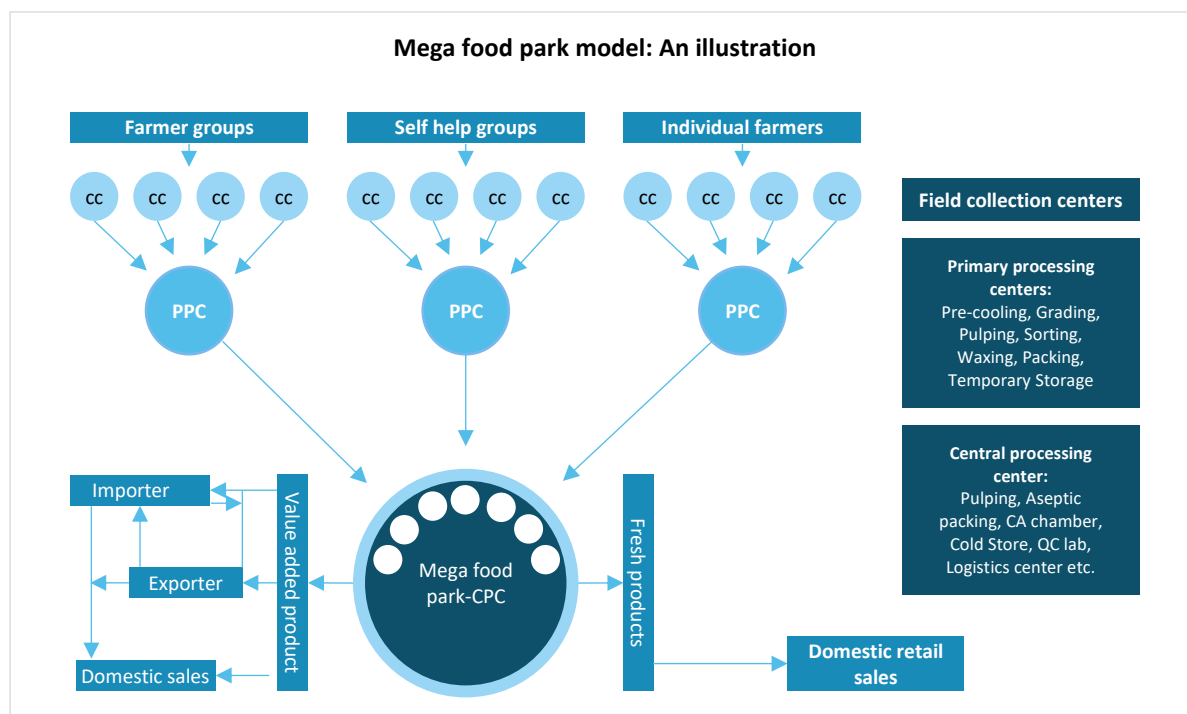
requirement for establishing a central processing centre is around 50-100 acres, however the actual requirement varies from project to project, depending on regional variation. On average, it is expected that each project will have around 25-30 food processing units. It is important to

<sup>29</sup> Sourced from: Ministry of Food Processing Industries.

note that the units in mega food parks do not own the land, which is why they cannot use land as collateral to get funds for investment in technology and equipment. Hence,

innovation in these units would depend crucially on government support.

**FIGURE 5: Project components of the Mega Food Park Model**



### 4.3 Challenges and Barriers in the Indian Food Processing Industry

The Indian food processing industry comprises two key segments - processed foods sold in packaged or unpackaged condition and value-added processed foods. These products have a short to medium shelf-life, depending on regional variations in storage conditions at value chain stages, so the challenges of contamination arise with processed foods. The value-added processed foods contain preservatives and therefore have a better shelf-life. Figure 6<sup>30</sup> below shows the key challenges that the industry currently faces including: the seasonality of operations and low-capacity utilisation, gaps in connection between production and processing, lack of uniformity in quality across suppliers, gaps in supply chain infrastructure for primary processing and storage, as well as distribution facilities. The GoI offers the “Krishi UDAAN 2.0 Scheme”, providing incentives for air transport of agriproduce. Challenges within the farm level, such as: low yield and

inadequate quality of produce, the rain-dependent nature of farming with conventional methods of farming, a lack of knowledge about the right inputs and prices, a lack of proper logistics, handling facilities or proper cold storage facilities, and improper grading and sorting make modernisation difficult. Food wastage stood at US\$ 1.5 billion during 2019 (Confederation of Indian Industry Report on Indian Food processing industry, 2019<sup>31</sup>). At the distribution level, the high cost of transportation, packaging, and cold chain, limited government support, fragmented supply chain with multiple intermediaries and lack of product traceability, inadequate information technology and communication support and poor coordination between farmers and processing units are key challenges. On the demand-side, key challenges in increasing consumption of processed foods are the lack of standardisation in food processing, lack of knowledge about balanced diets and nutrition along with cost-of-living pressures, income disparity and increasing incidences of lifestyle diseases (often attributed to processed foods) (Singh, Daultani and Sahu, 2021). The Indian food

<sup>30</sup> Sourced from: Gauravendra Singh, Yash Daultani and Rajendra Sahni (2021), “Investigating the barriers to growth in the Indian food processing sector”, OPSEARCH (2022), Volume no. 59, pp. 441-459, DOI: 10.1007/s12597-021-00553-1.

<sup>31</sup> “Indian Food Processing Industry-Trends and Opportunities”, Confederation of Indian Industry, Jubilant Bhartia Centre for Food and agriculture excellence. Available at: <https://face-cii.in/wp-content/uploads/2021/09/Food-Processing-Report-2019.pdf> (Last accessed on November 25, 2022).

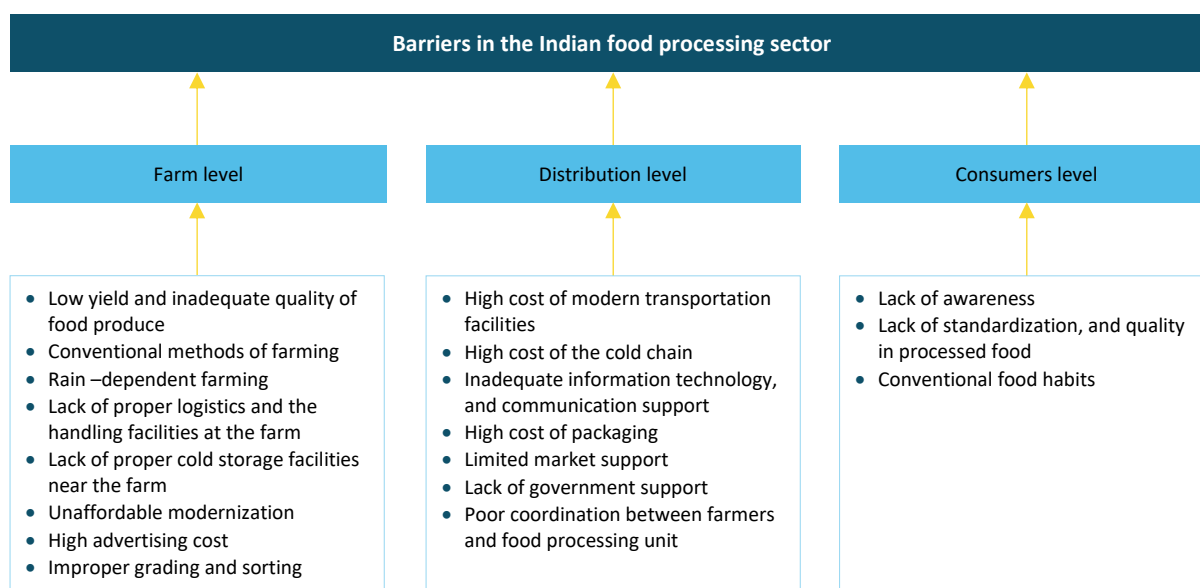
processing industry currently processes only 10% of its agricultural output, including the processing of fruits and vegetables at 2% and milk at 35% (Confederation of Indian Industry Report, 2019).

Rapid population expansion in India is the main factor driving the agri-food industry. The rising income levels in rural and urban areas, which have contributed to an increase in the demand for agricultural products across the nation, provide additional support for this. In accordance with this, the market is being stimulated by the growing adoption of cutting-edge techniques including blockchain, artificial intelligence (AI), geographic information systems (GIS), drones, and remote sensing technologies, as well as the release of various e-farming applications.

In terms of the challenges posed by the socio-economic profile of consumption of processed foods in India, particularly consumer spending and habits, the pandemic

has impacted the consumption patterns of the Indian population. As we recover from the pandemic, consumer spending in India will continue to grow in 2021 (post the pandemic-led contraction), expanding by as much as 6.6%<sup>32</sup>. The Indian food industry is therefore poised for huge growth, increasing its contribution to world food trade every year due to its immense potential for value addition, particularly within the food processing industry. The Indian food processing industry accounts for 32% of the country's total food market, is one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth (IBEF, 2021). However, given the barriers and challenges faced by the industry, reducing food losses, increasing productivity improvements, and extending the shelf-life of products will all play key roles and can only be achieved by involving supply chain stakeholders and optimising the supply chain on an end-to-end basis.

**FIGURE 6: Barriers in the Indian food processing industry**



Source: Singh et. al. (2022)

#### 4.4 The Technology-Shift in the Indian Food and Beverage Manufacturing Industry

The food processing industry is key to addressing food security concerns through improving productivity gains, value addition and the reduction of wastage. Food security mandates, according to the Rome Declaration 1996, involve not only provisioning issues, but also quality control and standards. From a historical perspective, the traditional focus was on food integrity and safety (until the 1950s),

enhancing flavours (1950-1980) and then health (from 1980-2000). However, the current evolutionary phase relates to the promotion of the “health of society” (Silva et al, 2018; Augusto, 2020). Industry 4.0 has a promising role in this context through application across a range of business functions, with a strong impact on products, processes, factories, and supply chains (Hasnan and Yusoff, 2018; Manavalan and Jayakrishna, 2019). The Internet of Things, robotics and automation, when introduced in production processes primarily increase operational efficiency (Bortoluzzi et al, 2020).

<sup>32</sup> Sourced from: <https://www.thehindu.com/business/Economy/indias-consumer-spending-to-return-to-growth-in-2021-fitch-solutions/article33213500.ece>

The low adoption of food processing overall and the bottlenecks that exist, in terms of the infrastructure, mean that there is an urgent need for addressing the challenges that this industry faces. In addition, the food processing industry has huge sustainability implications. Consumer trends towards healthier, more sustainable food accompanied with a rise in global food regulation around food safety and an increase in smaller, more personalised production methods have led to the adoption of Industry 4.0 technologies in the food sector.

The impact of the pandemic on this industry was considerable, in terms of the change in demand of restaurant products and staple foods (Lyat Avidor Peleg, 2021). The impact on supply chains coupled with vast swings in consumer demand led to shifts in demand from plant to plant. In developed countries, the industry was much further along digitally than several manufacturing verticals before the COVID-19 pandemic began. A significant number of plants already used automated equipment items such as ovens, processors, and cold chain storage units equipped with sensors in those developed countries. But when the pandemic began, few of them had smart devices that shared data with each other and a broader integrated data analytics system, or the connectivity that enabled remote operations. According to some studies, 73% of food and beverage companies in developed countries have continued or increased their investment in digital technologies, with supply chain operations (51%), data collection (38%), and improved business analytics (37%) standing out as the primary use cases of such digital manufacturing technologies. A leading issue for this (79% of food and beverage companies) is sustainability, as consumers seek better traceability and visibility (Global Food and Beverage Industry Trends Report<sup>33</sup>). In this regard, knowledge as to the environmental footprint and origins of the product are key information that consumers typically desire. In turn, these pressures travel to the food and beverage manufacturing plants, manifesting in improved supply chain solutions aimed at addressing the challenges that over-extended supply chains have posed during the pandemic. The adoption of tools ensuring greater transparency at the plant level, for both upstream and downstream activities, results in ensuring quick responses to requests for provenance in addition to identification and response to bottlenecks before they cause serious delay or a shortage in raw materials. In response to consumer demands for environmentally friendly manufacturing processes, plants

have adopted the use of predictive analytics solutions to help with efficiency gains, cut emissions, and reduce energy use and wastage of resources. Newer packaging equipment and methods allow companies to reduce the amount of packaging to meet the demands for more environmentally friendly manufacturing.

In addition to demands for green, sustainable manufacturing practices, food and beverage companies are focused on improving food safety. According to the Food and Agricultural Organization's (FOA) 2019 "Food Safety Report"<sup>34</sup>, 600 million or 10% of the global population becomes ill due to consuming contaminated food and 4,20,000 people die as a result. Public health organizations around the world are tightening food safety regulations, while manufacturers are highly aware of the disastrous impact that food recalls, or worse, food poisoning incidents, can have on their reputation. Several digital technologies that address food security are robotic process automation (RPA), better hygienic practices like cleaning-in-place technologies to monitor microbial levels and improving the reliability of cleaning protocols. In addition, improvements in supply chain visibility, through the use of industrial Internet of Things (IIoT) devices like temperature sensors, increase the confidence that perishable food and materials have been kept in good condition, while logistics logging tracks every step of the shipment until delivery.

Like other verticals, food and beverage plants found that the pandemic forced them to adopt technologies that enable employees to work from home and production to continue without disruption, such as cloud project management and communication tools; machine learning (ML) and big data for predictive maintenance; IIoT devices together with edge computing and augmented reality (AR) to support digital twins (Tzachor, Richards and Jeen, 2022); and robotic process automation on the factory floor. The use of digital twins through virtualisation of living or non-living physical entities, enabled by improvements in computing capabilities, exist as computer simulated models.

The deployment of sensors that detect biological, chemical, and physical properties of objects on a real-time basis ensure that the digital counterparts of these measured objects are live and accurate (Niederer et al., 2021). In such cyber physical architectures, changes occurring within the physical modify its virtual twin simultaneously and continuously. The repurposing of this digital twin technology addresses predicaments such as climate change

<sup>33</sup> Global Food and Beverage Industry Trends Report, Aptean and Reuters Events. Available at: <https://lp.aptian.com/rs/181-TRF-125/images/Aptean-Global-2020-Food-Beverage-Trends-Report.pdf?aliid=eyJpIjoIc3R5Y5YzhSNEo2WCIsInQIiCa3NrcE0xd1ZzeTR1bEhXWnZ3ZlRBT0ifQ%253D%253D>

<sup>34</sup> "The State of Food and Agriculture - Moving Forward on Food Loss and Waste Reduction", ISBN 978-92-5-131789-1. Available at: <https://www.fao.org/3/ca6030en/ca6030en.pdf>



and extreme weather in complex natural environments. Reinforcement learning (RL), an emerging subfield of AI that enables autonomous agents to make decisions in complex systems, can be deployed in digital twins to advise optimal control strategies to the physical counterpart. Reinforcement learning agents take the current state of a system as input and predict future action sequences that optimise system behaviour (Sutton and Barto, 1998). Digital twins allow agents to simulate many control sequences to determine their alignment with the control objective and advise the physical system accordingly. This combination of virtual replicas with advanced decision-making will have a transformative impact on the agri-food sector, addressing collective action problems like malnutrition, food waste and greenhouse gas emissions that affect developing countries disproportionately. Applications across key supply chain steps namely: (a) agricultural inputs, (b) primary agricultural production, (c) storage and transportation, (d) food processing, (e) distribution and retail, and (f) consumption are promising. The production of agricultural inputs like fertilisers and pesticides have a significant carbon footprint. Measures to improve heat conversion efficiency in power plants supporting the manufacture of these inputs can help achieve carbon intensity reduction mandates.

Their application at molecular, cell, tissue and organ levels can simulate crops precisely and allow stress-testing of these crops. These will help support seed improvements for climate resilient staples. These developments have applications in precision agriculture. In addition, the digital twin technologies have potential in addressing animal health, farming resource-efficiency and biodiversity loss. Even so, the applications in storage and transportation, particularly controlling storage conditions hold good potential for ventilation management. Cold chains of perishable produce, where fruit, vegetable, dairy, meat and seafood products are pre-cooled and provisionally stored in refrigerated facilities, use computer simulations that advise on energy efficiency measures to reduce carbon emissions. Paired with sensing technologies, digital twins can be integrated across food processing and packaging facilities that convert agricultural commodities, such as corn or cattle, to ingredients and end-user food products, including tinned vegetables, meat cuts, ready meals, and confectionery. They can support industrial ecology approaches to prevent food loss, in the same way they have been used to enhance circular economy applications in construction manufacturing.

Furthermore, their deployment in smart manufacturing plants to monitor ingredient delivery schedules, plant throughput, ingredient wastage, operator work schedules and demand forecasts can address demand-side

fluctuations in small batch processing, thus enabling personalised manufacturing, reducing food wastage.

These technologies can be used to monitor the location of delivery vehicles across the road network, food inventory in retail stores, food embodied emissions traffic, weather, and shelf-life of food in transit. The modelling of the cold chain on an end-to-end basis can help understand food quality on an in-store arrival basis. Using sensitivity analyses on these models, fruit shelf-life can be lengthened by optimising shipping conditions. Thus, reinforcement learning (RL) agents are used to optimise supply chain distribution to maximise producer profit and repurposed to maximise resource efficiency (Chen et al, 2021). Agrifood stakeholders must however be cognisant of four techno-economic limitations currently associated with the deployment of digital twins.

Firstly, robust virtual replicas rely on two elements: (a) appropriate sensor coverage and (b) model uncertainty quantification. For advanced decision-making systems to recommend optimal control strategies using a digital twin, its sensors must be sufficiently predictive of the agent's objectives. Even with sufficient sensor coverage, digital twins can only approximate the physical system meaning its state representation and future predictions are uncertain. In response, there are recommendations for building digital twins using Bayesian methods, but robust methods for dealing with uncertainty and decision-making remain an open challenge. In the same vein, setting 'live' replicas of entire supply chains that encompass re-distribution centres, such as food banks and soup kitchens in lower-income communities, would require hefty investments in data architectures, including cloud computing and on-premises sensors. However, it is likely that private firms at the forefront of research and development on digital twins would lack incentive to invest in cyber-physical systems that promote ecological and humanitarian causes, such as agro-biodiversity and food rescue that yield no direct financial returns. This may stifle the dissemination of digital twins for the agrifood sector transformation, particularly in areas where digital innovation is needed the most.

Secondly, designing digital twins that are robust to periods when sensor data is inaccessible requires technical innovation and is an important barrier to scaled deployment. Thirdly, modelling flaws are introduced in design, not through human error in coding or merging error-free, but discordant algorithms or data. A small notational error in the code of a computational model used for predictive maintenance of an irrigation system, for instance, could result in ill-informed decisions leading to crop yield failures and produce loss (Tzachor et al, 2022).

Fourthly, the lack of common modelling standards for digital twins might create compatibility difficulties in integrating separately created models. In particular, the expertise, methods and infrastructure involved preclude the utilisation of digital twins in lower-middle income economies—where the greatest number of small landholders operate, rural credit markets are immature, agricultural productivity is low, food spoilage and waste are widespread, and malnutrition is prevalent—much in the same way, Green Revolution technologies have bypassed the most vulnerable (Pingali et al, 2012). The development of advanced electronic, information, and manufacturing technologies is changing the production process of companies, which transforms traditional manufacturing into intelligent manufacturing, increasing the competitiveness and flexibility of organizations (L.M.A.L. dos Santos et al, 2021). Digital transformation and innovation processes are also making their way into the food industry, giving rise to Agriculture 4.0.

India is a large exporter of food products but of late the products are getting rejected in developed country markets due to the lack of traceability, not adhering to food safety requirements, contamination in the supply chain, etc. Industry 4.0 can help to mitigate this. Leading companies are therefore moving towards an integrated, automated system that handles demand forecasting, production scheduling, process configuration, maintenance planning, inventory management, supply chain Organization, and fulfillment. Since manufacturing industries are in a transition phase of Industry 4.0, they should be aware, ready, and capable of coping with the challenges that arise in this context. Key implementation barriers include the high cost of implementation, lack of knowledge about information technology systems, cybersecurity, data privacy, an unskilled workforce, poor value chain integration, uncertainty about economic benefits, challenges in data management and quality, lack of secure standards and norms, lack of infrastructure, the organizational and process changes required and employment disruptions, besides resistance to change (Kumar, Bhamu and Sangwan, 2021; Kamble et al, 2018).

Dependent barriers<sup>35</sup> like job disruptions and resistance to change, linkage barriers<sup>36</sup> such as poor value chain integration, cybersecurity challenges, high investment requirements, lack of infrastructure, data management and data quality challenges and lack of secure standards and norms appear germane. Driving barriers<sup>37</sup> such as unclear economic benefits and an unskilled workforce are considerably important. Resistance to change appears at

first level barriers and job disruptions at the second level, while the third level is occupied by the remaining linkage barriers. The lack of infrastructure is at the root level and therefore is the most significant barrier in the adoption of Industry 4.0 technologies. Successful implementation of Industry 4.0 can take place only if the manufacturing organizations have sufficient and capable technological infrastructure like reliable high-speed connectivity, uninterrupted energy supply, and the IoT architecture for cyber-physical systems in their manufacturing environment. The need for skilling the workforce arises as the next most important factor, as well as the integration of the value chain networks of suppliers and partners on a seamless basis.

In addition, there is a need to assess the economic benefits of adopting these technologies in their product and service offerings. Poor value chains may lead to high investment in addition to data quality and management issues. There is a need to develop digital infrastructure by governments and for research organizations to reveal the benefits and advantages of these technologies. The development of skills through capacity building must be focused on by universities, academic institutes and research organizations with regard to: sensor technologies, cyber security, machine-machine-human integration, data analytics, business intelligence, collaborative robotics, cyber-physical systems, the IoT, etc. In view of the challenges posed in the developing country context by missing links between production and processing and the barriers at the farm level and distribution level, there is an increasing mandate for reducing wastage and food productivity gains. In view of the problem of food wastage, there is a need for optimising the food processing operations, especially in manufacturing. Given the informational and communication challenges in processing, there is a need to implement digital manufacturing that can address these challenges.

On the sustainability front, there is a need to identify and measure sustainability indicators on a dynamic basis. In addition, adaptability to change, high levels of observation and skills are necessary. The technology of digital twin's answers to the real-time monitoring of such indicators during storage and transportation. The IoT technology can collect and transmit data with flexibility and scalability which justifies its use for developing a sustainable agricultural food supply chain. These technologies can deliver the necessary informational challenges that arise in this context, provided the barriers are overcome.

<sup>35</sup> Dependent barriers are those that demonstrate weak driving but strong dependence power.

<sup>36</sup> Linkage barriers are those that demonstrate both strong driving and dependence power.

<sup>37</sup> Driving barriers are those having strong driving power but weak dependence power.



# 5. Policy Landscape

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## Policy Landscape

When India faced an acute food shortage during World War II, a new Food Department was created under British rule. Soon after independence, on 29th August 1947, it was re-designated as the Ministry of Food, which was later merged with the Ministry of Agriculture to constitute the Ministry of Food and Agriculture, for greater administrative efficiency and economy (Department of Food and Public Distribution, 2022). In 2015, the nomenclature was further changed to the Ministry of Agriculture and Farmers Welfare bringing agriculture, dairying and fisheries under its ambit while food processing came under the Ministry of Food Processing Industries (MoFPI) (Department of Agriculture & Farmers Welfare Organizational History Document, 2017). In India the food industry is comprised of food production and food processing industries. It encompasses all activities related to the manufacturing and processing of food products and beverages and has a quintessential role in linking Indian farmers to consumers in the domestic and international markets.

India has made tremendous progress in providing food security to its population and becoming self-reliant in agriculture. Accordingly, the focus of policies has shifted from self-sufficiency to enhancing incomes for farmers by promoting opportunities in the Indian food processing sector, which is one of the largest in the world. Its output is expected to reach US\$ 535 billion by FY 2025-26 and it is expected to generate 9 million jobs by 2024 (Invest India, 2019).

Though the Indian food industry has been acknowledged as a high priority industry and the government is taking necessary steps for advancing the productivity, innovation and global competitiveness of the sector, such advancements require an inclusive and participatory multi-stakeholder approach. It is important for policymakers to consider the synergies among the vital actors in the food sectorial system of innovation (i.e., government, industry associations, knowledge-based institutions (KBI's), intermediaries and arbitrageurs) that can influence policy implementation.

Explained below are the core policies of the Indian food and beverages industry along with the supporting policies that have a bearing on it.

### 5.1 Core Policies of the Food sector

#### Draft National Food Processing Policy (2019)

The term “food policy” has diverse definitions. According to Drake University Agricultural Law Centre (2011) “Food policy is the area of public policy concerning how food is produced, processed, distributed, and purchased. Food policies are designed to influence the operation of the food and agriculture system. This often includes decision-making around production and processing techniques, marketing, availability, utilisation and consumption of food in the interest of meeting or furthering social objectives.” Good policies provide the potential for economic growth and lead to desired social and ecological outcomes. Smith (2016) argues that “Food policy should be an area of proactive public engagement, including with consumers, industry, the agricultural sector, and non-government and non-firm entities so that critical discussions are held and support the right policy decisions. If done properly, then governments should make the policy decisions publically available so there is a clear and consistent message to both internal and external stakeholders, including international stakeholders. Most importantly good food policy is fact-based and supported by sound scientific evidence”. In line with this, the Ministry of Food Processing Industries, GoI, is striving to make the policymaking process participative and inclusive by seeking the inputs of stakeholders in its food processing policy. The goal is to provide a favourable policy ecosystem that can support India's fast evolving food industry.

The food processing sector has emerged as an important segment of the Indian economy and constitutes as much as 9.9% and 11.4% share of Gross Value Added (GVA) in the manufacturing and agriculture sector respectively in FY 2019-20 at FY 2011-12 prices (MoFPI, 2021). Nevertheless, some of the key challenges faced by the sector are the supply chain infrastructure gaps, institutional gaps, the relatively low level of processing, technological gaps, a lack of seamless linkages between agri-production and processing, credit availability gaps, etc. (MoFPI, 2021). Due to the lack of supply chain infrastructure and inadequate processing and storage capacity, the agriculture products face high wastage, a high cost of production and a low level of value addition. In order to overcome these challenges and to create a conducive environment for attracting investment to the sector, ensuring higher deployment of credit in the sector to provide incentive for technology upgradation in existing units and for promoting ease of doing business, the Government of India announced the

“Draft National Food Processing Policy 2019”. The policy aims to achieve a six-fold increase in investment by 2035.

The ministry maintains that this policy is not just a roadmap for unhindered growth of the food processing sector but will also deal with food safety and nutrition issues in alignment with the “National Health Policy 2017”, to strengthen the government initiative for doubling farmers’ incomes under the “Agriculture Export Policy 2018” (MoFPI, 2019).

### **Pradhan Mantri Kisan SAMPADA Yojana (PMKSY) (2016 - 2020)**

As India is making efforts to find various means of achieving food and nutrition security, it is imperative for the country to ensure the sustainability of its food and land-use systems, along with the efficient and optimum utilisation of natural resources across its diverse agro-ecological regions. Achieving this target means building the capabilities and enhancing skills for adapting advanced technology, innovation, diversification, sustainability and increased productivity and efficiency across the value chain. With the objective of creating modern infrastructure with efficient supply chain management from farm gate to retail outlet, the Government of India launched the “SAMPADA- Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters” with an allocation of INR 6,000 crore for the period 2016-2020. A few months after the launch, the scheme was renamed as “Pradhan Mantri Kisan SAMPADA Yojana” (PMKSY). The scheme will not only provide a big boost to the growth of the food processing sector but will also help in creating employment opportunities, enhancing farmers’ incomes (especially in rural areas) and reducing the wastage of perishable agricultural products. With the approval of the Department of Expenditure, PMKSY was extended to 2020-2021. The government has approved the continuation of the scheme with an allocation of INR 4,600 crore until March 31st, 2026 (MoFPI, 2022). The following sub-schemes are covered under PMKSY:

- a. **Development of mega food parks** to provide modern infrastructure for the food sector, to ensure value addition of agriculture produce, to establish a sustainable raw material supply chain for each cluster, to facilitate the induction of latest technology, to address the need of small and micro food processing enterprises by providing plug and play facilities and to provide an institutional mechanism for producers, processors, and retailers to work together to build the supply chain.
- b. **Integrated cold chain and value addition infrastructure** to provide facilities from the farm gate to the consumer (without any break). It covers the creation of infrastructure facilities along the entire supply chain. The scheme allows flexibility in project planning with special emphasis on the creation of cold chain infrastructure at the farm level. So far 199 projects have been sanctioned under SAMPADA, out of which 85 have been completed. The MoFPI has proposed to sanction 30 additional projects during the 15<sup>th</sup> Finance Commission (FC) cycle with a total outlay of INR 1,062 crore to the scheme (MoFPI, 2022).
- c. **Creation/ Expansion of food processing/ preservation capacities (unit scheme)** to build processing and preservation capacities, modernisation and expansion of existing food processing units to increase the level of processing, adding value to reduce wastage. Against the targeted 305 projects, the MoFPI has so far sanctioned 296 projects for food processing units, out of which 45 projects have been completed. An additional 162 projects have been proposed for sanctioning during the 15<sup>th</sup> FC cycle with a total outlay of INR 1,292 crore (MoFPI, 2022).
- d. **Creation of agro-processing clusters (APCs)** for the development of modern infrastructure and common facilities to encourage groups of entrepreneurs to set-up food processing units based on a cluster approach by linking groups of producers/ farmers to the processors and markets through a well-equipped supply chain with modern infrastructure. Under the scheme, each agro-processing cluster has two basic components - **Basic enabling infrastructure** (roads, water supply, power supply, drainage, ETP, etc.) and **core infrastructure/ common facilities** (warehouses, cold storages, IQF, tetra pack, sorting, grading, etc.) and at least 5 food processing units with a minimum investment of INR 25 crore. Against the targeted 75 APCs, the MoFPI has so far sanctioned 68 projects for the creation of clusters in various segments of food processing and 30 additional projects are proposed to be sanctioned during the 15<sup>th</sup> FC cycle with a total outlay of INR 584 crore (MoFPI, 2022).
- e. **Creation of effective backward and forward linkages** for perishable agri-horti produce through the setting up of primary processing centres/ collection centres at farm gate, distribution hubs and retail outlets at the front end.
- f. **Food safety and quality assurance** to achieve all-round development of the food processing sector in the country and to ensure that the quality of food products manufactured and sold in the market meet the stringent parameters prescribed by the food safety regulator. Keeping in view the aforementioned

objectives, the government has been extending financial assistance under the scheme under the following components: setting up/upgrading of quality control/ food testing laboratory (FTLs) and HACCP/ISO standards/ food safety/quality management system. Against the targeted 100 FTLs, the MoFPI has so far sanctioned 54 projects for the creation of food testing laboratories and has proposed to sanction 25 additional projects during the 15<sup>th</sup> FC cycle with a total outlay of INR 145 crore (MoFPI, 2022).

- g. **Human resources and institutions** to ensure that end product/outcome/findings of R&D work benefit the food processing industry in terms of: product and process development, efficient technologies, improved packaging, value addition, etc., with commercial value along with standardisation of various factors viz additives, colouring agents, preservatives, pesticide, residues, chemical and microbiological containments and naturally occurring toxic substances within permissible limits. So far the MoFPI has sanctioned 28 projects for the creation of food processing skill centres and a total of 59 R&D projects. An additional 100 R&D projects have been proposed for sanctioning during 15<sup>th</sup> FC cycle with a total outlay of INR 31.50 crore (MoFPI, 2022).
- h. **Operation Greens (TOP to TOTAL)** The 2018-19 budget announced the launch of this sub-scheme for the integrated development of the tomato, onion and potato (TOP) crops value chain. Later, as a part of “Aatmanirbhar Bharat Abhiyan”, the MoFPI extended the scope of this scheme from TOP to all other perishable products (TOTAL) so as to boost value addition in these perishables. The MoFPI has identified these 22 perishables, which include mango, banana, apple, pineapple, carrot, cauliflower, beans, etc (MoFPI, 2022).

In 2021, the Parliamentary Standing Committee on Agriculture flagged the issue of underutilisation of allocated funds by the MoFPI. Commenting on the achievement of the eight sub-schemes under PMKSY, the panel noted that “there has been a shortfall in almost all the schemes as per the statement for the years 2018-19, 2019-20 and 2020-21”. The panel also raised questions on underutilisation of funds for disadvantaged classes and the northeastern region, to which the MoFPI responded by saying that this underutilisation was due to receipt of inadequate eligible proposals. However, the panel concurred with the MoFPI to bring two agencies – the Agricultural Processed Food Products Export Development Authority (APEDA) and

Marine Product Exports Development Authority (MPEDA) - which are currently under the Ministry of Commerce & Industry - under the purview of the MoFPI.<sup>38</sup> PMKSY is a flagship scheme of the MoFPI and therefore it needs to address the aforementioned shortcomings in a time bound manner.

### **Pradhan Mantri Formalisation of Micro Food Processing Enterprises Scheme (2020 - 2025)**

The Indian food processing industry has a wide variety of food products and the largest production base. There are over 25,00,000 food processing units in the unorganised food processing sector, with 66% of them located in rural areas and over 80% owned by family-based businesses providing an income source to rural communities (IBEF, 2021). Nevertheless, this unorganised sector faces substantial challenges such as the lack of institutional finance, access to credit, access to modern technological know-how, and commercialisation. To address these challenges and boost investment in the food processing sector, the GoI initiated various schemes and programmes such as permitting 100% foreign direct investment (FDI) through automatic routes. Consequently, the FDI inflows in this sector have increased from US\$ 628 million in 2018-19 to US\$ 904 million in 2019-20 (IBEF, 2021).

On June 29<sup>th</sup>, 2020, the Government of India launched the “Pradhan Mantri Formalization of Micro Food Processing Enterprises (PMFME) Scheme” under the “AtmaNirbhar Bharat Abhiyan” and “Vocal for Local” campaigns to provide financial, technical and business support to micro processing units in the country (IBEF, 2021). The objectives of this scheme are: ensuring increased access to credit and investment for existing micro food processing entrepreneurs, farmer producer organizations (FPOs), self-help groups (SHGs) and co-operatives; supporting the transition of the existing 200,000 enterprises into a formal framework; increasing access to common services like common processing facilities, laboratories, storage, packaging, marketing and incubation services; strengthening institutions, research and training in the food processing sector, and increasing access to professional and technical support for enterprises.

The scheme seeks to support micro food processing enterprises through a package of support and services that includes: training and financial assistance for technological upgradation; supporting FPOs, SHGs, producers and cooperatives along their entire value chain, and marketing support for their integration with the organised supply chain for compliance and registration under different

<sup>38</sup> Sourced from: <https://www.businesstoday.in/latest/economy-politics/story/food-processing-industries-ministry-consistently-under-utilised-funds-find-parl-panel-290339-2021-03-09>



regulatory frameworks (MoFPI, 2021). It will be implemented for a period of five years from FY 2020-21 to FY 2024-25 with an outlay of INR 10,000 crore. A unique feature of this scheme is that it adopts a “One District One Product (ODOP)” approach as part of a broader strategy of concentrated agro and industrial development focused on each district, offering an array of fiscal incentives, common facilities, credit, marketing, and policy support (MoFPI, 2021).

### **Blue Revolution: Integrated Development and Management of Fisheries (2015 - 2020)**

Fisheries is a sunrise sector playing an important role in the socio-economic development by providing employment to 14.5 million people and sustaining livelihoods for 28 million fishermen in the country (Department of Fisheries Press Release, 2022). The fisheries sector has witnessed tremendous growth with an increased fish production from 0.75 million tonnes in 1950-51 to 14.16 million tonnes during 2019-20. Constituting approximately 6.3% of global fish production and 5% of global fish trade, India has attained second place among the fish production and aquaculture producing countries in the world (Department of Fisheries Annual Report, 2017-18). Forecasting the potentiality of the fisheries sector, in December 2014, the Government of India launched the “Blue Revolution: Integrated Development and Management of Fisheries”, also known as “**Neel Kranti Mission**”. This was in accordance with international discourse on oceans and in line with the emergence of similar concepts like “blue growth”, “blue economy” and “blue finance” which all have the same aim of tapping the untapped economic potential of the oceans through the creation of newer frontiers to serve the world’s growing population (Immanuel and Narayanan, 2022). Its vision was to create a conducive environment for overall development to attain the full potential of fisheries along with significant improvements to the incomes of fishermen and fish farmers while maintaining sustainability, biosecurity and environmental considerations.

### **Pradhan Mantri Matsya Sampada Yojana (PMMSY) 2020**

With the Neel Kranti Mission coming to a close in 2020, the newly formed Ministry of Fisheries, Animal Husbandry & Dairying launched its first scheme, the “Pradhan Mantri Matsya Sampada Yojana” (PMMSY) in September 2020 with an estimated investment of INR 20,050 crore for a period of 5 years from FY 2020-21 to FY 2024-25 in all states and Union Territories (UTs). The PMMSY aims to double the

income of fish farmers and fishers in the country and focuses on sustainable development of the India’s fisheries sector as part of the Aatmanirbhar Bharat Scheme (IBEF, 2021). It was introduced to bring about the Blue Revolution through sustainable and responsible development of the fisheries sector including the welfare of fishermen (Department of Fisheries, 2020). The objectives of the PMMSY (Department of Fisheries, 2020) are: -

- Harnessing of fisheries potential in a sustainable, responsible, inclusive and equitable manner.
- Enhancing fish production and productivity through the expansion, intensification, diversification and productive utilisation of land and water.
- Modernising and strengthening of value chain – post-harvest management and quality improvement.
- Doubling fishers’ and fish farmers’ incomes and generating employment.
- Enhancing the contribution to agriculture GVA and exports.
- Social, physical and economic security for fishers and fish farmers.
- Robust fisheries management and regulatory framework.

The key achievements in the fisheries sector under Blue Revolution are (i) enhancement of fish production from 10.26 million metric tonnes in FY 2014-15 to 13.75 million metric tonnes in FY 2018-19; (ii) productivity increased from 2.3 tonnes per hectare to 3.3 per tonnes per hectare and (iii) exports increased from INR 33,442 crore to INR 46,589 crore in FY 2018-19<sup>39</sup>

Lakra and Gopalakrishnan (2021), in their review of Blue Revolution in India, states that “the main objective of the new schemes namely, PMMSY, the “Fisheries and Aquaculture Infrastructure Development Fund” (FIFA) and “Blue Revolution” launched in the country is to enhance production and productivity along with modern infrastructure development, increase employment generation for youth and women, improve the socio-economic conditions of fishers, augmentations of exports and adopting an integrated approach to marine and inland fisheries towards responsible and sustainable fisheries and aquaculture development. It is directed at comprehensive development of the sector through innovative technology applications and policy interventions addressing the critical gaps in knowledge, technology and governance.” They also recommend that special emphasis is given to increase the domestic consumption of fish and shrimps through

<sup>39</sup> Sourced from: <https://pmmsy.dof.gov.in/>

innovative marketing strategies based on the success stories of the poultry and dairy sectors.

### Conformity Assessment Scheme 2021

In order to ensure the quality and food safety of milk and milk products across the country, on 23rd December 2021, the Department of Animal Husbandry and Dairying, after extensive stakeholder consultation, launched a unified “Conformity Assessment Scheme”. This is a first of its kind certification scheme for the dairy sector and it was chalked out by the Bureau of Indian Standards (BIS) with the help of the National Dairy Development Board (NDDB). The scheme is a significant step towards simplification of the certification process and creation of an instantly recognisable logo for the public to be reassured about the quality of a dairy product. The scheme is expected to increase the sales of milk and milk products in the organised sector, enhance incomes of farmers and develop a quality culture in the Indian dairy sector (BIS, 2021).

### National Programme for Dairy Development (NPDD) 2021 - 2026

This scheme was launched in February, 2014 by the Department of Animal Husbandry and Dairying after merging three schemes of this department namely the i) “Intensive Dairy Development Programme” (IDDP) ii) “Strengthening Infrastructure for Quality & Clean Milk Production” (SIQ and CMP) and iii) “Assistance to Cooperative” (A to C) - with the objective of creating and strengthening the infrastructure for the production of quality milk including cold chain infrastructure, procurement, processing and marketing of milk and milk products. This central sector scheme was restructured with an allocation of INR 1790 crore from FY 2021-22 to FY 2025-26. The NPDD aims to enhance the quality of milk and milk products and increase the share of organised procurement, processing, value addition and marketing. This scheme has two components: Component 'A' focuses on creating/strengthening infrastructure for quality milk testing equipment as well as primary chilling facilities for the State Cooperative Dairy Federation/ District Cooperative Milk Producers' Union/SHG run private dairy/milk producer companies/farmer producer organizations; and Component 'B' provides financial assistance from the Japan International Cooperation Agency (JICA) as per the already signed project agreement. The central government share in this project is proposed to be funded through the NPDD (DAHD, 2021).

### Supporting Dairy Cooperatives and Farmer Producer Organizations Scheme (2021 - 2026)

A scheme named “Supporting Dairy Cooperatives and Farmer Producer Organizations Engaged in Dairy Activities” (SDCFPO) was approved to provide working capital loans to state cooperatives and federations along with providing stable market access to the dairy farmers. The scheme has two components namely Component ‘A’ - Working capital loan and Component ‘B’ - Interest subvention on working capital loan. The “working capital loan component” was kept in suspension for FY 2021-22 in order to provide interest subvention on working capital loan. This component will continue during FY 2021-22 to FY 2025-26. The products covered under the scheme for availing working capital loans are skimmed milk powder (SMP), whole milk powder (WMP), white butter and ghee. The Union Cabinet approved implementation of SDCFPO as a part of the umbrella scheme “Infrastructure Development Fund” from FY 2021-22 to FY 2025-26 with an outlay of INR 500 crore (DAHD Annual Report, 2021-22).

The Ministry of Fisheries, Animal Husbandry and Dairying has set-up dedicated infrastructure development funds for each of the 3 sectors that fall under its name: “Fisheries and Aquaculture Infrastructure Development Fund 2018”, “Dairy Processing & Infrastructure Development Fund 2018 - 2023” and “Animal Husbandry Infrastructure Development Fund 2018”. This was done to deal with the limited availability of funds through the normal budgetary process, lack of credit funding, and in order to fill the large gaps in infrastructure in each of these vital sectors.

### National Mission on Edible Oils-Oil Palm (NMEO-OP) 2021

India is one of the major oilseeds growers and importers of edible oils. India's vegetable oil economy is the fourth largest in the world<sup>40</sup>. During the FY 2020-21, India imported 13.35 million tonnes of edible oil, out of which the share of palm oil was around 56% (PIB Release ID: 1776581, 2021). With the objective of augmenting the availability of edible oil in the country and increasing crude palm oil production to reduce the import burden, the Ministry of Agriculture and Farmers Welfare launched the “National Mission on Edible Oils - Oil Palm” (NMEO-OP) in November 2021. Under the mission, the government will provide assistance for planting material, inputs for intercropping up to a gestation period of 4 years and for maintenance, establishment of seed gardens, nurseries, micro irrigation, bore well/pump set/water harvesting structure, vermicomposting units, solar pumps, harvesting tools, custom hiring centre cum harvester groups, farmers and officers training, and for replanting of old oil palm gardens. The total approved cost of the NMEO-OP is INR 11,040

<sup>40</sup> Sourced from: <https://nmoop.gov.in/Introduction.aspx>

crore, out of which INR 8844 crore is a central share and INR 2196 crore a state share. For FY 2021-22, a total of INR 10,422.69 lakh has been approved for various state annual action plans (PIB Release ID: 1776581, 2021).

### Tea Development and Promotion Scheme (TDPS) 2021-26

India is the second-largest producer of tea after China and is among the top 5 tea exporters in the world. The Tea Board of India was established under the Ministry of Commerce and Industry to look after the production, development and export of tea from India. In November 2021, the Government of India approved the Tea Board's "Tea Development and Promotion Scheme" for implementation during the 15th Finance Commission 2021-26, with a financial outlay of INR 967.8 crore. Apart from improving the overall production, productivity and quality of Indian teas, this scheme especially focuses on development of small and marginal tea farmers, explores potential of tea grown in the North Eastern states and encourages research and development and technological innovation. According to the Confederation of Indian Small Tea Growers' Association (CISTA), this is the first time in Indian tea history that the Tea Board has launched a scheme for small tea growers but its success will depend on sanction of funds by the Union government and implementation of the scheme at the grassroots.<sup>41</sup>

### Production Linked Incentive Scheme for Food Processing Industry (PLISFPI) (2021-22 to 2026-27)

In order to boost the domestic manufacturing sector, to cut down imports and to provide incentives to domestic firms on incremental sales, the MoFPI launched the "Production linked Incentive Scheme for Food Processing Industry" (PLISFPI). The PLISFPI has been formulated based on the "Production Linked Incentive scheme of NITI Aayog" under "AtmaNirbhar Bharat Abhiyaan for Enhancing India's Manufacturing Capabilities and Enhancing Exports". The food processing sector in India includes all segments of manufacturing firms i.e., from micro to large size industries. Furthermore, India has a competitive advantage in terms of resource endowment, large domestic market and scope for promoting value-added products (MoFPI, 2022). In order to achieve their full potential, the Indian companies in this sector need to improve their competitive advantage in relation to their global competitors in terms of productivity, efficiency, scale of output, value addition and a need to strengthen their linkages in the global value chain. The PLISFI was launched with the vision to support the creation

of global food manufacturing champions commensurate with India's natural resource endowment and support Indian food products brands in the international markets with an outlay of INR 10,900 crore and with an implementation period of six years from FY 2021-22 to FY 2026-27 (MoFPI, 2022). The objectives of the scheme are as follows:

- Support food manufacturing entities with stipulated minimum sales, willing to make minimum stipulated investment for the expansion of processing capacity and branding abroad to incentivise the emergence of strong Indian brands.
- Support creation of global food manufacturing champions.
- Strengthen select Indian food products brand for global visibility and wider acceptance in the international markets.
- Increase employment opportunities of off-farm jobs.
- Ensure remunerative prices of farm produce and higher incomes to farmers.

As mentioned above, the scheme is applicable to specific product categories only and minimum sales and mandated investment apply, which only large firms may be able to meet. Furthermore, in India, the majority of food producers are MSMEs who need to scale-up conventional products but they are not eligible for this. Nevertheless, industry experts feel that the incentives under the PLISFPI are attractive and will go a long way in creating large-scale capacities by helping firms manufacture on a large scale using advanced plant and machinery and competing with global brands in international markets.<sup>42</sup>

### National Mission on Food Processing (NMFP) (2012-17)

The food sector in any economy is considered to be critical for achieving growth in the agriculture sector. Growth of this sector is also important as it meets the twin national objectives of inclusive growth and food security. As an initiative to enhance productivity of the food sector and also to make it technologically advanced, the Government of India (GoI) launched the centrally sponsored "National Mission on Food Processing" (NMFP) scheme, implemented through state / UT governments during the 12<sup>th</sup> Five Year Plan (2012-17). The objectives of the NMFP were as follows: to assist MSMEs in setting up/modernisation of food processing units by providing need-based support in terms of capital/technology/skills etc.; to promote initiatives for

<sup>41</sup> Sourced from: <https://timesofindia.indiatimes.com/business/india-business/govt-eyes-small-tea-growers-uplift-in-5-yr-scheme/articleshow/88264711.cms>

<sup>42</sup> Sourced from: <https://economictimes.indiatimes.com/industry/cons-products/fmcg/pli-scheme-in-food-processing-to-go-a-long-way-in-creating-large-scale-capacity-fmcg-cos/articleshow/88148979.cms>

skills development, training and entrepreneurship which would meet the needs of both post-harvest management and the food processing industry; to spread the message of significance of food processing for enhancing agricultural productivity and farmers' incomes in the country.

The NMFP was to augment the capacity of food processing by the adoption of new technologies and improving the quality of food products as per national / international standards. It also aimed to reduce wastage of agricultural produce, infuse new technologies, and upgrade human resource capacities to provide impetus to the development of the food processing sector in the country (MoFPI, 2015). However, in 2015, the GoI delinked the NMFP from central government support and it was left to state governments to decide whether to continue (or not) with the NMFP scheme out of their increased resources resulting from the recommendations of the 14<sup>th</sup> Finance Commission (MoFPI, 2015).

### **MSME Champions Scheme (2021-22 to 2025-26)**

The Development Commissioner of the Ministry of MSME has been implementing the "Credit Linked Capital Subsidy and Technology Upgradation Scheme" (CLCS-TUS) for promoting competitiveness amongst MSMEs by way of wastage reduction through lean manufacturing, design improvement, building awareness on intellectual property rights, the "Zero Defect Zero Effect (ZED) Scheme", digital empowerment of MSMEs and facilitating adoption of latest technologies in manufacturing through Incubation across India. CLCS-TUS was operational till March 2020 and the "MSME Champions Scheme" has been formulated by merging all these components of erstwhile CLCS-TUS for a period of 5 years, 2021-22 to 2025-26 in the specified 51 sub-sectors, including the food processing sector. This new scheme has 3 components: MSME-Sustainable (ZED) Certification, MSME-Competitive (Lean) and MSME-Innovative (for incubation, IPR, Design and Digital MSME).

The main objective of the scheme is to pick up clusters and enterprises and modernise their processes, reduce wastages, sharpen business competitiveness, and facilitate global reach and excellence. However, according to the "2021-22 Annual Report of the Ministry of MSME", the expenditure on all 3 components of the MSME Champions Scheme remained miniscule with the MSME ZED certification component witnessing nil expenditure out of the budget allocated.<sup>43</sup>

### **National Intellectual Property Rights Policy 2016 (IPR Policy 2016)**

Government support is needed for businesses not only to innovate new technologies, but also to safeguard their technological inventions with effective IP protection. In May 2016, the Department for Promotion of Industry and Internal Trade (DPIIT) rolled out the country's first "National Intellectual Property Rights (IPR) Policy 2016" to foster creativity and to implement a strong IP-led innovation model. Prof. Sunil Mani, in his critique on the "New IPR Policy 2016: Not based on evidence" argues that even before the IPR policy, India had a functioning legal regime with individual acts on patents, trademarks, designs and geographical indications, all of which were suitably amended over time to comply with TRIPS (Agreement on Trade-Related Intellectual Property Rights) (Mani, 2016). He contends that "some measures in the IPR policy are laudable but the policy objectives are not evidence-based and are tailor-made to suit the requirements of the western governments." He further argues that the government should rather be spending time and money on improving the performance of patent offices that are understaffed and underfunded leading to major delays in patent approval in the country.

It is evident that India has been taking a decisive stand on patents to the advantage of domestic manufacturers, but it needs more such incentive programmes, with effective and widespread implementation. India has built pockets of knowledge-based growth but has not yet translated this into a broader economic model. Actions to promote knowledge-based economies will require strong, coordinated government policies coupled with investment in ICT (ADB, 2014).

## **5.2 Industry 4.0 Initiatives**

The global industrial automation market is predicted to be worth US\$ 297 billion by 2026, with food and beverage applications making up 11% of the market. Food is considered to be an inherent factor and a strong backbone of economic growth for any country (Deloitte, 2018). The diverse nature of Indian culture and changing consumer demands further add complexities in the food production and distribution of the country. These changes are shaping the Indian food and beverages sector by creating disruptions in business models, changing the modalities of communication or interaction with consumers and responsiveness to their needs. With the GoI's drive to augment processing levels through campaigns like "Make in India" and Industry 4.0's role in elevating the

<sup>43</sup> <https://www.financialexpress.com/industry/sme/msme-eodb-msme-ministry-releases-2021-22-annual-report-expenditure-on-multiple-schemes-remains-minuscle/2440274/>

manufacturing as well as supply chain and distribution landscape through technologies (Internet of Things (IoT), block chain, predictive analytics, etc.), the food industry in India is expected to witness a radical shift (Deloitte, 2018).

Food processing operations can greatly benefit from the application of Industry 4.0 technologies by improving traceability, food quality and safety, predicting sensory and consumer preferences, and by minimising errors, cost, time and wastage. Industry 4.0 allows firms to optimise their level of operations (i.e., equipment, manufacturing operations management, business systems) by minimising the error in the whole process. It allows a company to make better decisions on large volumes of data that are being produced at different levels of production and to find out the entire performance or efficiency of the operation so that timely solutions can be initiated whenever an issue arises.

The food and beverages sector can truly leverage the potential of Industry 4.0 by using it to enhance quality, productivity and food safety compliance, thus making it easier for the sector to face unique challenges in production, and operations. For example, the Food Safety and Standards Authority of India (FSSAI) is exploring the possibility of using Industry 4.0 technology tools such as blockchain and machine learning to ensure food safety and quality.<sup>44</sup> The FSSAI is also coming up with an online Food Safety Compliance through Regular Inspections and Sampling (FoSCoRIS) mobile app, which will monitor, on real-time basis, onsite inspection carried out by food safety officers as per the inspection checklist.<sup>45</sup> Industry 4.0 can also help the food and beverages sector in establishing connectivity between production facilities and distributors so that products get to market quickly, maintain an efficient supply chain, optimise resources, and reduce cost and time gaps. It offers a great opportunity for the sector to study and predict consumer behaviour and accordingly adapt to changes and technological advancements to minimise the limitation on supply-side. It can simplify operations and enhance efficiency as the IoT-enabled solutions give a variety of logistical benefits for food and beverage companies. Connected devices can also support the food and beverage manufacturing industry by increasing efficiency and improving business processes while also working to prevent machine downtime and expensive issues. Further, the IoT can provide simpler, smarter and more intelligent inventory management solutions thus,

minimising the cost and wastage of perishable produce due to overstocking (Ceolnsights, 2022).

In October 2018, India took a big step towards shaping the future of emerging technology policy with the opening of its Centre for the Fourth Industrial Revolution in collaboration with the World Economic Forum (WEF). The National Institute for Transforming India (NITI) Aayog was appointed as the designated nodal agency to interact with the WEF for elaborating the new policy frameworks for emerging technologies. Since then, the Indian government has been working on creating an enabling policy framework and setting up incentives for infrastructure development on a PPP (public-private partnership) model. **"SAMARTH Udyog Bharat 4.0"** is a flagship initiative of the Ministry of Heavy Industry & Public Enterprises, Government of India, for the promotion and adoption of Industry 4.0. The experiential and demonstration centres for Industry 4.0 have been proposed to spread awareness amongst the Indian manufacturing industries. Five centres of Industry 4.0 having a unique identity for spreading awareness and branding have already been sanctioned under SAMARTH Udyog. It is emphasised that these centres would have resource sharing, common platforms of Industry 4.0 and network each other's resources for maximum utility. Under this initiative, government, industry, academic institutions, and industry associations have joined forces to promote digital transformation in manufacturing with an aim to propagate technological solutions to all manufacturing units by 2025.<sup>46</sup> With India assuming the G20 Presidency on 1st December 2022, use of Industry 4.0 in sustainable food systems will be one of the key issues discussed at G20 this year. Even though the concept of Industry 4.0 may seem to have greater applicability in advanced technological industries like automotive and aerospace, the food and beverages sector can also significantly absorb the advantages of the fourth industrial revolution. Currently, this sector is facing a competitive environment thus, firms that apply the strategies of Industry 4.0 will not only survive in this competitive environment, but will also prosper with improved operating performance, producing a better quality of food, an increase in market share, and higher shareholder value. The revolution will not only help the industry to grow but also will allow their workforce to enhance their skills by getting their hands on new technology. It must be noted that technology and innovation are not enough, enabling policies and a skilled workforce that can respond to the changing needs of the sector is also needed.

<sup>44</sup> <https://retail.economicstimes.indiatimes.com/news/food-entertainment/food-services/fssai-mulling-using-next-gen-technology-tools-to-ensure-food-safety-quality/84823068>

<sup>45</sup> <https://foodregulatory.fssai.gov.in/foscris>

<sup>46</sup> Sourced from: <https://www.financialexpress.com/industry/industry-4-0-technology-the-key-game-changer-for-indian-manufacturing-sector/2199098/>



### 5.3 Initiatives for the Future Workforce

India's food processing sector is one of the largest in the world - its output is expected to reach US\$ 535 billion by FY 2025-26 and it is expected to generate 9 million jobs by 2024 (IBEF Report, 2020). The food processing sector is considered to be a powerful engine for job creation and inclusive growth in the country. The policymakers have identified it as a key sector in generating employment by encouraging labour to shift from agriculture to manufacturing. The food processing industry provides plenty of opportunities because its collaborative structure consists of agriculture and industry (Meeta, 2007). It increases employment, gives remunerative prices to the farmers, ensures value addition, provides opportunity to diversify, curbs migration, tackles food inflation, and reduces wastages. It also has potential to double farmers' incomes (Mehta, 2012).

Though India is a labour-intensive economy, the biggest challenge to its growth is the lack of availability of skilled manpower which in turn poses a challenge to its growth and global competitiveness. The Ministry of Food Processing Industries (MoFPI) is working in close collaboration with "**Food Industry Capacity and Skill Initiative**" (FICSI), which is a Sector Skill Council (SSC) for the food processing sector working under the aegis of the Ministry of Skill Development and Entrepreneurship, in regularly guiding and assisting it in achieving its mandate. The FICSI is engaged in various skill development initiatives of central/state government and ministries, either as a project implementation agency or as an assessment agency. The FICSI has signed a memorandum of understanding (MoU) with knowledge-based institutions to support the development of Qualification Packs (QPs), create training and course materials, promote skill development and skill transfer at both the national and international level. The MoFPI is helping to strengthen the FICSI by helping in all possible ways to complete the validations of QPs for each job role developed and is helping in the development of the course curriculum through the National Institute of Food Technology Entrepreneurship and Management (NIFTEM), an institute under the MoFPI. Regular meetings with all stakeholders to review the progress (MoFPI, 2017) are also conducted by the MoFPI. Under **Pradhan Mantri Kisan SAMPADA Yojana**, the MoFPI has formulated a scheme for developing skilling infrastructure and the development of course curriculum with a budget outlay of INR 27.50 crore from FY 2017-18 to FY 2019-20. The scheme has two components:

- Development of course curriculum for training modules and its translation in English, Hindi and regional languages.
- Assistance for creation of infrastructure facilities for skill training centres.

Guidelines of the scheme are being finalised and proposals shall be called for upon its finalisation.

The National Institute of Food Technology Entrepreneurship and Management (NIFTEM) and the NIFTEM-Thanjavur (formerly Indian Institute of Food Processing Technology) are two research and educational institutions of national importance formed under the MoFPI for conducting programmes/courses on skill development and entrepreneurship for the youth, farmers, self-help groups and industry. These institutions also undertake entrepreneurship development through skilling/capacity building, outreach programmes and village adoption programmes. The MoFPI has also included a module on 'Entrepreneurship' in the course curriculum of all the job roles. Similarly, the National Agriculture and Food Analysis and Research Institute (NAFARI) is a GoI recognised research institute, business incubator and training institute established in 2002 and promoted by Consortium of Food Industry & Trade (COFIT) and Maharashtra Chamber of Commerce, Industries and Agriculture (MCCIA) Pune, with support by the Ministry of Food Processing Industries, Small Industries Development Bank of India (SIDBI), National Bank for Agriculture and Rural Development (NABARD) and the United Nations Industrial Development Organization (UNIDO). The NAFARI provides services to the food industry and its supply chain (including food analysis, training and education, and consultancy services related to product / process development, etc.) These services are made available across India and also to NAFARI clients from overseas. Thus, the NAFARI has established a rich network of various knowledge-based institutions, industry, supply chain of raw materials, processed materials, machinery and other auxiliary needs of the food processing industries. Recent trends in technological advancements and globalisation warrant similar efforts to stimulate skill development through collaborative multi-stakeholder actions and partnerships across the public and private sector.

In conclusion, the food sector in India has enormous potential in terms of generating employment and enhancing income through value addition due to the availability of resources, labour, technology, demand and favourable business environments. India's growth and development is significantly defined by the food processing sector because of the vital linkages and synergies that it promotes between the two pillars of the economy -



manufacturing and agriculture. Even today in India, 70% of its rural households still depend primarily on agriculture for their livelihoods. With 82% of farmers being small and marginal, agriculture is still the largest source of livelihood in India (FAO, 2022). Thus, development of the food sector will bring enormous benefits to the economy of the country by enhancing the efficiency and productivity of agricultural produce, increasing agriculture yields and enhancing employment and income opportunities throughout the country, especially in rural regions. Over the years, the government has taken various initiatives and formulated several schemes and policies for this sector to maintain food security, enhance the efficiency and productivity of

produce by making huge investments and technological upgradation. As the manufacturing sector in India is moving towards Industry 4.0, it is said that food and beverage manufacturers are likely to benefit from the implementation of Industry 4.0 more than most industries (Deloitte, 2018). However, multi-stakeholder collaboration is required between government, firms/companies, research institutions and industry bodies for promoting Industry 4.0. Therefore, the government needs to monitor the diffusion of digital technology and innovation in the Indian food and beverages sector, promote its adaptation to local needs and scale-up successful implementation.



# 6.

## Results and Analysis

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## Results and Analysis

This chapter sets out to analyse the results of the “Indian Food & Beverages SSI Survey” (IFBSSI) using a combination of univariate and multivariate analysis which provides a strong empirical foundation. The frame of analysis can be divided into the following sections. Firstly, the characteristics of the survey are described in terms of the composition of the sample and its respondents. This is followed by a comprehensive analysis of the relationships/linkages between the actors of the system. This then leads to the elucidation of the barriers that exist within the food and beverages system of innovation, and those that are most predominant for each actor group. This is also linked to the question of how successful existing

policies are at highlighting either the convergence or divergence between the results and what is articulated in government policy. With this in mind, this chapter aims to highlight the avenues that need attention within the IFBSSI.

### 6.1 Descriptives

The composition of the actors in the IFBSSI has been detailed in the “Survey Methodology” section. In this section, we will discuss the characteristics of the IFBSSI Survey that are described in terms of the composition of the sample and its respondents. Table 3 below shows the actor distribution and response rate.

**TABLE 3: Indian food & beverages SSI - Convenient sample, data collected and response rates.**

Firm			Non-firm				Total Number of Non-Firm Actor			Total
Industry			Government	Knowledge based institution	Intermediary	Arbitrageur				
Sample	Data collected	Response rate	Data collected				Sample	Data collected	Response rate	
4206	2713	64.50%	12	6	74	26	200	118	59.00%	2831

The overall response rate of the IFBSSI Survey is 64%. As shown in Table 3 above, the response rate of industry is 65% while the response rate of non-firm actors is 59%, out of which intermediaries account for 63% of the data collected in the non-firm category, followed by arbitrageurs, government and KBIs at 22%, 10% and 5%, respectively.

Figure 7 below summarises the distribution of respondents by actor group, with the majority belonging to industry at 96%, followed by intermediaries, arbitrageurs, government and KBIs.

**FIGURE 7: Actor distribution of respondents**

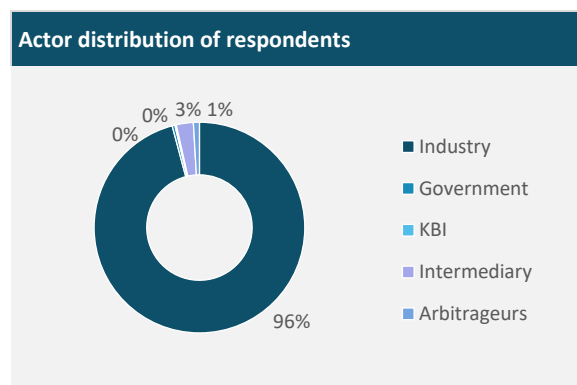


Figure 8 below shows the ownership structure of firms surveyed. Out of 2713 firms surveyed, 2709 are domestically-owned and only 4 are foreign-owned firms.

**FIGURE 8: Ownership structure of firms**

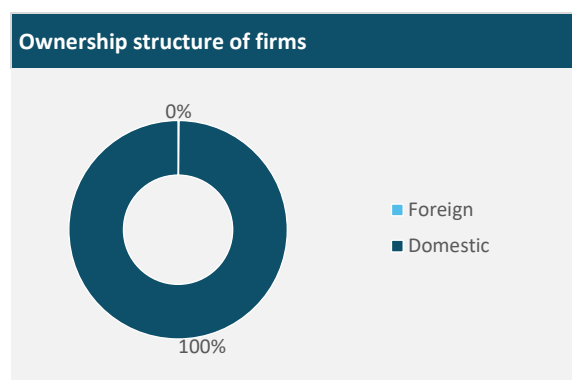
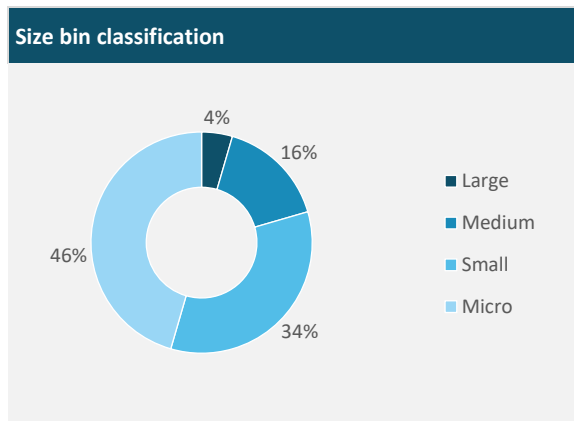
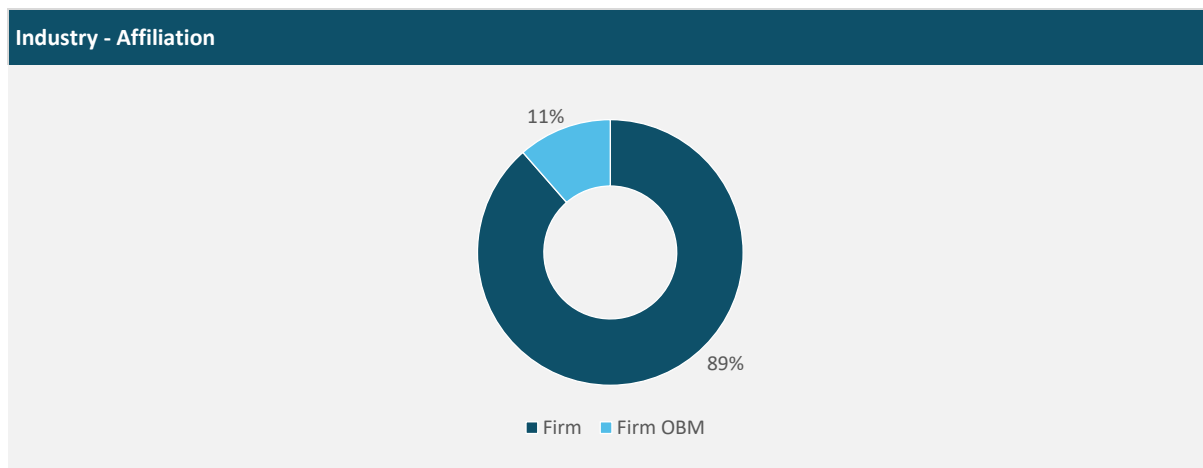
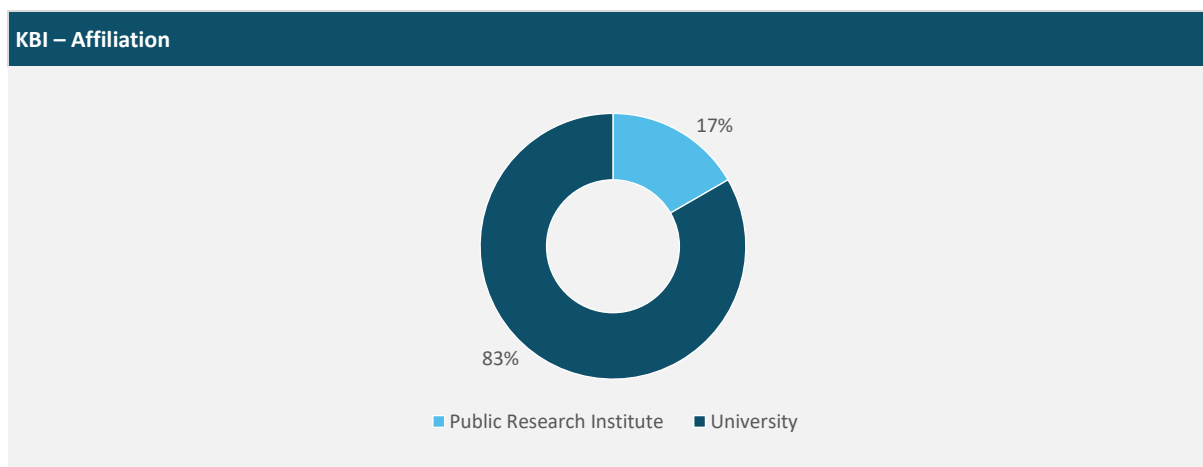


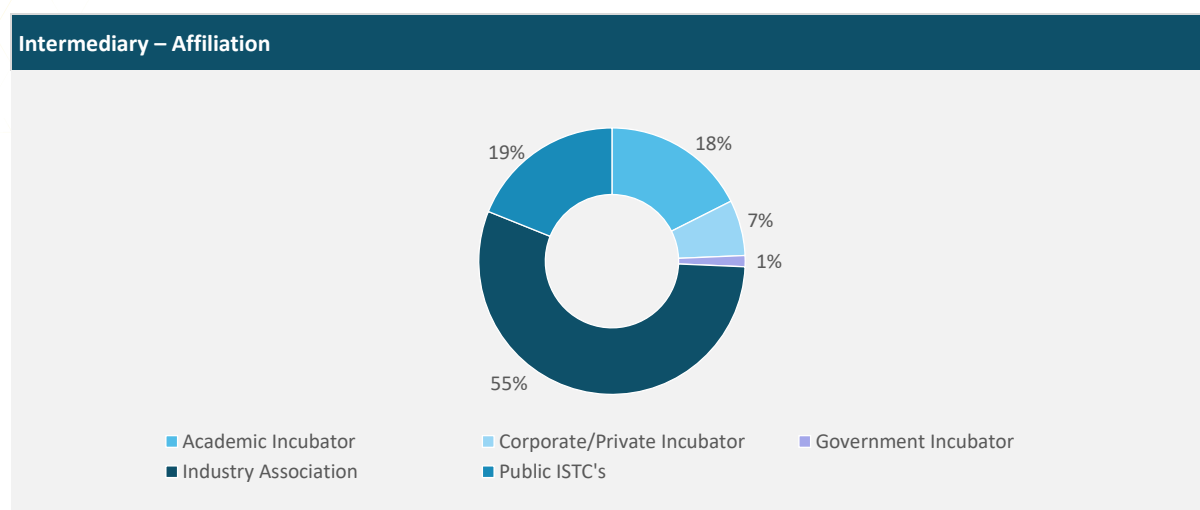
Figure 9 below shows the size classification of the firms surveyed. It is important to know the size of firms that participated in the survey as it can determine the level of innovation, internationalisation and adoption of emerging technologies. It can be seen from the figure below that the majority of the firms surveyed belonged to the micro size category, followed by small and medium size firms. Large size firms constitute only 4% of the total firms surveyed.

**FIGURE 9: Size classification**

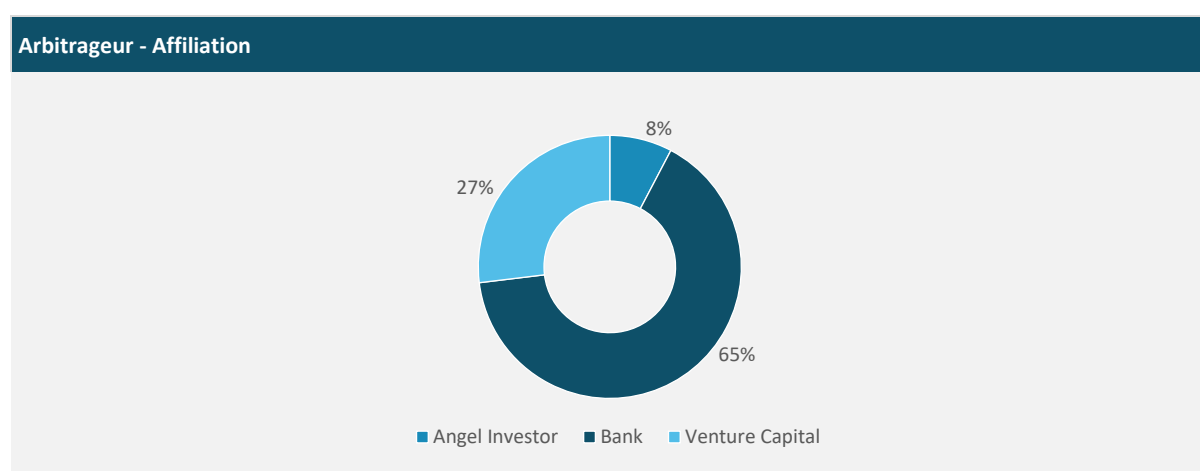
The following figures depict the distribution of respondents by affiliation for each actor group. Figure 10 below shows that the industry actor group is made up of 2403 identifying as 'Firm' (89%) and 310 as 'Firm OBM' (11%). Figure 11 depicts KBI affiliation comprising universities and public research institutes, the majority being universities. Subsequently, Figure 12 shows that intermediaries are composed of public institutions supporting technical change (ISTCs), incubators (academic, corporate/private and government) and industry associations. Arbitrageurs are composed of banks, angel networks and venture capitals while the government comprises both central and state governments and the majority representation has been from state government agencies. This is outlined in Figure 13 and Figure 14, respectively

**FIGURE 10: Industry – Affiliation****FIGURE 11: KBI – Affiliation**

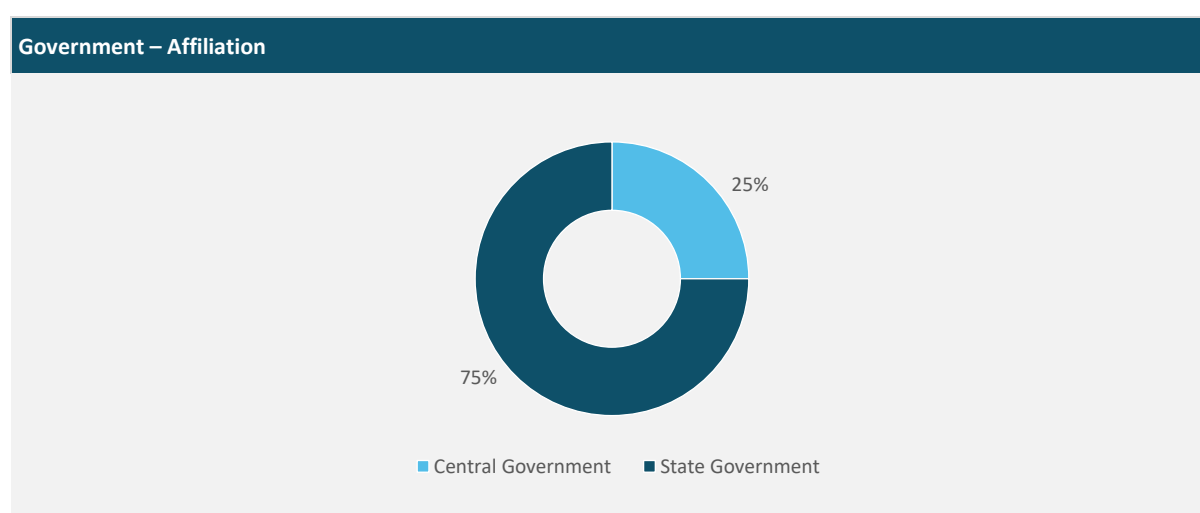
**FIGURE 12: Intermediary – Affiliation**



**FIGURE 13: Arbitrageur – Affiliation**

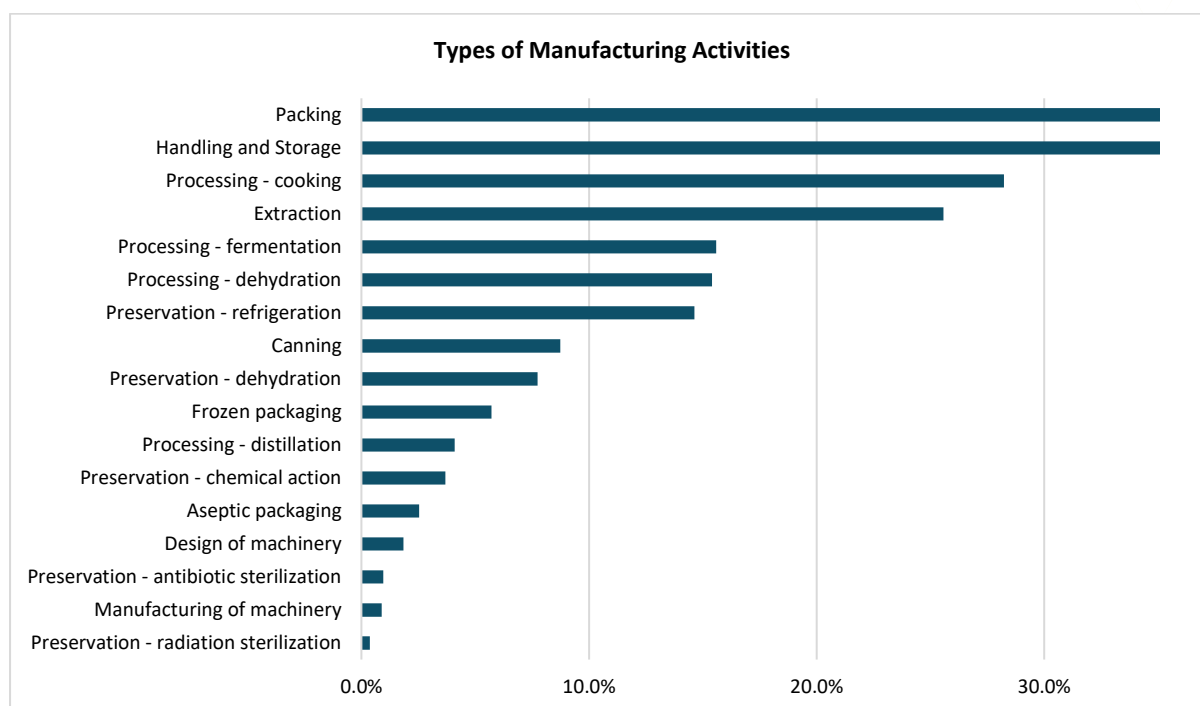


**FIGURE 14: Government – Affiliation**



It is important to get further clarity with respect to the industry actors in order to better elucidate the data in this report, particularly as the majority of innovation takes place

at the firm level. Figure 15 below depicts the types of manufacturing activities of the firms surveyed.

**FIGURE 15: Types of manufacturing**

The majority of firms surveyed are involved in packing, handling and storage activities. Only a limited number of firms surveyed are into specialty and high-value processing, preservation and packaging segments.

## 6.2 Linkages

Before the issue of the linkages between the actors in the IFBSSI is brought to the fore, it is essential to reiterate the importance of linkages from the perspective of the SSI. For instance, in their critique of the linear approach to innovation, Edquist and Hommen (1999) stress the importance of interactive learning and innovation networks, for which linkages between actors are crucial (Oyelaran-Oyeyinka, 2005). Cavalcante (2011) articulates that interaction between agents through formal and informal linkages can take the form of: joint research and publications; personnel exchanges; patents and licenses; the purchase of equipment, or the transfer of particular technologies or methods. In this light, the analysis conducted is twofold: an understanding of the type of relationships that are present and who initiates them.

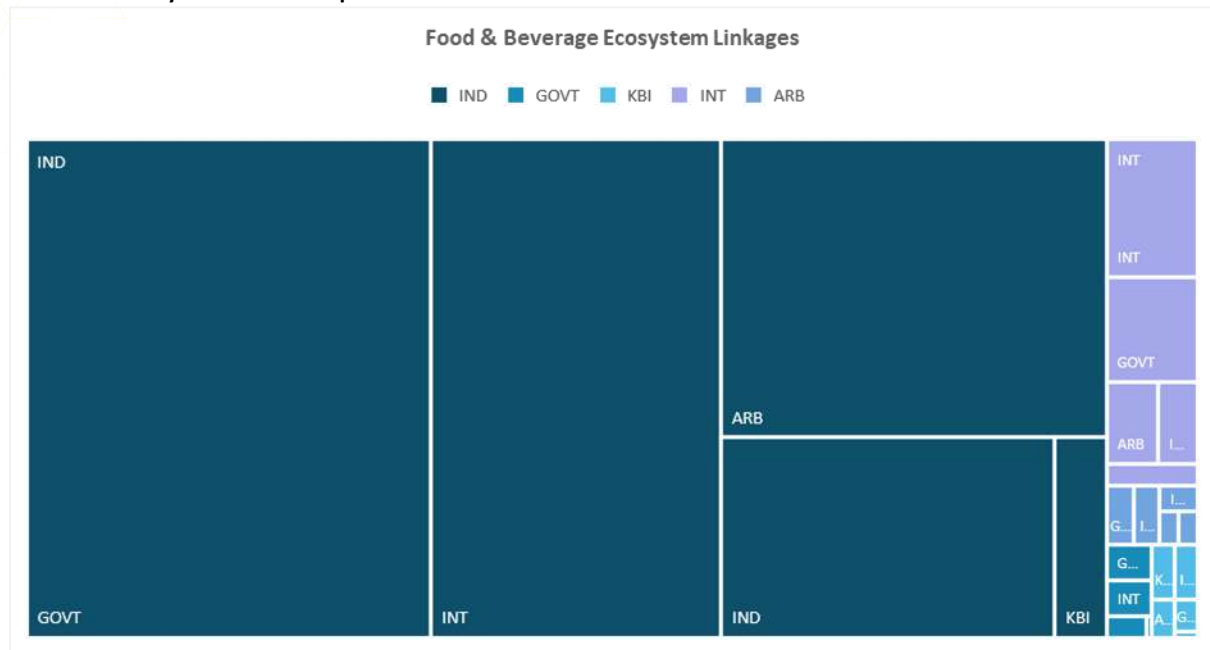
### Type of Linkage

The next point of analysis is to determine which type of engagement occurs when an actor interacts with players in the system. This can be broken down in terms of intra- and inter-relationships. Each respondent was asked to list other actors (industry, government institutions, KBIs, intermediaries, arbitrageurs and financial institutions) their organization engaged with and the respective type of

engagement. The types of linkages indicated include contract buyer, contract supplier, joint patents, non-disclosure agreements, trademarking, joint research, co-publishing, secondments, licensing agreements, procurement contracts, formal meetings, informal meetings, seminars/training, recipients of funding, recruitment/placement and joint ventures. This chapter highlights both the major and minor intra- and inter-relationships as well as strategic interactions that are crucial to driving innovation in the SSI. Finally, those interactions that are truncated or missing are highlighted in order to better understand and articulate interventions that need to be undertaken to bolster the SSI.

In general, it can be seen from Figure 16 that the majority of relationships are in proportional terms between the actors in the sectorial system of innovation. Firstly, in terms of the number of respondents, the actors who participated (in order of magnitude) are industry, intermediary, arbitrageurs and financial institutions, government followed by knowledge-based institutions. The low representation of knowledge-based institutions is due to data collection being undertaken during the height of the COVID-19 pandemic and faculty being based at home. Industry actors have the lion's share of interaction with government and intermediaries. Intermediaries mostly interact with themselves and the government. Financial institutions and arbitrageurs primarily interact with the government. The government is seen to mostly interact with themselves, and knowledge-based institutions primarily interact with themselves and intermediaries.



**FIGURE 16: Ecosystem relationships**

Sankey diagrams (refer to Figures 18, 19, 21, 22 and 23 below) have been used to display the types of relationships (intra- and inter-linkages) between the system actors, from the perspective of each actor. The diagram is composed of two distinct sections. The left-hand side of the diagram shows the specific system actors being engaged from the perspective of a selected actor, as well as the number of interactions. This provides an indication of who is connected to whom.

From the right-hand side of the diagram we can see the various types of interactions, as well as the total cumulative number for all actors engaging in these types of interactions. However, the specific number of interactions for each actor are not represented in this visualisation.

Overall, the Sankey diagram offers valuable insights into the complex network of relationships and linkages that exist within a particular sector. It can help identify knowledge and resource flows between actors, thus making it a useful tool for understanding the dynamics of the sector.

### 6.2.1 Industry

Figure 18 highlights the industry intra- and inter-linkages.

#### Intra-relationships

With respect to industry actors, the major intra-relationships are 'Formal meetings' and 'Informal meetings', followed by user-producer relationships in the form of 'Contracts buyer' and 'Contracts supplier'. The user-producer relationships related to the production process, given the size representation of firms in the sample, largely focus on primary processing and packaging.

Knowledge transfer through formal and informal meetings takes place in the provision of formal trainings for example Mother Dairy, India's leading milk and dairy firm has signed an agreement with Ramco Systems, an enterprise software product company focused on delivering enterprise resource planning (ERP) on the cloud, to connect its extended network of 30+ suppliers with an end-to-end ERP that can seamlessly integrate with its existing system applications and products (SAP). Additionally, information sharing takes place through annual meetings of suppliers.

Formal meetings also contribute to the process of sharing information, exchanging and developing ideas, as well as expressing disagreement, and managing conflict (Shasital, 2022), however this mechanism indicates there is a structured approach with a focused agenda. Whereas informal communication is crucial for idea generation and the timely transmission of information (McAlpine, 2017), the combination of both formal and informal channels of communication greatly boosts innovation (Grimpe and Hussinger, 2008).

The supply chain of the Indian food and beverages industry involves five stages: inputs, production, procurement, processing and retailing. The food processing industry is a key step in the value chain and it is broadly categorised into two segments:

- Primary processing, which includes basic steps of processing like cleaning, grading, sorting, packing etc to make the products fit for human consumption. Finished products in this case include packed milk, fruits and vegetables, milled rice, flour, pulses, spices and salt, and are largely unbranded.

- Value-added processed food (secondary/ tertiary processing), which includes dairy products (ghee, cheese and butter), bakery products, processed fruits and vegetables, juices, jams, pickles, confectionery,

chocolates and alcoholic beverages. These products undergo a higher level of processing to convert them into new or modified products.

**FIGURE 17: Main processing steps**

Product	Primary processing	Secondary processing	Tertiary processing
<b>Milk</b>	Grading & refrigerating	Cottage cheese, Cream, Simmered and dried milk	Processed milk, spreadable fats (butter and cheese yogurt)
<b>Fruit &amp; vegetables</b>	Cleaning, sorting, grading & cutting	Slice, pulps, flakes, paste, preserved & flavored	Ketchups, jams, juices, pickles, preserves, candies, chips, etc
<b>Grains &amp; seeds</b>	Sorting & grading	Flour, broken, rice, puff, malt & milling oil cakes	Biscuits, noodles, flakes, cakes, namkeen sunflower, groundnut, mustard, soya, and olive oil
<b>Meat &amp; poultry</b>	Sorting & refrigerating	Cut, fried, frozen & chilled	Ready-to-eat meals
<b>Marine</b>	Chilling & freezing	Cut, fried, frozen & chilled	Ready-to-eat meals
<b>Beverages</b>	Sorting, bleaching & grading	Leaf, dust & powder	Tea bags, flavored coffee, soft drinks, alcoholic beverages

Source: Various Industry Resources

Figure 17 above highlights the main processing steps involved. The user-producer relationships found in the food and beverages sector include migration from primary to tertiary processing, then further on to packaging.

In specific terms, there are obligations for large firms to procure from licensed vendors which sets a certain quality requirement. This in turn has a trickle-down effect through disseminating knowledge on standards, quality, materials and hygiene practices.

### Inter-relationships

When examining the collective inter-relationships with other actors of the system, the most prominent interactions are in terms of formal and informal meetings, seminars and training, as recipients of funding, licensing agreements and trademarking.

When examining the relationship between industry associations and industry there is a clear indication of the transfer of tacit and codified knowledge between manufacturers with their industry associations. For instance, Annapoorna - ANUFOOD conference and exhibition on the food and beverage trade and retail market, which is jointly organised by the Federation of Indian Chambers of Commerce & Industry (FICCI), Ministry of Food Processing Industries and Koelnmesse YA Trade fair. It remains one of the most important B2B platforms for food and beverage trade and retail market in the Indian

subcontinent<sup>47</sup>. Similarly, the Confederation of Indian Industry (CII) has been organising Foodpro – India’s biennial event on food processing, packaging and food technology since 1995<sup>48</sup>.

Such channels provide ideal opportunities for the industry fraternity to interact with each other, give them a platform to voice their issues and concerns, thus providing the association with the means to communicate this to the government and guide discussions and decisions affecting the sector.

The Ministry of Food Processing Industries (MoFPI) launched a pan India scheme called “Pradhan Mantri Formalization of Micro Food Processing Enterprises”, in partnership with the state/ UT governments with the objective to build the capability of microenterprises in the unorganised segment of the food processing industry and promote formalisation of the sector. To obtain these challenging targets effective communication and knowledge transfer are key. A core component of the initiative is capacity building.

With respect to seminars and training, the knowledgebase is seen as a prime source of technical knowledge. Thus, the knowledge transfer between the knowledgebase and industry plays a critical role in contributing to growth and furthering competitive advantage of the food and beverages sector. A specific example of this is Pertecnica,

<sup>47</sup> Sourced from: <https://anufoodindia.com/index.php>

<sup>48</sup> Sourced from: <http://ciifoodpro.in/fp/foodpro.php>

which is a unique corporate and online training platform offering job-oriented training courses for engineering graduates.

Food and beverages is one of the largest industries in the world and India is one of the biggest consumer markets but also exports a good number of food items and beverages globally. In India, manufacturers are generally concentrated on the local market and have only recently started eyeing on the international markets. Robust supply chain strategies are required for export success. With this in mind, training is being offered on industry-specific modules with a complete business cycle right from identifying the raw materials until delivery to the customer. Specific modules include:

- Manufacturing strategies, product testing – research and development, competition analysis, production outsourcing, packaging technologies
- Procurement, sourcing of raw materials, supplier selection, quality control, specifications, standards
- Mergers, acquisitions, collaborations, joint ventures as production planning strategies, product allocation
- Data analytics, management information systems, ERP packages, software and development
- Design of supply chain, pricing strategies, cost containment, sales & distribution, margin analysis, financial management
- Inventory optimisation, logistics, warehousing, cargo & freight handling, ensuring product freshness, transportation route optimisation,

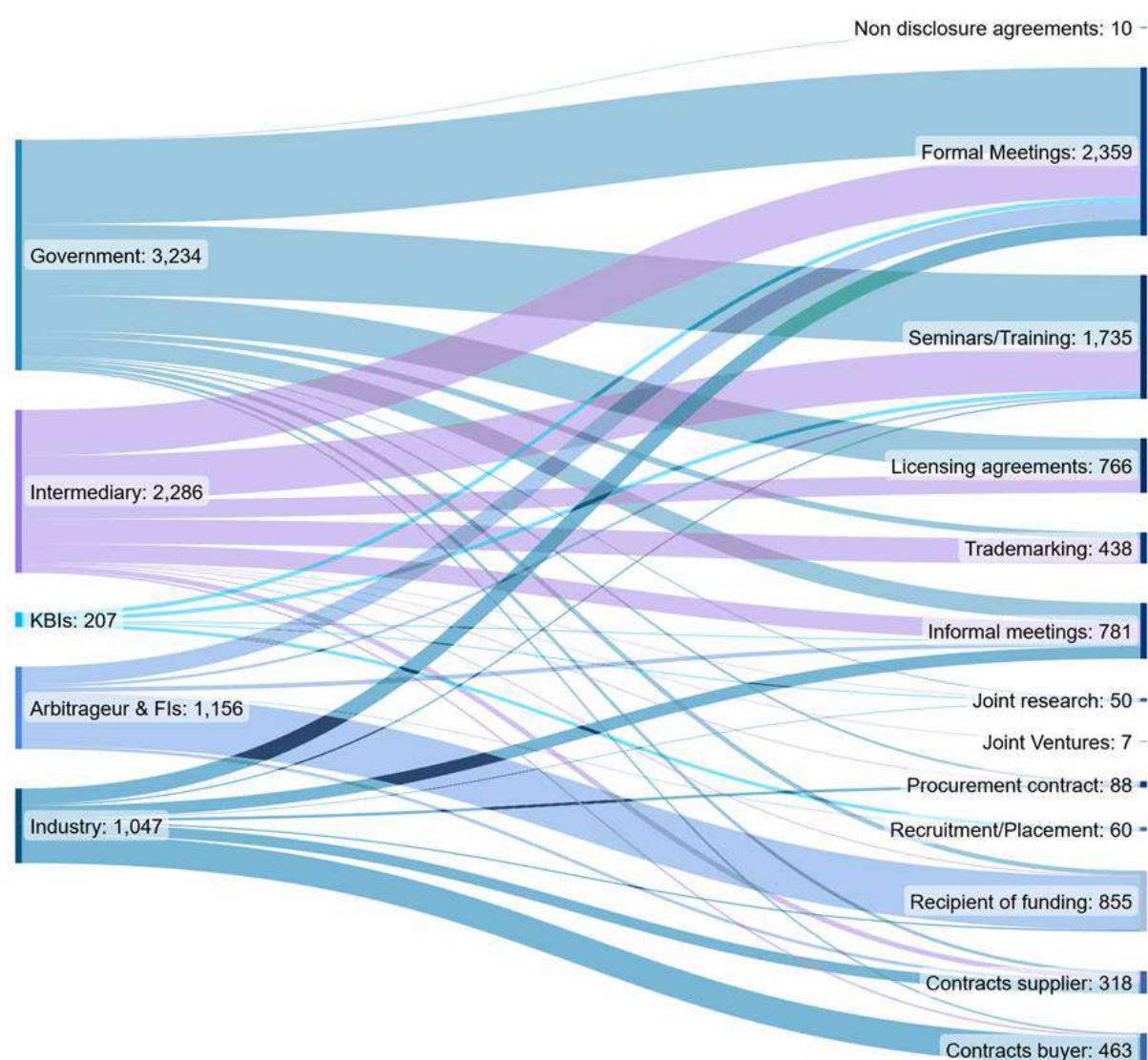
- Imports, exports, customs clearance procedures
- Shipping & documentation, receipts
- Contracts management
- Risk analysis and management, sales, inventory and operations planning

Industry engagement with financial institutions and arbitrageurs is primarily in the form of the recipients of funding. This is a reflection of the formality of the relationship between firms and financial institutions, particularly with the acquisition of loans or credit facilities from financial institutions. Often this is linked with knowledge dissemination as is seen by the Export-Import Bank of India (EXIM) which organises virtual business opportunity seminars for industry.

In the case of licensing agreements for import-export purposes, firms are required to obtain an Importer-Exporter Code (IEC) from the Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry.

Reporting of trademarking/standards as a linkage between industry and intermediaries is an indication of industry interacting with public/private institutions supporting technical change (ISTCs) for certifications/standards like BRC, Halal, and HACCP, etc. Additionally, in the food sector, trademarks mostly represent geographical indication (GI) tagging. Darjeeling tea is a globally recognised brand and was the first Indian product to get GI tag. Interestingly, to date, India has received 365 GI tags and the number of foods, spices and herbs have topped the list<sup>49</sup>.

<sup>49</sup> Sourced from: <https://timesofindia.indiatimes.com/life-style/food-news/did-you-know-these-5-indian-foods-got-gi-tags/photostory/77354553.cms>

**FIGURE 18: Industry relationships**

### 6.2.2 Knowledge-Based Institutions

Figure 19 highlights the knowledge-based institution intra- and inter-linkages.

#### Intra-relationships

The majority of intra-linkages reported by KBIs are as 'Joint research', 'Seminars/Training', and 'Secondments'. However, it is crucial to note the low number of responses obtained from knowledge-based institutions during the data collection.

The level of communication between KBIs indicate that there is some degree of collaboration taking place between them. For example, the National Institute of Food Technology Entrepreneurship and Management (NIFTEM) and the College of Agriculture and Life Sciences at Cornell University (CALS) signed a memorandum of understanding (MoU) in January 2008 to collaborate in the fields of human

resource development, applied research and industry-oriented innovation. A point of note is the general cost associated with R&D and whether or not this translates at the level of Tier2 and Tier3 institutions that are more resource constrained. What is lacking from the results is the level of knowledge codification and dissemination through joint publishing.

Seminars and training act as a conduit for the dissemination of knowledge and information. An example of a successful platform is NIFTEM and National Institute of Solar Energy jointly hosting a workshop entitled "Solar Energy in Food Processing Industries". Such strategic initiatives have contributed to knowledge exchange in the areas of microbiology in food safety, integrative concepts for mass personalisation of nutrition, export challenges and mitigation strategies.

Secondments can act as a tool to increase knowledge translation and help in developing a shift in organizational culture. There are around 120 Councils for Scientific and Industrial Research (CSIR) and Indian Councils of Agricultural Research (ICAR) institutions in the country and mobility of human capital takes place in the form of institutional transfers.

### Inter-relationships

Among the collective inter-relationships with other actors of the system, the most prominent interactions are 'Seminars/Training', 'Formal meetings' and 'Informal meetings', 'Licensing agreements' and as 'Recipients of funding'. In October 2022, the New Delhi-based company, Vikas Lifecare Ltd announced collaboration with the Indian Institute of Technology Varanasi, Stockholm University of Sweden, Lignflow Technologies AB and Lixea Compute to share the research inputs and work on developing various viable materials like cellulose, lignin and silica from rice husk. The objective of this agro-circle project is to develop techniques to produce new bio-based materials from the natural polymers extracted from farm waste materials and establish the production process for cellulose from agricultural rice residue using Lixea's Dendritic Process. This project will seek to patronise the production of lignin and the Indian company will be instrumental in developing a technology to produce nano silica from rice husk<sup>50</sup>

With respect to KBI interaction with the government, 'Seminars/Training' are prominent. This signals that the knowledgebase is acting as a knowledge-resource for the government. Seminars focused on skills development and awareness building for the government include the NIFTEM

conducting training sessions for the Food Safety and Standards Authority of India (FSSAI) officers.

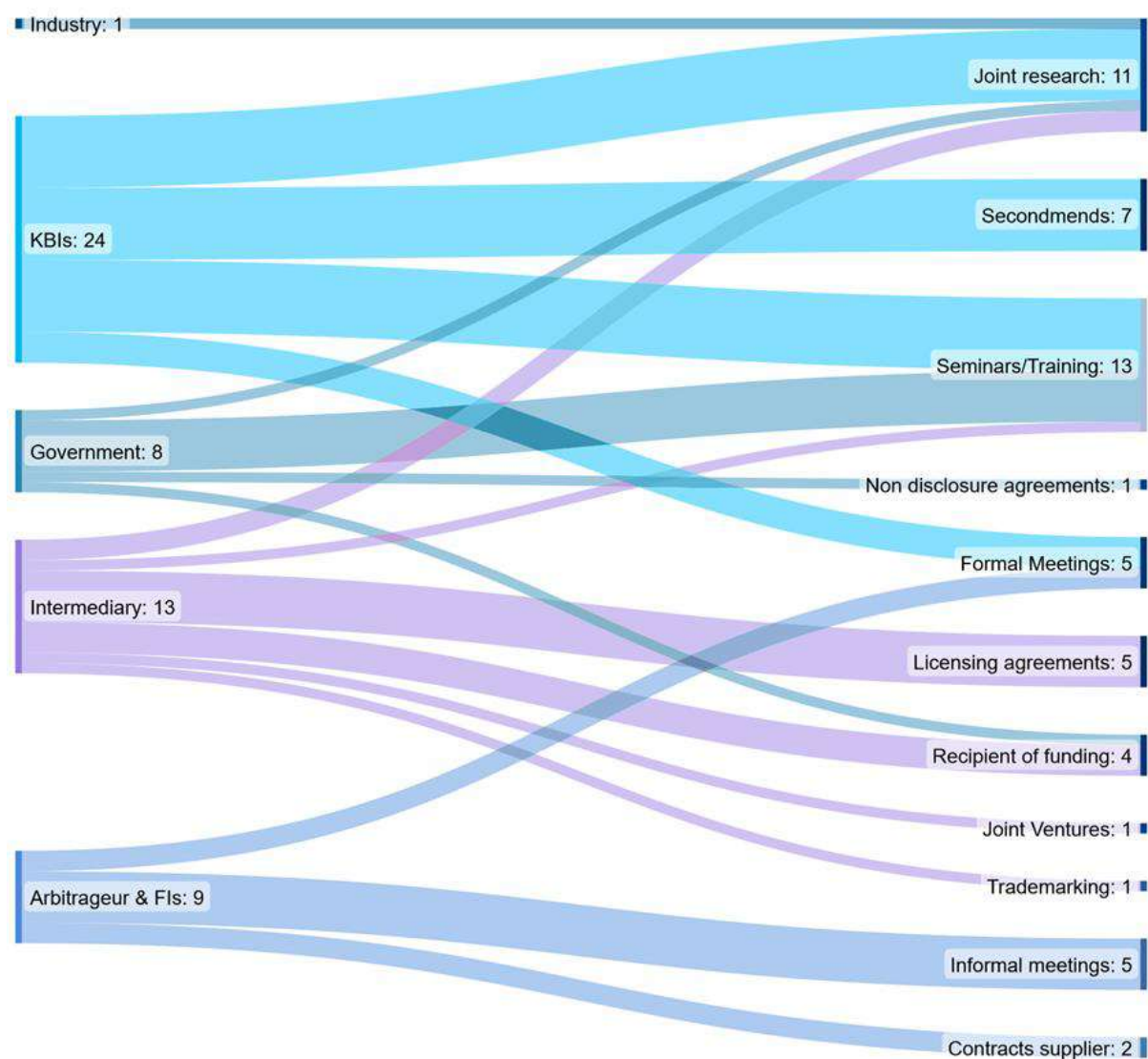
From the perspective of knowledge-based interaction with other system actors, the combination of formal and informal mechanisms of interaction enables the dissolution of organizational rigidities to some extent and better exchange of ideas, which may then be formalised in terms of formal transfer mechanisms like licensing and the acquisition of patents (Jensen and Thursby, 2001; Thursby and Kemp, 2002), joint research (Cockburn and Henderson, 1998) or consulting (Thursby et al., 2007). This is exemplified by the NIFTEM's Research Development Council which consists of 87 members drawn from industry, academia and research institutions. It has been tasked with the articulation of a research roadmap for the next 10 years.

'Licensing agreements' and 'Recipients of funding' are highlighted by KBI interaction with intermediaries, with host institutions licensing software and equipment to incubators as an example. Fund flows between KBIs and intermediaries can be seen in examples like the Nirma Incubation Centre being funded by Nirma University. Host Institutions like universities provide partial funding (25-50%) while the rest comes from the state or central government.

Another example of licensing agreements between KBIs and intermediaries is the NIFTEM pilot plants, which were established to cater to the needs of the food industry by following the disposal and management of solid waste as per the Pollution Control Board's regulations.

<sup>50</sup> Sourced from: <https://www.bizzbuzz.news/opinion/transforming-food-by-products-into-useful-raw-materials-1176263>



**FIGURE 19: Knowledge-based institution relationships**

**BOX 1: Amul - The white revolution in Gujarat****Objective**

Founded by a few dairy farmers to eliminate the exploitation by middlemen, Amul has emerged as the 8th largest milk processor in the world.<sup>51</sup> It has helped India become the world's largest milk producer with production doubling to some 130 million tons annually over the last two decades. The milk production in India is projected to jump 3-fold to 628 million tonnes in the next 25 years.<sup>52</sup>

**Approach**

Created in 1946 in response to the exploitation of marginal milk producers by traders who enjoyed monopoly over sourcing of milk from farmers, the milk revolution in India is defined by Anand Milk Union Limited popularly known as 'Amul'. Located in India's "Milk Capital" Anand in Gujarat, Amul came into existence when the farmers took control of their supply and formed a cooperative. Verghese Kurein, a dairy engineering graduate, led the revolution and pioneered systems through which producers could participate in their own development and connect directly with end consumers.

A decade later, Amul expanded to manufacture infant food under the brand name "Amulspray". It was based on a technology developed by the Council of Scientific and Industrial Research (CSIR) - Central Food Research Institute (CFTRI) that helped buffalo milk usage in infant food at the time when there was a paucity of cow's milk and all infant food required was imported as buffalo's milk was considered unsuitable for easy digestion by a baby. As a result, 50% of the baby foods imported were substituted by indigenous Amul baby food by the 1960s.<sup>53</sup>

**Outcomes**

Amul has brought together research organizations, a novel cooperative model, innovative supply chain, innovative packaging (design innovation), processing and testing at different stages, bringing new levels of automation. The Amul model is cited and adopted in many developing economies. Other cooperative federations in India have also borrowed from this model.

**6.2.3 Government**

Figure 21 highlights the government intra- and inter-linkages.

**Intra-relationships**

The main intra-linkages reported are 'Formal meetings', 'Informal meetings', 'Seminars/Training' and as 'Recipients of funding'.

Due to the complexity of policymaking, the division of labour between government agencies makes it almost impossible for one agency to dominate the process. Joint efforts involving different agencies are essential as is highlighted by formal and informal communication. Therefore, communication, coordination and mutual adjustment between these stakeholders and between the stakeholders and the environment against which policy is made is required (Flanagan et al., 2011). However, there is ample literature on silos in government and it often focuses on their failure to engage effectively in horizontal

coordination. In this context, silo is defined as a hierarchical organization that seeks to maximize vertical coordination at the expense of horizontal coordination. It is inward looking and self-contained with little regard for outcomes other than those which affect its own narrowly conceived goals.

While this is often true, rigid and isolated administrative systems may still find ways to overcome or prevent incoherence in government. The problem is not so much with the structure of silos but with the lack of effective coordination mechanisms between them (Scott and Gong, 2020).

Government stakeholders in the food and beverages sector make use of standard channels of communication for information and knowledge sharing, such as the Ministry of Food Processing Industries (MoFPI), in association with the Ministry of Development of North Eastern Region (MDoNER) organising a meeting with all northeastern state governments to discuss constraints in poor utilisation of funds under various schemes of the MoFPI. It is conceivable that organizational relationships may evolve gradually from

<sup>51</sup> Sourced from: <https://timesofindia.indiatimes.com/city/vadodara/amul-worlds-8th-largest-milk-processor-now/articleshow/79516847.cms>

<sup>52</sup> Sourced from: <https://www.livemint.com/news/india/indias-milk-production-to-jump-3-fold-to-628-mn-tonnes-in-25-yrs-amul-chief-11662989347817.html>

<sup>53</sup> Sourced from: <https://www.newstrailindia.com/inner.php?id=3798&cat=karnataka>

cooperation to coordination and then to collaboration. However, as a note of caution this is not the case in silo-dominated governments, where cross-cutting issues are likely to be resolved, and if at all, at the cooperation and coordination stages and may never proceed beyond that.

In the case of funding, the Ministry of Agriculture & Farmers' Welfare (MoAFW) and Ministry of Food Processing Industries (MoFPI) jointly launched a convergence portal between the "Agriculture Infrastructure Fund" (AIF), the "Pradhan Mantri Formalization of Micro Food Processing Enterprises (PMFME)" and "Pradhan Mantri Kisan Sampada Yojana" (PMKSY) schemes. The objective of which is to ensure effective collaboration between all ministries and departments, improving access to these schemes and creating a positive impact for farmers and small-scale entrepreneurs of the food processing industry.

Funds flow between government entities include the central government providing financial assistance to state governments for setting-up the common facility infrastructure.

The "National Food Processing Mission" and "Agro Processing Cluster Scheme" are some initiatives, which aim at the development of modern infrastructure and common facilities; They encourage groups of entrepreneurs to set-up food processing units based on a cluster approach by

linking groups of producers/ farmers to the processors and markets through a well-equipped supply chain with modern infrastructure.

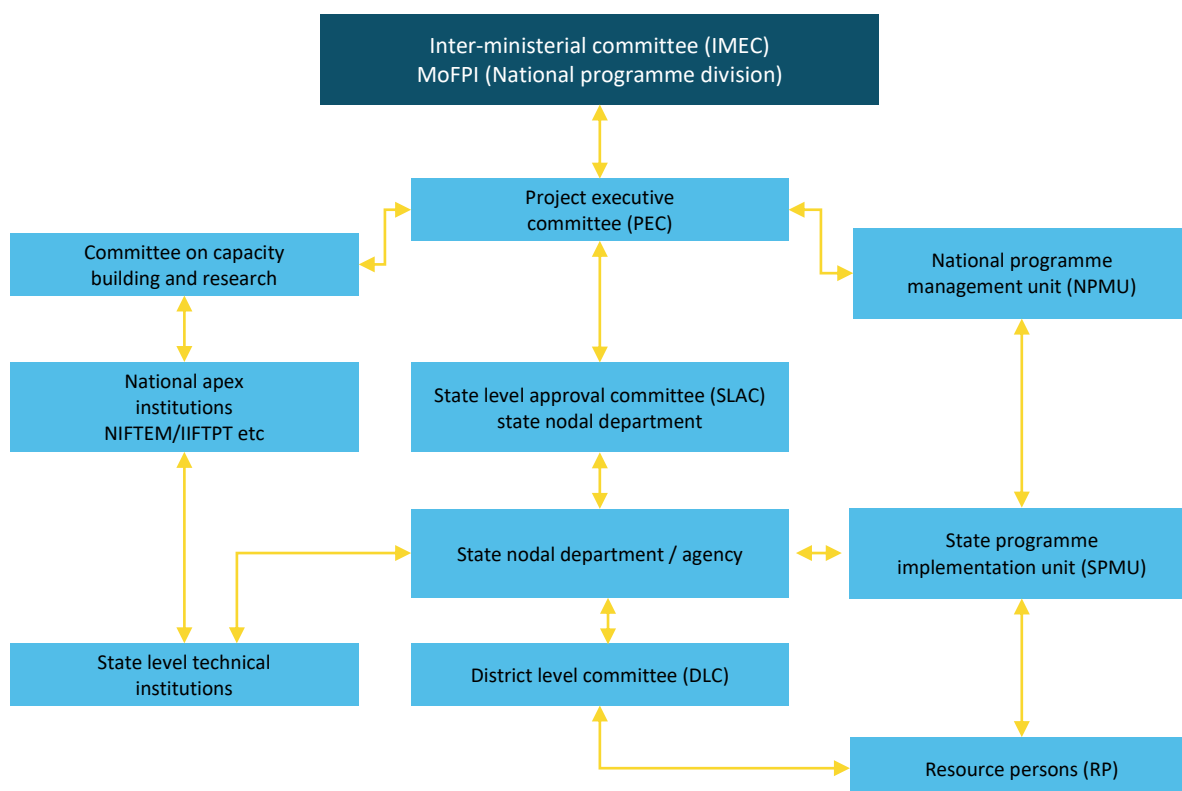
### Inter-relationships

On review of the inter-relationships between government and other system actors, the most prominent types of interaction are 'Formal meetings', 'Informal meetings', 'Seminars/Training', as 'Recipients of funding'.and 'Licensing agreements'.

With respect to industry, no direct linkages were reported, this may signal that the sole means of communication is through industry associations. The efficacy of this relationship would need further examination, as it could signal a possible disconnect in the government's understanding of the needs of industry.

The communication between KBIs and the government is related to policy guidance and implementation. Figure 20 below represents the robust institutional architecture at all administrative levels set-up for the "PM Formalization of Micro Food Processing Enterprises (PM-FME) Scheme". There are committees at national, state and district levels (for policy guidance) for implementation and to monitor the progress of the scheme comprising consultants and experts engaged on a full-time basis from KBIs like the NIFTEM to support the National Programme Division at the MoFPI and the state nodal agencies.

**FIGURE 20: Institutional architecture for PM-FME Scheme**

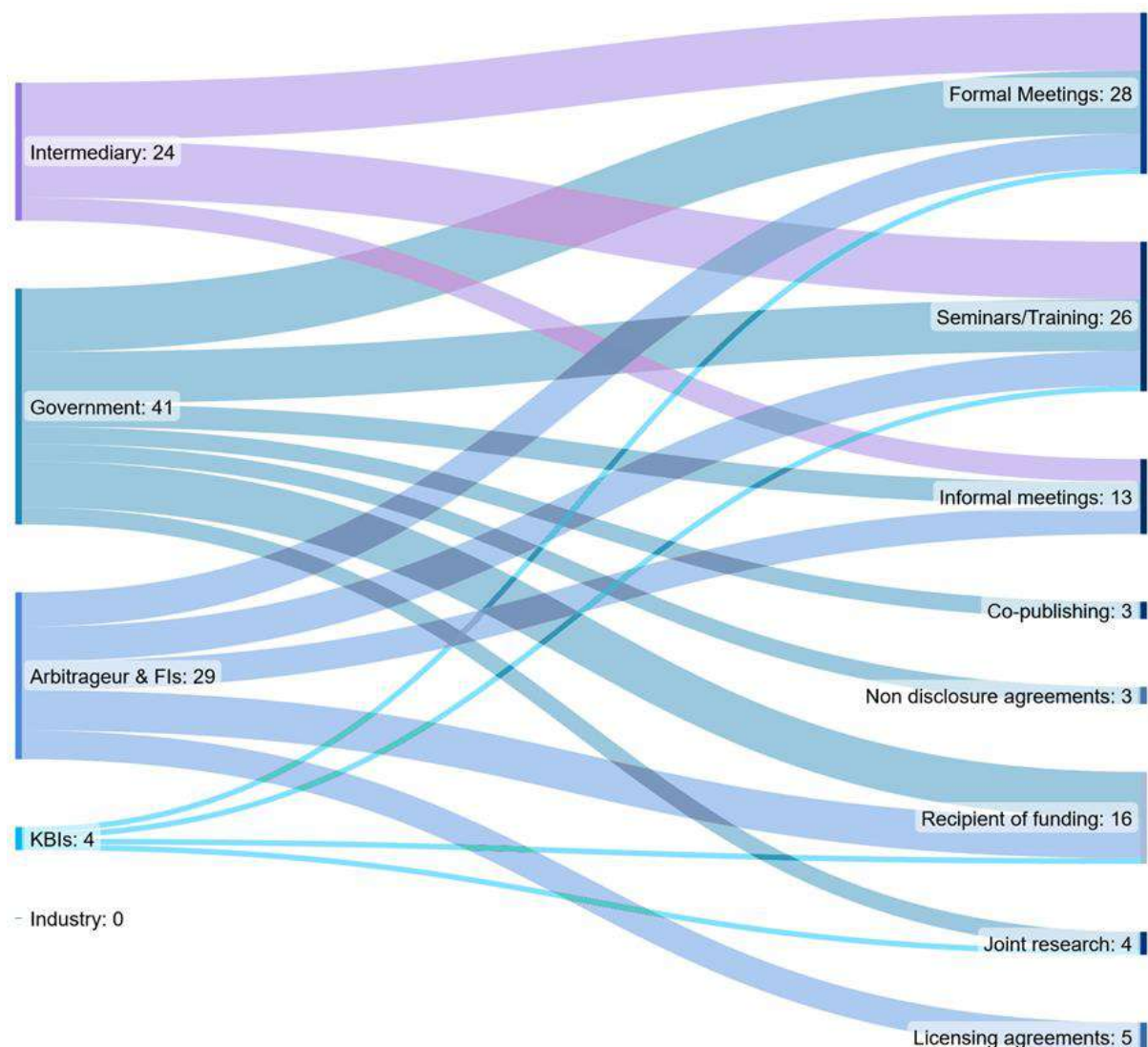


In the case of government interaction with the intermediaries, tacit knowledge transfer through formal and informal meetings, as well as seminars/training emerges. This indicates regular communication between government and industry associations and government bodies in the form of global conventions, conferences, exhibitions. An example being the MoFPI, Agricultural and Processed Food Products Export Development Authority (APEDA) and the Plant-Based Foods Industry Association (PBFIA) coming together to organise India's 1st Plant-Based Foods Summit on May 26th, 2022. This summit offered strategic opportunities to the players in the plant-based foods industry and facilitated a platform for networking eliciting conversations surrounding the market size, emerging technologies, existing concerns facing the

industry, and contributions leaders in powerful positions can make<sup>54</sup>.

Flow of government funds is traditional in nature as for higher education and are in the form of R&D grants. This is easier for public KBIs than private KBIs and as per the revised guidelines for the "Scheme of Research & Development in Processed Food Sector" (2017-2020), it is important to note that R&D projects would need to be carried out in collaboration with the industrial partners. However, in the case of financial institutions, the government provides funds to nationalised banks under the Animal Husbandry Infrastructure Development Fund or Special Food Processing Fund through the National Bank for Agriculture and Rural Development (NABARD).

**FIGURE 21: Government relationships**



<sup>54</sup> Sourced from: <https://www.plantbasedfoods.org/celebration-of-indias-burgeoning-plant-based-foods-industry-heralded-at-inaugural-plant-based-foods-summit/>

### 6.2.4 Intermediary

Figure 22 highlights the intermediaries intra- and inter-linkages.

#### Intra-relationships

The main intra-linkages reported are 'Formal meetings', 'Informal meetings' and 'Seminars/Training' which indicate high tacit knowledge transfer between intermediaries. As is exemplified by the Partner's Forum, jointly organised by the Federation of Indian Chambers of Commerce & Industry (FICCI), All India Food Processors Association (AIFPA), Association of Food Scientist & Technologist of India (AFSTI – Mumbai), Chamber for Advancement of Small and Medium Businesses (CASMB), and Indian Flexible Packaging & Folding Carton to address the current prevailing issues related to the food and beverage industry in India. The forum focused on technical and policy requirements which can elevate the Indian food industry to global benchmarks giving the country its due share in the world food trade as a leading producer of most agri-commodities.

World Food India (WFI) is a gateway to the Indian food economy and an opportunity to showcase, connect, and collaborate. It is a global event to facilitate partnerships between Indian and international businesses and investors. Organised by the MoFPI, WFI is held in partnership with the Confederation of Indian Industry (CII), KPMG as the knowledge partner and "Invest India" for the investment facilitation.

The Inter FoodTech Conclave is a one-of-a-kind premier food technology fair for the food and beverage industry, which is organised by Inter FoodTech, supported by the Plant-Based Foods Industry Association and ValueSmart as its knowledge partner<sup>55</sup>. Through insightful seminars and interactive experiences, the conclave creates ideal opportunities for the industry fraternity to interact with each other and explore collaborations that can foster innovation in the sector.

#### Inter-relationships

With respect to inter-relationships, the most prominent are those of the intra-relationships, namely Formal meetings', 'Informal meetings', 'Seminars/Training', as 'Recipients of funding', 'Joint research', and 'Trademarking'.

Formal and informal communication along with knowledge dissemination between industry associations and industry would enable them to stay attuned to the views of their membership. The presence of both formal and informal

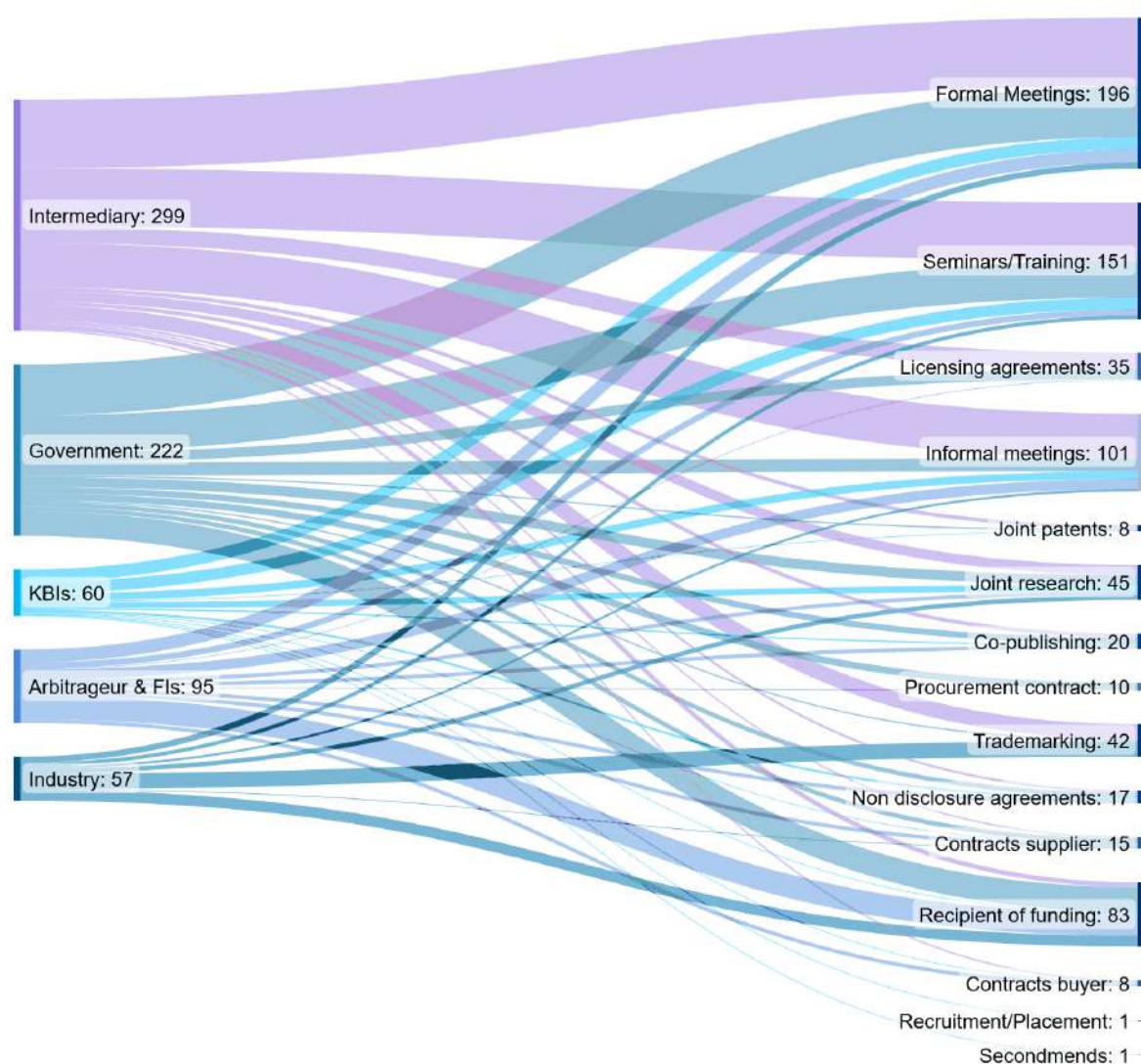
communication supports problem solving. Actively building and maintaining relationships through discussions can lead to intermediaries contributing to the process and can increase the likelihood that experience will inform policy decisions. This would underscore their function of providing a collective voice for their members and conveying the same to the government. Knowledge dissemination activities for the food and beverages sector take place through events like AAHAR - International Food & Hospitality Fair which is a flagship B2B event organised by the India Trade Promotion Organisation (ITPO), the premier trade promotion body of the Government of India. Similarly, the Trade Promotion Council of India (TPCI) organises IndusFood, one of the largest food fairs supported by the Department of Commerce. In addition, being linked to the knowledgebase through knowledge sharing platforms enables the latest in technical information to filter through to their members. An example of this being the NIFTEM - CII Food and Agriculture Centre of Excellence (FACE) joint workshop on food safety risk mitigation in the food chain. In the case of intermediary linkages with industry, all food businesses in India across the food value chain are required to be licensed or registered under the provisions of the Food Safety and Standards Act 2006. The Food Safety and Standards Authority of India (FSSAI) has laid down general and specific food safety and hygiene requirements for Food Business Operators (FBOs). Further, the FSSAI requires every food business operator to have a documented Food Safety Management System (FSMS) plan, which includes sector-specific Good Hygienic Practices (GHPs) and Good Manufacturing Practices (GMPs). This often translates into industry associations providing consultancy services or specific policy focus advisory services to their members.

An example of joint research is the FICCI Food Processing Division conducting joint studies/surveys with industry partners like Unilever, ITC Ltd.

There are a lot of venture capital activities in the food and beverages sector. Venture capitalists are investing in alternative pathways like nutraceutical products, and high-quality food for babies. An example of this is Periyar Technology Business Incubator engaging with Nativelead Angel Network for portable jaggery production. Sector-specific knowledge outreach between industry associations and arbitrageurs includes initiatives such as the CII & EXIM Bank on Indo-Africa partnership for food processing and energy security. Joint research and its codification manifest as studies for the sector conducted by the FICCI and IBA - Survey of Bankers.

<sup>55</sup> Sourced from: <https://www.interfoodtech.com/index.html>



**FIGURE 22: Intermediary relationships**

### 6.2.5 Arbitrageurs and financial institutions

Figure 23 highlights the arbitrageur and financial institution intra- and inter-linkages.

#### Intra-relationships

The main intra-linkages reported are as 'Recipients of funding'. This indicates financing between banks, that is, refinancing rural and co-operative banks for investment credit purposes (long-term and short-term loans). One such case is that of the National Bank for Agriculture and Rural Development (NABARD) which provides a concessional refinance of INR 15,000 crore to cooperative and regional rural banks for boosting capital formation in food processing and systems (NABARD, 2022). NABARD also

provides cooperative banks and regional rural banks loans so as to improve credit flow at the ground level. Furthermore, NABVENTURES, a wholly owned subsidiary of NABARD, is a venture growth equity fund that invests in early to mid-stage startups in agriculture, agtech, agri-biotech, food, FinTech and rural businesses.

There also emerges some crucial minor interactions related to knowledge dissemination, namely 'Formal meetings', 'Informal meetings' and 'Seminars/Training'. In order for arbitrageurs and financial institutions to effectively stay on track with the market and assess risk, information flow is crucial. The Bank of Baroda's Banking Beyond Tomorrow: Annual Banking Conference 2022, is a good example of this as it focuses on strengthening financial inclusion, innovative technologies and new business models for digital banking, ESG finance and tackling climate change<sup>56</sup>.

<sup>56</sup> Sourced from: <https://www.bankofbaroda.in/hi-in/-/media/project/bob/countrywebsites/india/content/media/press-releases/banking-beyond-tomorrow-annual-banking-conference-2022-22-07-2022-26-10.pdf>

With respect to financial institutions two facets of communication emerge, namely, external and internal. The latter involves exchange of information and dialogue between departments and communication between the management and staff. While external (with other financial institutions and system actors) communication shapes market expectations, internal communication facilitates trust-building and inculcates a sense of belonging among the employees, thereby leading to increased productivity and efficiency. The channels of communication are: (i) publications (including circulars/notifications); (ii) speeches; and (iii) others including seminars and fora.

### Inter-relationships

With respect to inter-relationships, once again formal and informal channels of communication are prominent, followed by knowledge dissemination activities in the form of 'Seminars/Training', followed by 'Recipients of funding'.

As was previously highlighted, formal communication contributes to the process of sharing information, exchanging and developing ideas, as well as expressing disagreement, and managing conflict (Shasitall, 2022), however this mechanism indicates there is a structured approach with a focused agenda which is to be expected between actors.

With respect to government and arbitrageurs and financial institutions, a joint workshop was hosted by the Department of Industries & Commerce, Government of Tripura with the Tripura Grameen Bank for disseminating information and knowledge-sharing, and to popularise the "Pradhan Mantri Kisan SAMPADA Yojana" in the northeastern region (NER). The aim of the workshop was generating interest amongst SC/ST and other

entrepreneurs of NER to set-up food processing units, as well as to provide hand holding on a sustainable basis (MOFPI, 2019).

With respect to KBIs, tacit knowledge transfer coupled with receipt of funding indicates that the process of ideation to market is encouraged. An example of which is the Higher Education Financing Agency (HEFA), a joint venture of the Ministry of Education and Canara Bank for financing creation of capital assets in premier educational institutions in India<sup>57</sup>.

In the case of intermediaries, the Deshpande Sandbox Incubator, is one such example where it organised startup dialogue in 2022 with investors to support technology entrepreneurs<sup>58</sup>. With respect to Industry, 100% reported receiving funds which indicates credit facilities opted by the industry from banks or NBFC's (non-banking financial institutions). A clear example of this is the State Bank of India (SBI) offering MSME/SME loans to encourage units engaged in the food processing industry<sup>59</sup>. Additional direct financial support emerges in the form of the MoFPI's scheme for setting-up / upgradation of quality control / food testing laboratories, which highlights where financial assistance is provided through banks (MoFPI, 2022).

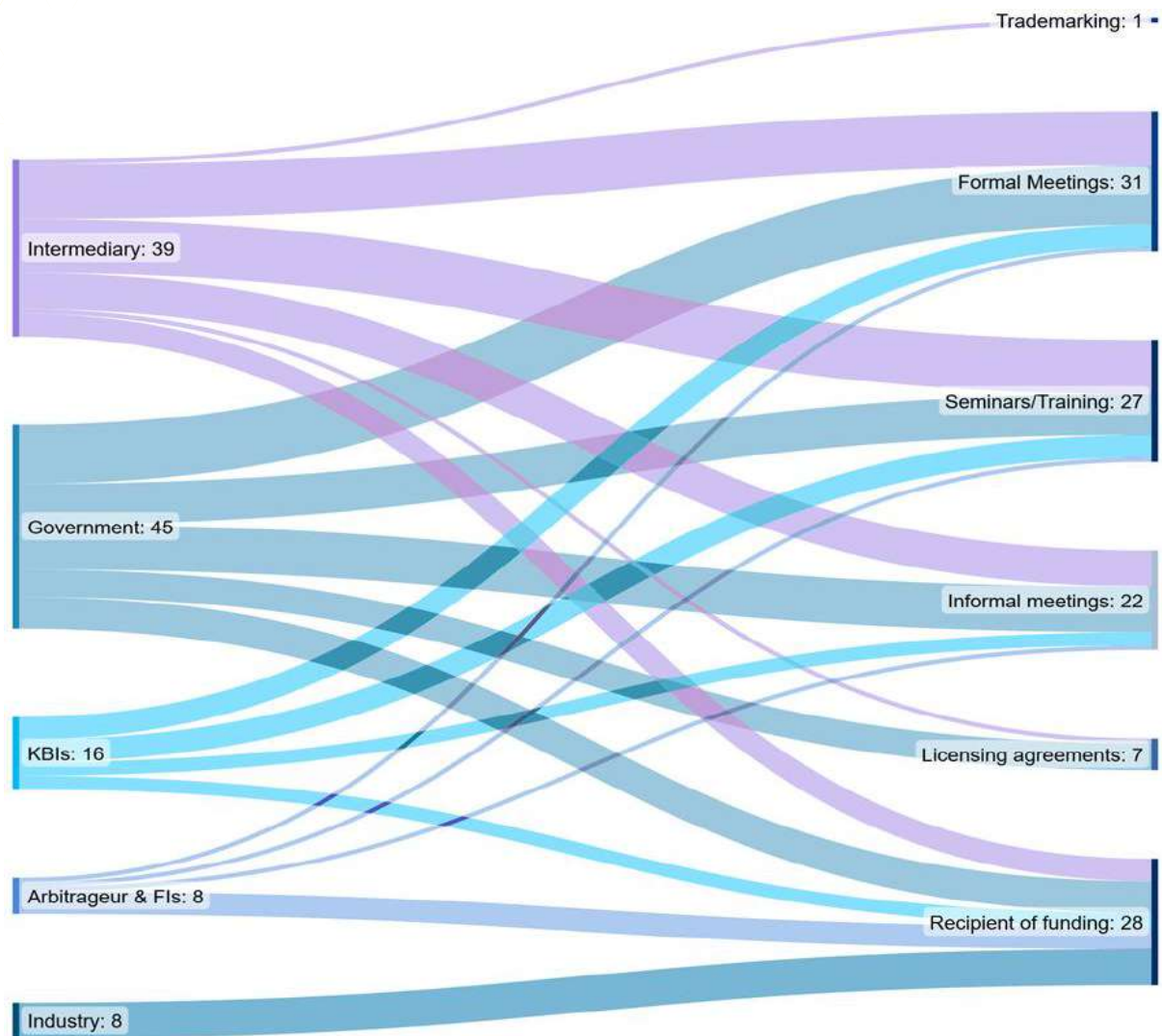
True Elements, a clean label health foods brand startup operated by HW Wellness Solutions Pvt. Ltd., has raised INR 10 crore (US\$ 1.36 million) in funding from the "Maharashtra State Social Venture Fund" (MSSVF). MSSVF is an alternative investment fund established on September 15th, 2015, as a close ended unit scheme of the Maharashtra Laghu Vikas Trust. SIDBI Venture Capital Limited is the investment manager and SIDBI Trustee Company Limited is the sole trustee for the fund<sup>60</sup>.

<sup>57</sup> Sourced from: <https://hefa.co.in/about-us/>

<sup>58</sup> Sourced from: <https://startupdialogue.org/>

<sup>59</sup> Sourced from: <https://sbi.co.in/web/business/finance-to-food-processing-industry>

<sup>60</sup> Sourced from: <https://www.vccircle.com/true-elements-raises-funding-from-fund-managed-by-sidbi-venture-capital>

**FIGURE 23: Arbitrageur and financial institution relationships**

In the relationships presented above, there are some interactions which are robust, however what emerges is the need to bolster certain truncated relationships in order to facilitate knowledge and resource flows within and between the actors and hence foster innovation. According to the literature, the scope and intensity of these interactions between the actors are reflected in varying institutional arrangements, referred to as Triple Helix Type I, II, and III (TH-Type I, II and III) (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2003b, 2008; Ranga and Etzkowitz, 2013). In the specific case of the food and beverages sector, we observe TH Type II arrangement. TH Type II refers to mechanisms of communication between the actors that are strongly influenced by the market and technological innovations and the point of control is at the interfaces and consequently new codes of communication are developed. The role of the government is primarily to limit cases of market failure. It can be considered a 'laissez-faire' model of interaction in which actors are expected to act

competitively rather than cooperatively in their relations with each other.

Therefore, interactions that need attention are:

- Fostering more joint research between industry actors.
- Promoting joint research between industry and the knowledgebase.
- Fostering of knowledge sharing between industry and the knowledgebase through secondments with the objective of aligning curricula in line with the requirements of industry.
- Closer relationships between industry and the knowledgebase for the absorption of skilled human capital.
- Closer linkages between industry and financial institutions for the purposes of knowledge transfer and ultimately better access to finance.

- Boosting joint research between knowledge-based institutions, being inclusive of T2 and T3 institutions.
- Strengthening linkages between knowledge-based institutions and arbitrageurs in order to facilitate ideation to market.

### 6.3 Barriers to Innovations

This section sets out to analyse the results of the IFBSSI Survey. It uses a multivariate analysis approach which provides a strong empirical foundation. The focus of this chapter is the elucidation of the barriers that exist within the food and beverages system of innovation. It is crucial to understand which barriers to innovation are significant for the food and beverages sector in order to critically understand where resources need to be applied to bolster the system of innovation and boost innovation for the sector.

To this end, factor analysis is used to indicate the underlying factors that significantly influence barriers to innovation, enabling evidence-based policy design to be targeted specifically and accurately to overcome the barriers to innovation in prioritised sequencing. Factor analysis condenses observed variables into factors in a pattern matrix (clusters of inter-correlated variables) with mutual interdependence (Gaur, 1997). The factors represent the underlying structure that is responsible for the variation of variables in the data and thus the population (Kim Jae-On and Mueller 1978). The next section aims to articulate this both from the system perspective, as well as from the level of each individual actor.

#### Description of Table Structure

The column 'Factor Number' indicates the descending rank order (by importance) of the factor, which influences the sets of barriers to innovation variables. The column 'Factor Name' provides a description for the grouped variables

influenced by the factor and enables meaningful policy discussion of the barriers to innovation. The factor names are assigned based on the factor loading of the variables taking the higher loading variables into consideration as well as the judicious use of empirical evidence and theory in the literature of SSI. The naming of factors therefore reflects the variables that are most influenced by the underlying factor, and hence there are commonalities and differences regarding actor responses. Furthermore, the column 'Factor Loading' indicates the correlation between factors and variables, i.e., the extent to which the factor influences the variable. The column 'Cronbach's Alpha' indicates the internal consistency and reliability of the factor, and hence the cohesion of variables as a group. The dominant heuristic, or commonly accepted rule of thumb for describing internal consistency and reliability using Cronbach's Alpha, is indicated in Table 4 (George and Mallery, 2003; Kline, 1999; Cortina, 1993).

For the purpose of policy analysis, factors influencing groups of variables with Cronbach's Alpha below 0.7 are deemed inconsistent and unreliable and are rejected for policy purposes. The factors enable economy-wide policy prescriptions, as well as actor- (sector-) specific policy prescriptions to be carefully and accurately designed.

The column 'Total Variance Explained' (TVE) indicates the amount of variance (variation) of the groups of variables in the data sample and population, which is accounted for by the factor. It is an indication of the extent or power of the influence of the factor. The column 'Kaiser-Meyer-Olkin' (KMO) is a measure of sampling adequacy. It indicates the robustness of the sample in terms of the distinct and reliable factors extracted (Kim Jae-On and Mueller, 1978). The Bartlett's Test of Sphericity (BTS) indicates the significant confidence level regarding the coherence of factors, reproducibility and generalisability of the results (Kaiser, 1974; Dziuban and Shirkey, 1974, p.359; Kim and Mueller 1978, p.54; Rummel, 1970) (see Table 5)

**TABLE 4: Internal consistency of factor**

Cronbach's Alpha	Internal Consistency/ Reliability
$a \geq 0.9$	Excellent
$0.9 > a \geq 0.8$	Good
$0.8 > a \geq 0.7$	Acceptable
$0.7 > a \geq 0.6$	Questionable
$0.6 > a \geq 0.5$	Poor
$a < 0.5$	Unacceptable



**TABLE 5: Kaiser-Meyer-Olkin (KMO)**

Internal consistency of factor	
KMO = 1	Perfect
KMO > 0.9	Marvellous
0.9 > KMO > 0.8	Meritorious
0.8 > KMO > 0.7	Middling
0.7 > KMO > 0.6	Mediocre
0.6 > KMO > 0.5	Miserable
KMO < 0.5	Unacceptable

Source: Kim Jae-On and Mueller, 1978

From the analysis of all actors (see Table 6) four factors emerge which account for 53.68% of the total variance explained (TVE), namely, **‘Market Dynamics and Structure’**, **‘Industry 4.0’**, **‘ICT’**, and **‘Organization’**.

Factor 1- **‘Market Dynamism & Structure’** is the most significant factor barrier to innovation in the food and beverage sector. It accounts for 23.34%, % of the TVE within the sample, hence the population. It shows the importance of markets in driving innovation through demanding customers and innovative customers, as well as distinct ‘rules of the game’ articulated through higher resolution regulations. The variables loading on the factor are: ‘Lack of innovative customers’, ‘Lack of clear national innovation strategy’, ‘Lack of demanding customers’, ‘Lack of explicit policy support (government)’, ‘Lack of traditional infrastructure’ and ‘Excessive perceived economic risk’. The Cronbach’s Alpha value indicated the internal consistency of the factor as ‘Good’.

Market dynamism and structure can be described by rapid changes in technologies, changes in market structure, the instability of market demand, intense fluctuations in supply of materials, and the probability of market shocks (Nguyen & Harrison 2019; Jansen, Van Den Bosch and Volberda 2006; Sirmon, Hitt and Ireland RD, 2007), as well as the related infrastructure and institutions. Volatility and unpredictability characterises market dynamism (Miller and Friesen, 1983), therefore a high level of market dynamics restricts the ability to distinguish the market boundaries, develop clear successful business models, and identify market participants such as competitors, customers, and suppliers and their respective needs (Eisenhardt and Martin, 2000).

Consequently, this leads to external uncertainty thus making it more difficult to predict future market situations, plan and organise their resources, and respond with their own knowledge and related processes. Therefore, firms are required to improve and modify their products and services with innovation continuously to meet customers’ needs. Less dynamic markets, in contrast to highly dynamic

markets, present not so frequent changes that market players can usually anticipate or regular changes that occur periodically and are hence predictable. In less dynamic market environments, there is better clarity on market boundaries, the market participants (e.g., firms, customers and suppliers) know each other well and customer demand is relatively stable. Hence, firms do not feel the need to innovate or modify their products or business processes (Eisenhardt and Martin, 2000; Schilke, 2014).

In light of the above, in order to promote innovation, a dynamic market is required. “Regulations which encourage market dynamism, innovation and competitiveness improve economic performance. The aim of regulatory reform is to increase efficiency and effectiveness and to have a better balance in delivering social and economic policies over time” (OECD, 2011 p.4). Poorly designed or weakly applied regulations can hamper business responsiveness, divert resources away from productive investments, hinder entry into markets, reduce job creation and generally discourage entrepreneurship. Hence, there is the need for administrative simplification (OECD, 2009) with the provision of clear, consistent and coherent rules for dynamic markets to function well and long-term planning is an important consideration in this process.

While India has favourable supply- side dynamics on the back of the agriculture base, the food and beverages sector faces challenges such as rising food prices which are expected to impact demand if not controlled (Grant Thornton & CII, 2014).

Product development and innovation focus is lacking. However, changing consumer preferences are expected to drive innovation particularly as more than 50% of the consumer base is below the age of 30 years. This young consumer base is gradually influencing consumption patterns, which is driven by quality (freshness of product), variety (range of products) and convenience (access to product).



Product development and innovation in the sector has taken a back seat due to the lack of investments and incentives. The current infrastructure is poor, and the operating procedures followed need improvement for the industry to evolve. An example is the cold chain industry, which is one of the most critical components of the food processing value chain, where perishables form one of the largest segments. Even now, some sub-segments of perishables see wastage as high as 40%, where a lack of cold chain infrastructure is a major aspect (Narayan, 2022). The Indian cold chain industry is at a nascent stage and remains largely untapped due to several factors, such as the requirement of high capital investment, and the lack of requisite supporting infrastructure (roads, bridges, warehousing). The sector has been facing a lack of funds as banks are reluctant to extend loans to the industry as this is perceived to be a high risk, high gestation period and low returns business.

These issues need to be addressed, particularly as the demand for cold storage is expected to grow to 47 million tonnes as the food sector (retail and service) is getting organised with support from government initiatives on the back of demand for processed and frozen food. Nevertheless, ambiguity in the regulations is still a concern as there is no comprehensive national level policy for the food processing sector and also as there are inconsistencies in the central and state policies (Grant Thornton & CII, 2014).

Factor 2- '**Industry 4.0**' is the second most significant factor and accounts for 13.81% of the TVE. The variables that load on the factor are: 'Lack of understanding of I4.0 technologies', 'Cost of I4.0 technologies', 'Lack of access to I4.0 technologies', and 'Lack of infrastructure for I4.0', which are deemed to be 'Excellent' (Tabachnick and Fidell, 2007).

The 4IR consists of a set of complex, interrelated and advanced digital production (ADP) technologies that have changed the face of global manufacturing. The key technology pillars of 4IR include: the Internet of Things (IoT), big data, artificial intelligence, robotics, additive manufacturing, cloud computing, augmented reality, virtual reality, cyber-physical systems, system integration and simulation. The complexity of 4IR technologies demands a high interdependency of competences and technological complementarity (Dalenogare et al., 2018; Reischauer, 2018; Rübmann et al., 2015). Implementation of 4IR technologies at a broader organizational level is required for a measurable impact of digital transformation.

The Internet of IoT assists food and beverage companies in acquiring substantial visibility over their manufacturing, transportation and production operations. This yields

higher quality products for end consumers while preserving operational efficiency and remaining adaptable with governmental rules. Additionally, Industry 4.0 can help in the expansion of food and beverage safety. Taking sufficient food safety measures is not only an essential part of giving quality food and beverage products to the end consumer but it also plays a crucial role in supporting compliance.

Before the COVID-19 pandemic, many firms were excited about 4IR implementation with 90% respondents of McKinsey's "Annual Industry 4.0 Survey" who were convinced of the value of 4IR technologies. However, the pandemic has altered the flow of resources from 4IR adoption as many firms, especially SMEs, froze their 4IR initiatives. Transforming factories from being manual and labour-intensive to being automated and highly digitised requires enhanced capabilities, not limited to investment in technologies. Firms require a vast set of capabilities to digitally transform their entire operating model using 4IR technologies (Boer et. al, 2021). Such capabilities are hard to be found in a single technology provider, especially in the case of small and micro enterprises (SMEs) (APO, 2019).

In real terms the challenges of adopting I4.0 in the Indian food and beverages sector are multi- faceted. Firstly, the IoT which is the technology for linking manufacturing and supply chain is still relatively novel. It requires a level of collaboration and trust between diverse businesses at the production, processing, wholesale, and retail levels, some of which are very traditional in their outlook so sharing that much information does not come naturally. This kind of transparency also requires improvements in Internet security. Secondly, capital cost is a factor, particularly as many food and beverage companies function with technology and equipment that was installed with significant capital outlay well before the IoT became a reality and replacing it may not be an immediate possibility. Finally, there is the aspect of a skilled workforce that is capable of running their transformed facilities. (Delliotte, 2018).

The first step towards 4IR implementation is a clear understanding of I4.0 technologies. A lack of understanding of the value, goals and needs of 4IR technology still exists among many firms (Bai et al. 2020). Robust evaluation mechanisms and decision support tools can help manufacturing firms understand the impact of 4IR technologies and effectively implement them. A clear understanding of 4IR technologies, their benefits and impact can help firms develop an organization-wide 4IR strategy and set implementation targets. Educating the workforce on 4IR technologies and up-skilling them is key to its effective implementation. A well-functioning

innovation ecosystem can allow collaborations between system actors for knowledge sharing and awareness building. It will enable firms to integrate resources and co-create 4IR solutions (Grant Thornton & CII, 2017).

Factor 3- '**ICT and Knowledge Flows**' accounts for 9.43% of the TVE in the sample, hence the population. The variables that load on the factor are: 'ICT capacity', 'Rate of access to ICT' and 'Lack of willingness to share the knowledge' and are deemed to be 'Good' in terms of the Cronbach's Alpha. Increased ICT adoption reduces information asymmetry (Mushtaq et al., 2022) and information flows are vital for the innovation process (Allen 1977; Katz and Tushman 1981; Tushman and Scanlan 1981; De Meyer 1985; Macdonald and Williams 1993; Assimakopoulos and Yan 2006; Allen, James et al. 2007; Doak and Assimakopoulos 2007). Although ICT penetration is good across India (Kantar, 2021), sectors such as milk and dairy are still seeing a transformational change with many facilities still using outdated dairy automation systems (Panda, 2018). India's dairy sector is unorganised and technology advancements in the sector have been minimal leading to sensitive issues such as poor quality of milk, inadequate infrastructure, lack of storage facilities, wastage, gaps between demand and supply and adulteration to name a few (Kumar, 2022). Out of various issues defined above, the lack of ICT development has inhibited the Indian dairy industry in reaching its full global potential. The lack of knowledge within the sub-sector about advanced technologies such as Enterprise Resource Planning (ERP), Radio Frequency Identification (RFID), Global Positioning System (GPS), Business Intelligence (BI), and block chain technology have been key. Moreover, the dissemination of ICT is low in the dairy sector due to several infrastructural problems.

Implementation of an ICT enabled supply chain process equipped with sensing tools, improved information sharing and control technology can provide significant support toward sustainability in the dairy industry and managing supply chain operations (Cleaver and Schreiber, 1994; Sigrimis et al., 2001). Dairy farmers need to equip themselves with a two-way information system ranging from farm level to enterprise level. This will enable better quality, transport, production, marketing, and services, and foster skilled manpower and local revenue generation (Kumar, 2022).

ICT can help in integration and can reduce variability and uncertainty through real-time information sharing (Barnett et al., 2019; Amarnath et al., 2018; Zhou et al., 2018; Siddh et al., 2017). It can also mitigate risk through risk-based analysis (Zhang et al., 2016b; Kilubi, 2016; Mensah et al., 2015; Neaslund and Hulthen, 2012). Affective application can ensure quality, efficiency and safety (Tian et al., 2019; Zhong et al., 2017; Akhtar et al., 2016). Additionally supply chain co-ordination helps in ensuring the protection and on-time delivery of products from production to consumption (Naik and Suresh, 2018; Zhong et al., 2017; Handayatiet al., 2015). Apart from this, ICT helps in logistics integration and communicating effectively with suppliers along with providing quality information (Pham et al., 2019; Haulderet al., 2019; Narkhede et al., 2017). Thus, transparency in the supply chain helps to safeguard business sustainability, customer trust and product desirability (Sarpong, 2014). These factors are extremely essential given the perishable nature of milk and dairy products.

**BOX 2: Licious - Use of AI/ML in supply and cold chain for D2C delivery of seafood and meat.****Objective**

Licious is an app-based Indian e-grocery company that sells animal proteins such as eggs, fish and meat with a proprietary cold chain network

**Approach**

The company extensively deploys data-science, ML and AI-driven innovations to track, train and deliver different aspects of its business to achieve robust cold chain networks and address the challenges in managing, processing and distributing meat and seafood<sup>61</sup>.

Licious works on a farm-to-fork model that entails the entire supply and cold chain for sourcing, procuring, processing, storing and delivering highly perishable products. The success of its cold chain models is in building and deploying the right IoT solutions where information on temperature breach, shelf-life, etc., are automatically captured using sensors and its AI technology monitors these data on products allowing the company to take appropriate responses and actions, from sourcing the produce from farms and fisheries to delivery at the customer doorstep. Machine learning (ML) techniques are used in demand planning, product recommendations, supply chain failure prediction, product quality assessment, among others, to manage the lifecycle of products<sup>62</sup>. These technologies allow the product to continuously remain between 0-4°C. AI technology trains meat technicians to master precise cuts to ensure meat will be clean and cut correctly and achieve the highest quality of hygiene in its handling, preservation and delivery. To encourage and ensure customer loyalty, using data collection and analytical algorithms customer behaviour is tracked and strategised accordingly, thereby ensuring all deliveries are achieved within 90 minutes. It allows pre ordering of out-of-stock products and delivery within 4 - 24 hours. Using Google maps platform and geocoding APIs, its logistics and delivery operations are able to fetch real-time location tracking farm pick-ups, validate customer addresses, calculate delivery times, and map out the route for couriers. The products are sourced from bio secure farms and fisheries and go through 150 quality checks before they are on the app. Licious is India's first meat brand that has secured the FSSC 22000 certification<sup>63</sup>.

**Outcomes**

Using AI and ML technologies extensively in a highly unorganised sector, Licious brought increased competition among the emerging pool of e-grocery service providers and is positively impacting the quality aspect of meat and fish produce procurement, storage and distribution.

Launched in 2015, the company went from 100 orders per day to 20,000 orders in 2021, thereby achieving a 3,000% year on year growth since its inception. Licious is currently valued at more than US\$ 1 billion.

Factor 4 - **'Human Capital and Organization'** has the variables 'Brain drain', 'Lack of competition', and 'Hierarchical organizations' loading on it and accounts for 7.10% of the TVE where the internal consistency is deemed as 'Acceptable'.

An FICCI survey reveals that irrespective of the firm size in the Indian food and beverages sector, there is a huge demand for skilled professionals, both at the higher-end technical skills and lower-end skills (FICCI, 2015). To compound this, although the Indian economy is showing healthy progress, there is generally an increase in attrition in Indian SMEs (Kar et al., 2011). The aspect of 'brain drain' may not be in the traditional sense of skilled human capital

leaving the country, but rather moving to more lucrative sectors (FICCI, 2015) particularly as they offer better rates of remuneration.

A question that arises is: does a lack of competition and the prevalence of hierarchical organizations lead to a less dynamic and non-innovative environment, and does this in turn impact human capital retention and attrition?

Komm et al., (2021) posit that in a post-pandemic era a management system based on old rules—a hierarchy that solves for uniformity, bureaucracy, and control—will no longer be effective. Taking its place will be a model that is more flexible and responsive, built around four interrelated

<sup>61</sup> Sourced from: <https://www.itnext.in/article/2022/01/07/liciouss-tech-uplift-meat-supply-chain-transformation>

<sup>62</sup> Sourced from: Licious CPTO Himanshu Verma shares the tale of India's first D2C unicorn in the animal protein industry ([yourstory.com](https://yourstory.com))

<sup>63</sup> Sourced from: [How Licious revolutionised the meat industry with AI \(indiaai.gov.in\)](https://indiaai.gov.in)

trends: more connection, unprecedented automation, lower transaction costs, and demographic shifts.

Emerging models will need to be creative, adaptable, and anti-fragile. Corporate purpose fuels bold business moves. Labour becomes talent and hierarchies become networks of teams, while competitors become ecosystem collaborators. Companies become more human: inspiring, collaborative, and bent on creating an employee experience that is meaningful and enjoyable.

Factors 1 and 2 rank as the most important factors as they contribute close to 37.14% of the TVE and should be the main focus of system-oriented policies. Once again this expounds the importance of market forces and Industry 4.0

technologies as drivers for innovation, particularly in the food and beverages sector.

The overall implications for policy emerging from the analysis of barriers to innovation is that resources should use more overarching interventions at the level of the system, however the specific needs of actors should be taken into consideration for optimal impact. Each of these will be articulated in the “Recommendations” chapter. A structured dialogue between stakeholders is required to orient which policies can be most effectively used to address barriers and challenges. Policies and their targets should not be unattainable or out of reach and issues need to be addressed from a realistic perspective.

**TABLE 6: System-wide barriers to innovation**

Barriers to innovation faced by all actors in the Food sector (N = 2831)									
Factor Number	Name of Factor	Variables	Factor loading	Cronbach's Alpha	Total Variance Explained (TVE)	KMO	Bartlett's Test of Sphericity		
							Chi squared	Df	Sig.
1	Market dynamism & structure	Lack of Innovative customers	0.756	0.848	23.34%	0.916	41751.76	325	0
		Lack of clear national innovation strategy	0.705						
		Lack of demanding customers	0.692						
		Lack of explicit policy support (government)	0.682						
		Lack of Traditional Infrastructure	0.636						
		Excessive Perceived Economic Risk	0.628						
2	Industry 4.0	Lack of understanding of I4.0 technologies	0.906	0.914	13.81%				
		Cost of I4.0 Technologies	0.902						
		Lack of access to I4.0 technologies	0.852						
		Lack of infrastructure for I4.0	0.814						
3	ICT and Knowledge flows	ICT Capacity	0.764	0.825	9.43%				
		Rate of access to ICT	0.733						
		Lack of Willingness to Share the Knowledge	0.634						
4	Human Capital and Organization	Brain Drain	0.772	0.752	7.10%				
		Lack of Competition	0.672						
		Hierarchical Organizations	0.666						
Cumulative Total Variance Explained						53.68%			

The determinant of the R matrix should be greater than 0.00001; if it is less than this value, look through the correlation matrix for variables that correlate very highly ( $R > .8$ ) and consider eliminating one of the variables (or more depending on the extent of the problem) before proceeding<sup>64</sup>.

## 6.4 Success of Policy Instruments

Having analysed the barriers to innovation, both at the actor and system level, it is important to ascertain how actors perceive various policies, and consequently, an understanding of whether or not they effectively calibrated and configured to reach their intended target's needs. To begin with, it is important to understand what public policy instruments are defined as “a set of techniques by which

<sup>64</sup> Sourced from: <http://users.sussex.ac.uk/~andyf/factor.pdf>

governmental authorities wield their power in attempting to ensure, support and effect (or prevent) social change” (Borras and Edquist, 2013., pg.1515). Unsurprisingly, the objectives of innovation policy have to do with the different national traditions and forms of state-market-society relations, not to mention the orientation of governmental ideology.

Generally speaking, there are three main categories of policy instruments: i) Regulatory frameworks<sup>65</sup>; ii) Economic and financial instruments<sup>66</sup>; and iii) Soft instruments.<sup>67</sup> Phrased differently, these can be considered as “sticks”, “carrots” and “sermons”. In this vein, the respective perceived success or failure of national policies is reviewed grouping them as per the aforementioned classifications.

An alternative way to classify innovation policy is in terms of supply-side measures and demand-side measures (see Figure 24). Supply-side policies are seen to create a supply push to innovate (Voß and Simons, 2014); whereas “demand-side innovation policies are defined as all public measures to induce innovations and/or speed up diffusion of innovations through increasing the demand for innovations, defining new functional requirements for

products and services or better articulating demand” (Edler and Georghiou, 2007., pg. 953). Supply-side measures can be further split into the grouping of finance (equity support, fiscal measures, support for public research, support for training and mobility, and grants for industrial R&D) and services (information and brokerage support and networking measures). Demand-side policies can be presented in four main groupings: systemic policies, regulation, public procurement, and stimulation of private demand (Edler and Georghiou, 2007).

Using this classification to order policy instruments of the Indian manufacturing sector, the following groupings emerge: i) Supply-side finance policies include – research grants, subsidised loans, government-backed venture capital, donor funds; ii) Supply-side services include – ICT access and focused skills development initiatives; iii) Demand-side measures include – tax breaks, spatial policies, government procurement, standards setting, regulation and labour mobility (laws and incentives). The system as whole, as well as the views of each of the individual actors will be reviewed to understand how successful policy is through the aforementioned lens.

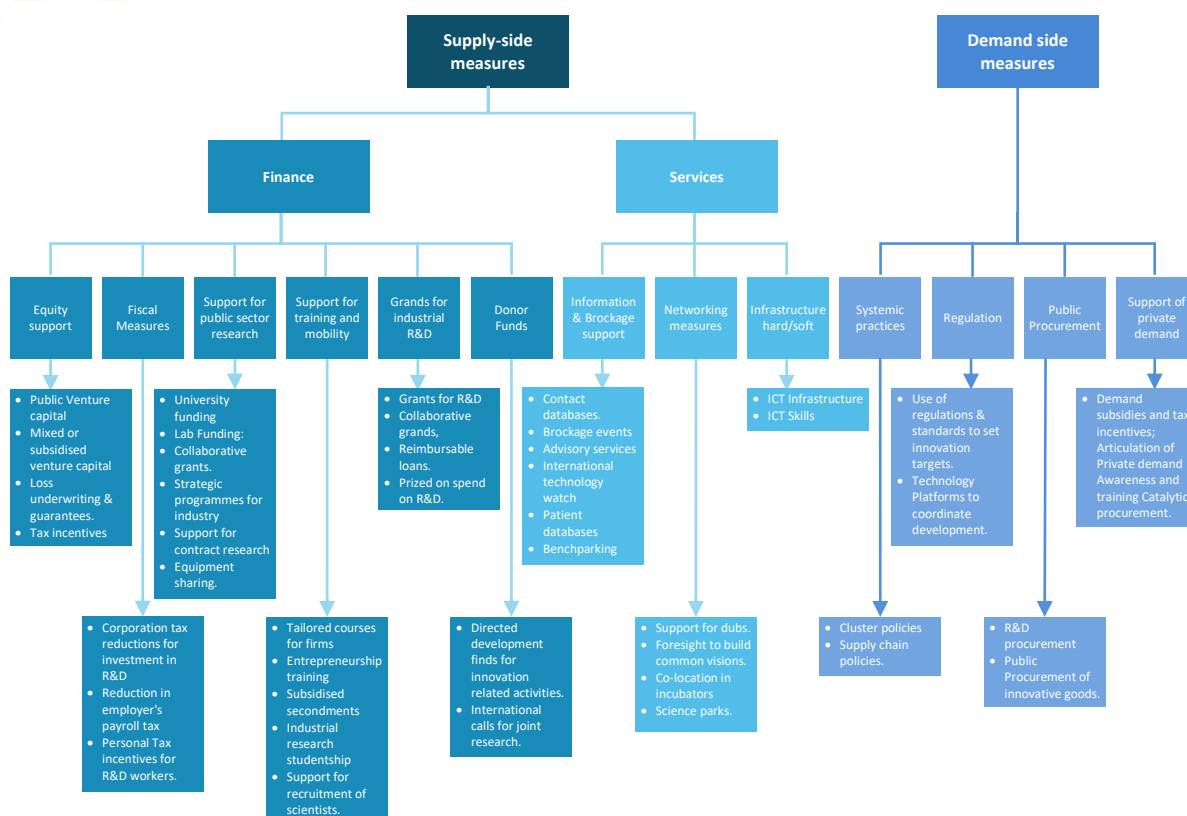
<sup>65</sup> “The first type, regulatory instruments, use legal tools for the regulation of social and market interactions. The logic behind this type of instrument is the willingness from the government to define the frameworks of the interactions taking place in society and in the economy. Naturally there are many different types, but common to them all is that these regulatory instruments (laws, rules, directives, etc.) are obligatory in nature, meaning that actors are obliged to act within some clearly defined boundaries of what is allowed and what is not allowed. Obligatory measures are typically backed by threats of sanctions in cases of non-compliance. These sanctions can be very different in nature (fines and other economic sanctions, or temporary withdrawal of rights), depending on the content of the regulation and the definition of legal responsibility. Some authors believe that sanctioning is the most crucial property of regulatory instruments (focusing on the imposition and hierarchical side of regulation). Others see the normative authority of governments as the most important feature of these instruments (hence focusing on the normative-positive side of obligatory regulation). From the point of view of innovation policy, regulatory instruments are often used for the definition of market conditions for innovative products and processes” Borras and Edquist, 2013., pg.1516.

<sup>66</sup> “Economic and financial instruments provide specific pecuniary incentives (or disincentives) and support specific social and economic activities. Generally speaking, they can involve economic means in cash or kind, and they can be based on positive incentives (encouraging, promoting, certain activities) or on disincentives (discouraging, restraining, certain activities)” Borras and Edquist, 2013., pg.1516.

<sup>67</sup> “Soft instruments are characterised by being voluntary and non-coercive. With soft instruments, those who are ‘governed’ are not subjected to obligatory measures, sanctions or direct incentives or disincentives by the government or its public agencies. Instead, the soft instruments provide recommendations, make normative appeals or offer voluntary or contractual agreements. Examples of these instruments are campaigns, codes of conduct, recommendations, voluntary agreements and contractual relations, and public and private partnerships. These instruments are very diverse, but generally based on persuasion, on the mutual exchange of information among actors, and on less hierarchical forms of cooperation between the public and the private actors.” Borras and Edquist, 2013. pg.1516.

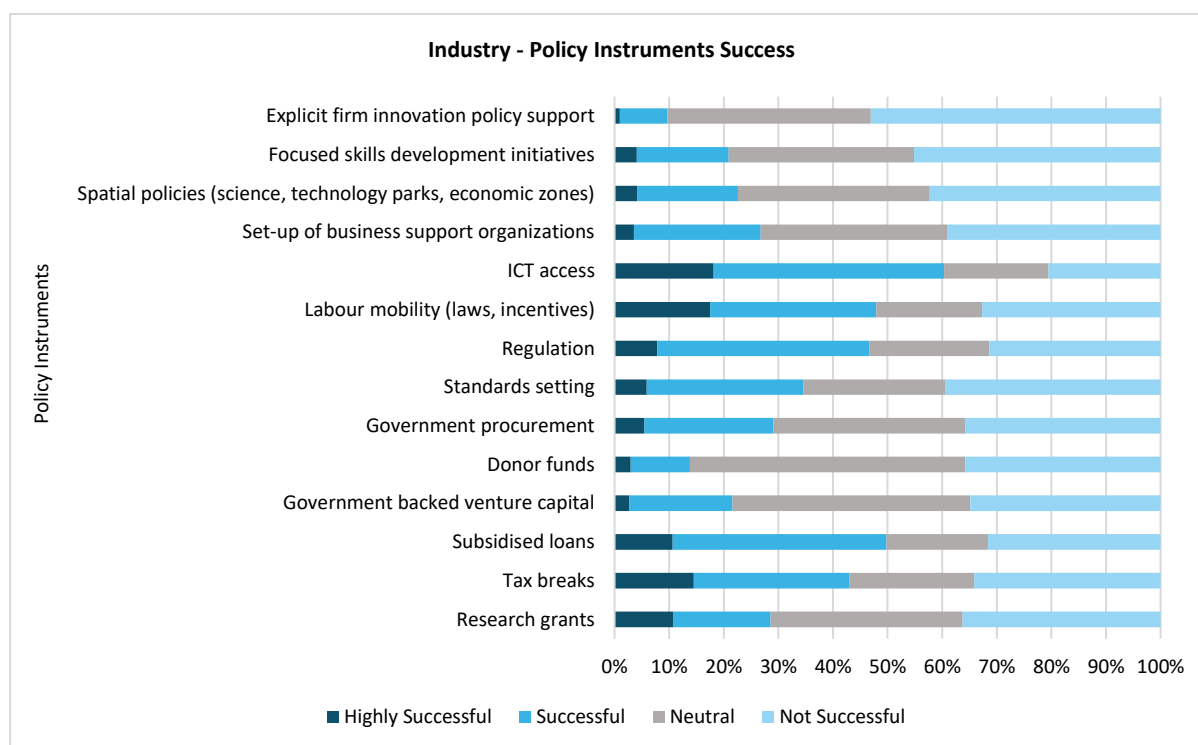


**FIGURE 24: Policy taxonomy**



## 6.4.1 Industry

**FIGURE 25: Success of policy instruments – Industry**



From the perspective of industry respondents (see Figure 25 above), supply-side service, namely, 'ICT access' is deemed to be the most successful as reported by 64% of survey respondents (16% reporting it as 'Highly Successful' and 48% as 'Successful'). This is followed by the supply-side finance instrument of 'Subsidised loans' that has been reported as 'Successful' and 'Highly Successful' by 10% and 40% of respondents, respectively.

The importance of ICT access is recognised by the "National Policy on Information Technology 2012" as it highlights the need "to enable long-term partnerships with Industry for: i. Using ICT in cutting-edge technology for improved efficiency and productivity; ii. Driving development of new ICT technologies through strategic sectors; iii. Facilitating growth of IT SMEs and use of IT across all SMEs" (MEITY, 2012:7). With the Government of India's (GoI) drive to augment food processing levels through the "Make in India" campaign and Industry 4.0's role in elevating the manufacturing as well as the supply chain and distribution landscape by usage of technologies including the Internet of Things (IoT), block chain, and predictive analytics, the food industry in India is expected to witness a radical shift (Deloitte, 2018). Contrary to this, it is important to highlight that in accordance with the Global Innovation Index (GII), while India has been ranked 46th out of 132 economies, the country's ICT access ranking declined from 108 in 2012 to 111 in 2021.

The success of 'Subsidised loans' as a supply-side finance policy instrument is convergent with the fact that the Indian food processing industry is heavily dependent upon financial assistance from the government in form of subsidies and grants.<sup>68</sup> The development of the food processing industry is accorded top priority by the GoI due to its critical links in the agriculture value chain. The Small Industries Development Bank of India (SIDBI) and National Bank for Agriculture and Rural Development (NABARD) provide funds to the agro-industry and food processing sector. In addition, these banks also invest in the capital creation, technological innovation, development, and

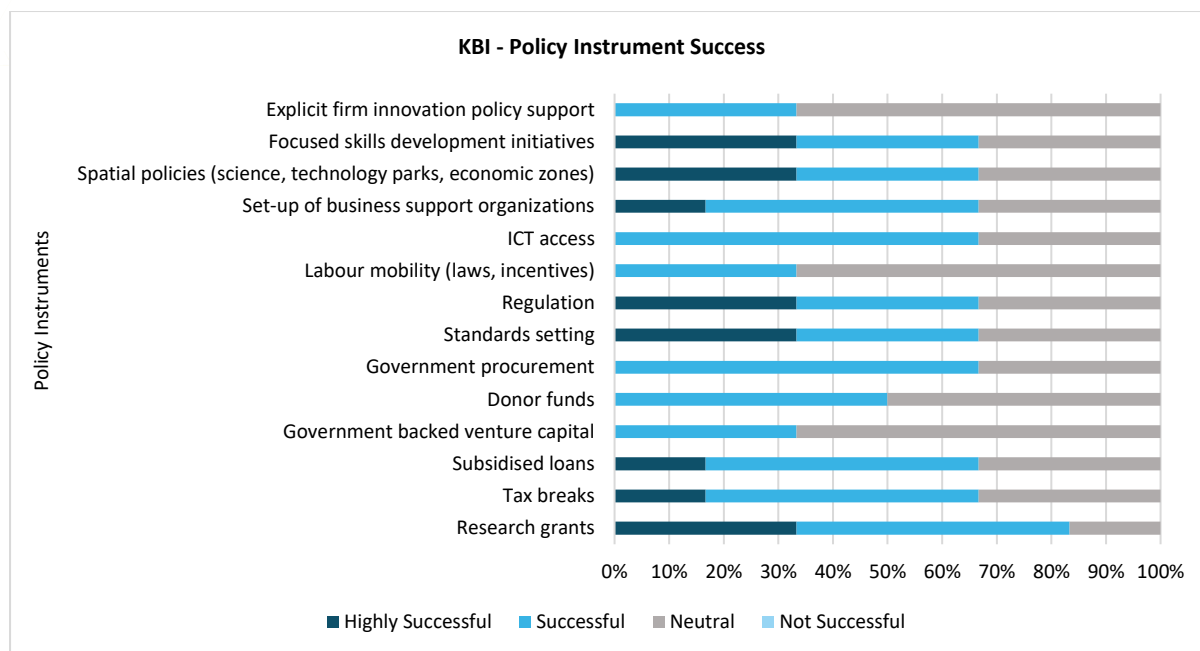
improvement of the food products (Singh, Daultani and Sahu, 2021). In 2014, the GoI announced setting up of a Special Fund of INR 2,000 crore in the NABARD for providing direct term loans at affordable rates of interest to Designated Food Parks (DFPs) and food processing units in the DFPs. In 2021, the Department of Animal Husbandry and Dairy (DAHD) approved a "Scheme for Supporting Dairy Cooperatives and Farmer Producer Organizations" (2021 - 2026) to provide working capital loans to state cooperatives and federations. As per RBI's "Master Directions" dated 04.09.2020, all food and agro- processing activities have been included as eligible under Priority Sector Lending (PSL). Finally, the "Production Linked Incentive Scheme of Food Processing Industry" (PLISFPI) has been formulated by the government as part of "AatmaNirbhar Bharat Abhiyaan" for incentivising the manufacturing of major food product segments, incentivising innovative/ organic products of SMEs in those food segments, and finally to support branding and marketing abroad to incentivise the emergence of strong Indian brands. Such incentives are attractive and can go a long way in creating large scale capacities by helping firms manufacture using advanced plant and machinery to compete with global brands in international markets.

On the other hand, 53% of respondents have reported 'Explicit firm innovation policy support' as unsuccessful indicating the need for policy instruments that target firm level innovation and that focus on the firm as the prominent target group. Further, technology and innovation are not enough, enabling policies and a skilled workforce that can respond to the changing needs of the food sector are also needed. Only 21% of respondents reported 'Focused skill development initiatives' as 'Successful' whereas 45% of respondents reported it as unsuccessful and the remaining 34% chose to stay 'Neutral'. Similarly, in the case of the demand-side measure 'Spatial policies', only 23% of respondents reported it as 'Successful', whereas 42% of respondents reported it as unsuccessful and the remaining 34% stayed 'Neutral'.

<sup>68</sup> Sourced from: <https://www.pfionline.com/government-subsidy-for-small-food-business-in-india/>

## 6.4.2 Knowledge-Based Institutions

**FIGURE 26: Success of policy instruments - Knowledge-based institution**



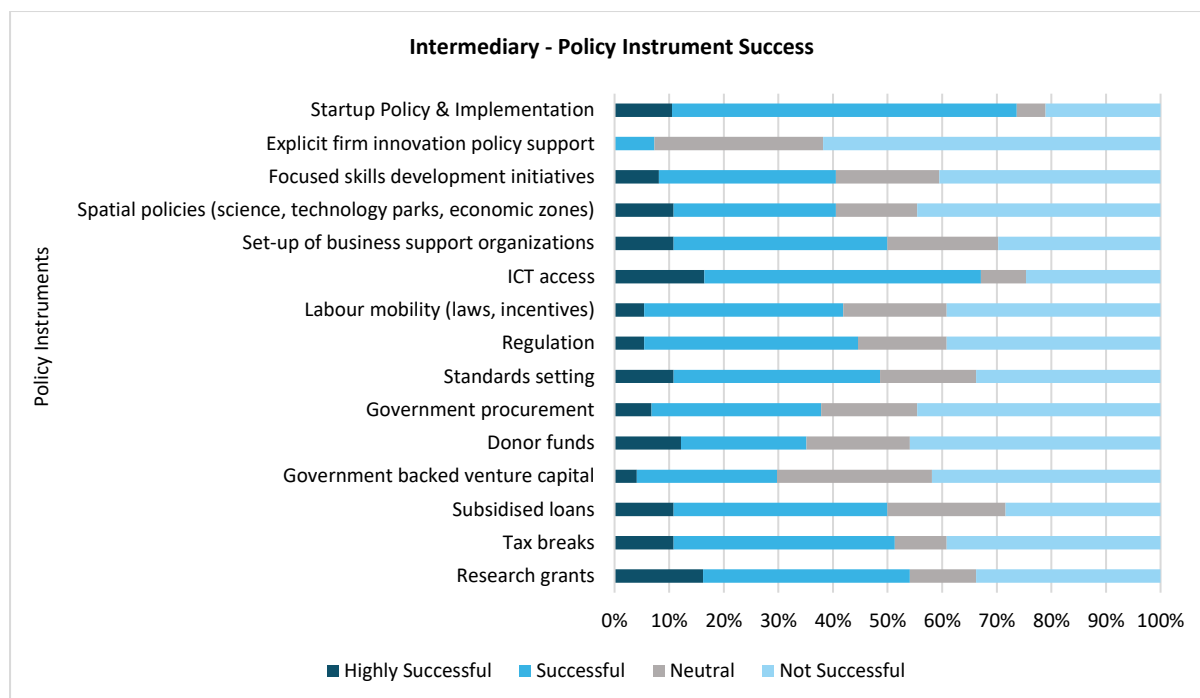
From the view of knowledge-based institution respondents (see Figure 26 above), it is evident that none of the policy instruments have been reported as unsuccessful. The supply-side finance instrument ‘Research grants’ emerges as a clear winner with 50% of respondents reporting it as ‘Successful’ along with 33% reporting it as ‘Highly Successful’. The success of ‘Research grants’ as a policy instrument can be attributed to the funds received from the government under its various schemes such as the “Pradhan Mantri Formalization of Micro Food Processing Enterprises (PMFME) Scheme 2020” launched under the “AtmaNirbhar Bharat Abhiyan” and “Vocal for Local” campaigns to provide financial, technical and business support to micro processing units in the country (IBEF, 2021). The scheme aims to ensure increased access to credit and investment for existing micro food processing entrepreneurs, farmer producer organizations (FPOs), self-help groups (SHGs) and cooperatives. Similarly, the “Research & Development in Processed Food Sector Scheme” launched by the Ministry of Food Processing Industries has been extending financial assistance to undertake the demand-driven R&D work for the benefit of the food processing industry. This includes product and process development, efficient technologies, improved packaging, value addition, etc., with commercial value

along with standardisation of various factors viz. additives, colouring agents, preservatives, pesticide residues, chemical contaminants, microbiological contaminants and naturally occurring toxic substances within permissible limits. Such programmes aim to incentivise research and intellectual property (IP) development in the country.

Out of a total of 14 policy instruments, 9 emerged as the second most successful after combining the ‘Highly Successful’ and ‘Successful’ response options chosen by the respondents. These include ‘Focused skill development initiatives’, ‘Spatial policies’, ‘Set-up of business support organizations’, ‘ICT access’, ‘Regulation’, ‘Standards setting’, ‘Government procurement’, ‘Subsidised loans’ and ‘Tax breaks’. Opinion on ‘Donor funds’ is divided as 50% of respondents seem unaware of the concept of donor funding, while those who know have reported them as ‘Successful’ which raises questions on the level of direct engagement of KBIs in multilateral projects related to the food sector. Three policy instruments for which the majority of respondents (67% each) chose to stay neutral include “Explicit firm innovation policy support”, Labour mobility (laws, incentives)’ and ‘Government-backed venture capital’

### 6.4.3 Intermediary

**FIGURE 27: Success of policy instruments – Intermediary**

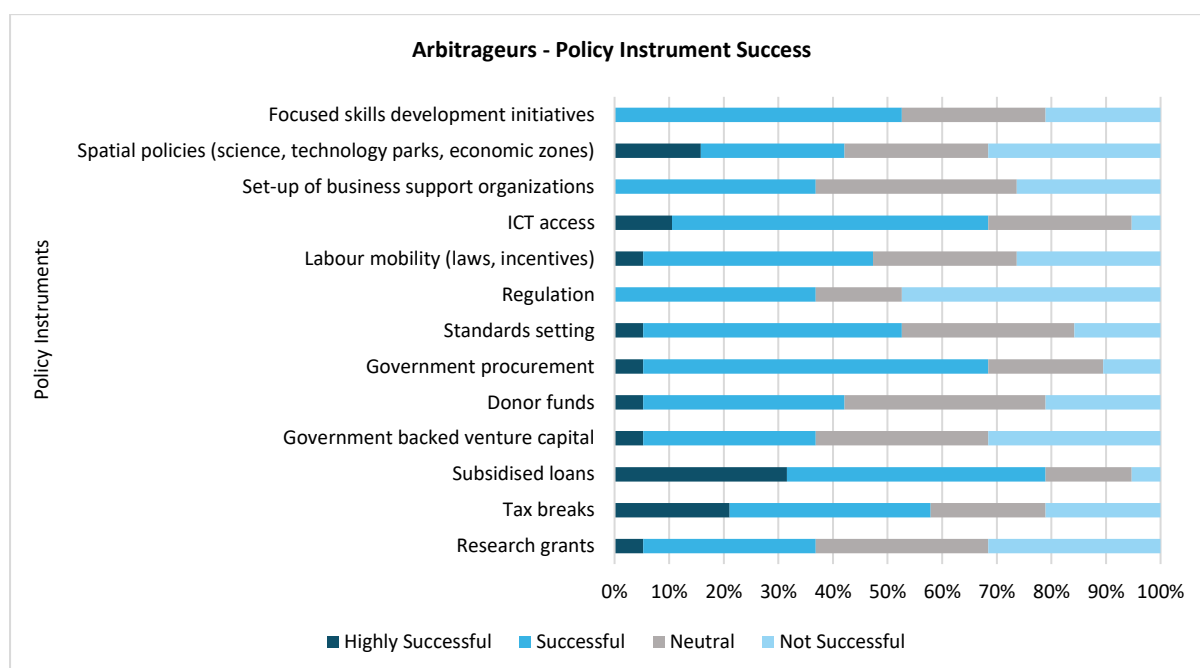


It is evident from Figure 27 above that the most successful policy instrument, as reported by 68% of intermediaries, is the supply-side service 'ICT access', followed by the supply-side finance instrument 'Research grants' at 54%. On the

other hand, the most unsuccessful policy instrument reported by 62% of respondents is 'Explicit firm innovation policy support'. This mirrors the view of the industry and has been explained in the previous section.

### 6.4.4 Arbitrageurs

**FIGURE 28: Success of policy instruments – Arbitrageurs**



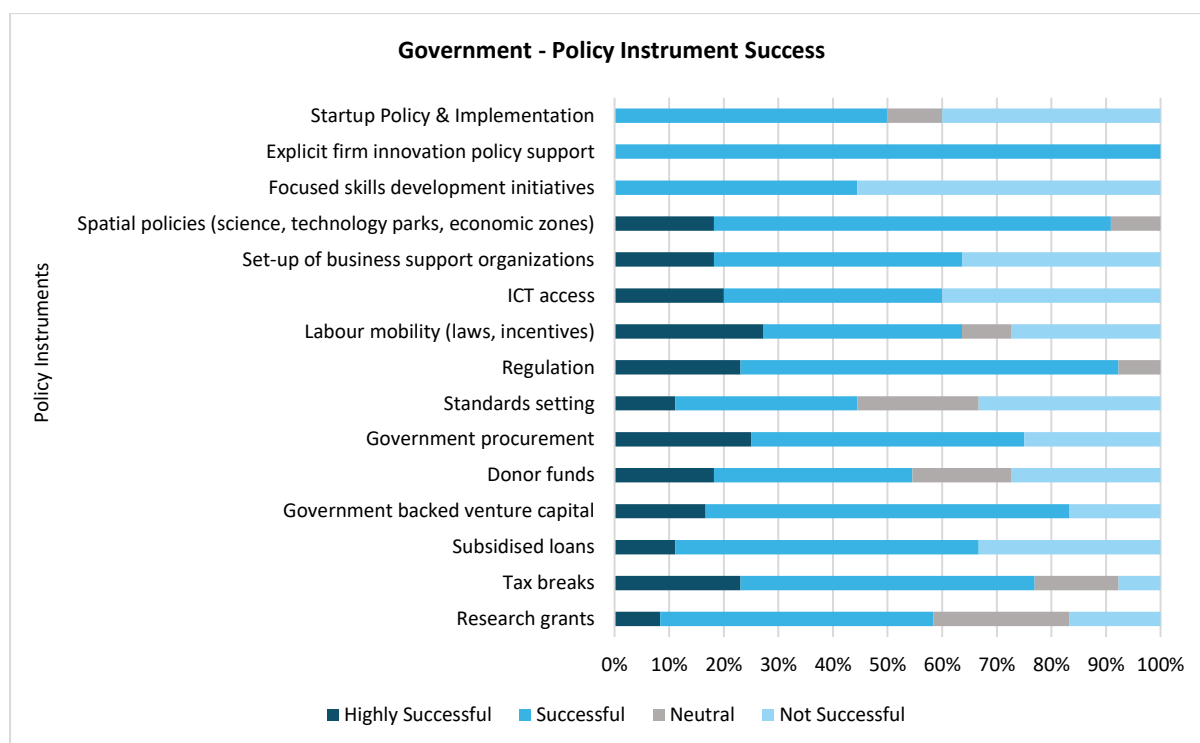
The next actor perspective on the relative success of policy instruments is that of arbitrageurs (Figure 28 above). The most successful policy instrument reported by arbitrageurs is the supply-side finance instrument of ‘Subsidised loans’ with 47% and 32% of respondents reporting it as ‘Successful’ and ‘Highly Successful’ respectively. This is followed by the supply-side service ‘ICT access’ and demand-side measure of ‘Government procurement’ at 68% each. Explanations for ‘Subsidised loans’ and ‘ICT access’ have been provided in the previous section on industry. On the other hand, the most unsuccessful policy instrument reported by 47% of intermediaries is the demand-side measure of ‘Regulation’. In India, the Food Safety and Standards Act, 2006 is the primary law for the regulation of food products; formulation and enforcement of food safety standards; and harmonisation of country’s food regulations as per international standards. The Preamble to the Act states that it seeks to “consolidate the laws relating to food and to establish the Food Safety and Standards Authority of India (FSSAI) for laying down science-based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import, to

ensure the availability of safe and wholesome food for human consumption.” The FSSAI functions under the administrative control of the Ministry of Health and Family Welfare. Though the legal framework is in place, India still struggles with effective enforcement of food safety norms and standards, mainly due to an insufficient number of food testing laboratories in the country, outdated laboratory testing infrastructure and a lack of skilled human capital in these labs<sup>69</sup>.

In general, regulations can both enhance and constrain a business activity. Improvements in firm entry regulation are associated with higher productivity (GII 2020). Amirapu and Gechter (2019) find that restrictive labour regulation in India is associated with a 35% increase in firms’ unit labour costs. The NITI Aayog Innovation Index 2021 underscores this by articulating that “governments that enact and enforce open and fair procedures, regulate markets efficiently, protect property rights, and lower the burden of regulations are more likely to see higher levels of innovative entrepreneurial activity”.

### 6.4.5 Government

**FIGURE 29: Success of policy instruments – Government**



The last actor perspective on the relative success of policy instruments is that of the Indian government (see Figure 29

above). It is interesting to note that the most successful policy instrument, as per government respondents, is

<sup>69</sup> Sourced from: <http://www.swaniti.com/wp-content/uploads/2017/11/Food-safety-in-India.pdf>



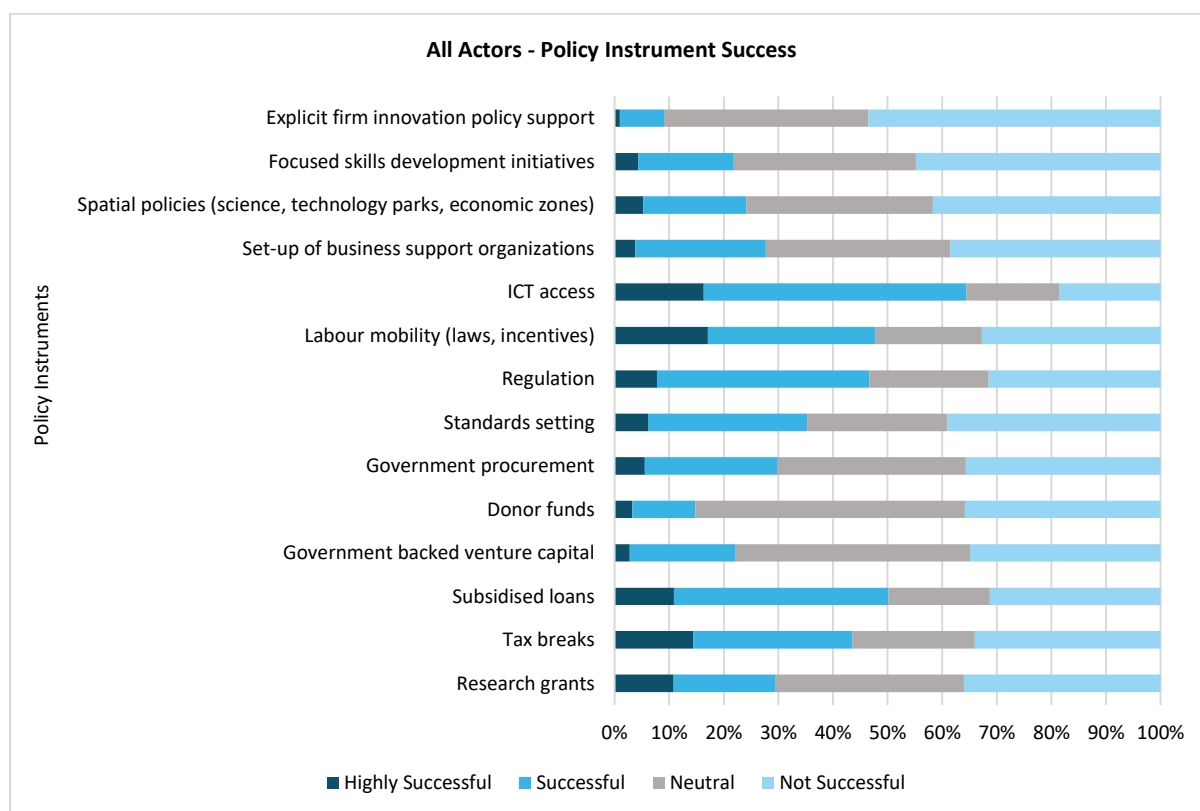
‘Explicit firm innovation policy support’ with all respondents reporting it as ‘Successful’. This is contrary to what industry and intermediaries have reported above. On the other hand, the most unsuccessful policy instrument was reported by the majority of government respondents pertains to ‘Focused skill development initiatives’. This mirrors the view of industry (where it emerges as the second most unsuccessful policy instrument) but contradicts with that of KBIs.

The Indian food processing sector has been identified as a key sector in generating employment. The food processing industry provides plenty of opportunities because its collaborative structure consists of agriculture and industry (Meeta, 2007). In spite of this, one of the biggest challenges to its growth is the lack of availability of skilled manpower

which in turn poses a challenge to its growth and global competitiveness. To address this, the Ministry of Food Processing Industries is working in close collaboration with the Food Industry Capacity and Skill Initiative (FICSI), which is a Sector Skill Council (SSC) for the food processing sector working under the aegis of the Ministry of Skill Development and Entrepreneurship, in regularly guiding and assisting it in achieving its mandate. Additionally, the FICSI is engaged in various skill development initiatives of central/state government and ministries either as a project implementation agency or as an assessment agency. Given the emergence of recent trends in technological advancements and globalisation, efforts need to be made to stimulate skill development through collaborative multi-stakeholder actions and partnerships across the public and private sector.

#### 6.4.6 All Actors

**FIGURE 30: Success of policy instruments - All actors**



Summarising the above results, the most successful policy instruments reported by all actors in the food and beverages sector are ‘ICT access’ (85%) and ‘Subsidised loans’ (50%) while the most unsuccessful policy instruments include ‘Explicit firm innovation policy support’ (53%) and ‘Focused skill development initiatives’ (45%). This is reflective of the barriers reported by all actors (see

Table 5 below) such as ‘Lack of explicit policy support (government)’ indicating the need for a comprehensive national level policy on the food processing sector. Similarly, workforce-related issues with respect to ‘Lack of understanding of Industry 4.0 technologies’ have also been reported as prominent barriers to innovation.



7.

Recommendations

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## Recommendations

The literature on innovation policy draws attention to the complex and heterogeneous nature of policy instruments at hand. It captures the growing interest in understanding the effects that different policy instruments have on innovation performance, how (combinations of) individual instruments interact with market mechanisms and the overlapping or complementary effects that can be associated with different policy instruments within systems of innovation (Borrás and Edquist 2013; Izsák, Markianidou, and Radošević 2013; Mohnen and Röller 2001). This diversity reflects the complexity of innovation systems which entail a series of elements or subsystems that can reinforce, but also block each other (Hekkert et al. 2007; Kuhlmann and Arnold 2001). The underlying innovation-related policy objectives or policy domains subject to specific policy interventions can be grouped around one or more of the following objectives (Borrás and Edquist 2015):

- Support investment in research and innovation.
- Enhance innovation competences of firms.
- Increase adoption of Industry 4.0 through digital transformation in the food and beverages sector.
- Support services for innovating firms.
- Competence building through individual/organizational learning, involving formal/informal education and training.
- Demand-side activities involving the creation of new markets.
- Provision of constituents or supporting the development of agents within the system.
- Enable integration of MSMEs into GVCs.
- Strengthen linkages within innovation systems.

This list is not exhaustive but helps to illustrate the ramifications of the policy decision tree around innovation and industrialisation. Addressing these policy problems calls for a portfolio approach in which a combination of instruments simultaneously targets several objectives and groups of policy problems (Izsák, Markianidou, and Radošević 2013; Nauwelaers 2009).

Policy instruments result from policies aimed at facilitating different forms of innovation, including products or services, which denote the acquisition/ development of new proprietary technologies protected by patents or other forms of intellectual property rights (IPRs); yet some others are closer to business process innovations in the form of changes in operations (manufacturing techniques, optimisation of workflows and process re-engineering), product development, business process development, marketing and sales, procurement, logistics and distribution, as well as organizational innovation through changes in administration and management. Whereas some policies aim to support forms of innovation with clear and rapid market potential, some others aim to address more upstream issues with no immediate commercial value.

The possibility of combining policy instruments is what makes innovation policy systemic (Borrás and Edquist 2013). However, finding ‘optimal models’ for the combination of instruments, otherwise interpreted as one-size-fits-all solutions, is problematic; significant differences result from framework conditions but also from the ‘quality’ of implementation (Flanagan, Uyarra, and Laranja 2011), the degree of maturity reached by certain agents or the innovation system as a whole (Izsák, Markianidou, and Radošević 2013), and even the particular governance structures around innovation (Dutrénit et al. 2010). Moreover, identifying the impacts of individual innovation policy interventions on social and economic outcomes is extremely difficult. There is a complex chain of direct and indirect, vertical and horizontal effects, and the ultimate results may only be perceptible many years after implementation (Padilla-Pérez and Gaudin, 2014; Santiago and Natera, 2014).

Finding an optimal innovation policy mix is not a one-off exercise, but a continuous process that adjusts to the dynamics of an innovation system. The formulation of effective policy is therefore a highly complex affair. Table 7 highlights the short-, medium- and long-term recommendations based on the analysis conducted.

**TABLE 7: Policy recommendations**

Observation	Implication	Recommendations
<b>Fragmented system-wide actor information</b>	<p>Better access to public goods in order to have an up-to-date understanding of who's who and who's where in the IASSI.</p> <p>Robustness and credibility of data shared at the system level.</p>	<p>Need to integrate and standardise national actor databases with respect to the IASSI.</p> <ul style="list-style-type: none"> <li>Review and consolidation of existing data.</li> <li>Regularly update centralised sectorial database.</li> <li>Purpose driven Platform to be developed in PPP approach (beyond search engine, for example Startup India, IRCTC - Indigo).</li> <li>To be owned by government and managed by institutions with access by all major institutions (market driven).</li> <li>Integrated feedback mechanism for improvement (stakeholders at all levels).</li> </ul>
<b>Need to improve target response rate, especially in the case of Government actor group</b>	<p>Better clarity in systems analysis for evidence-based policy craft incorporating longitudinal benefits of data collection</p>	<ul style="list-style-type: none"> <li>Institutionalise the IASSI Survey within a national institution with top-down mandate.</li> <li>Make the IASSI Survey a mandatory census (4 years) and linked to the national database.</li> <li>Targeted promotion strategy (including use of multimedia and social media, dissemination of value information, creation of ownership, multiple level campaign).</li> <li>Actor or entity (state level, district level etc.) level competition for response rate.</li> <li>Incentivization through a sense of belongingness, continuity and follow-up.</li> <li>Acknowledging and lauding of contributions by leading institutions - creation of champions.</li> <li>Data collection driven regional outreach initiatives.</li> <li>National level agencies to be coordinated and partnered with - ISIs,</li> <li>Planning and onboarding to make utility of champions.</li> <li>Upstream driven sensitization approach.</li> </ul>
<b>Need for better institutional coordination between regions / clusters.</b>	<p>Ease of skills and knowledge flow between and sharing of best practises between actors.</p>	<ul style="list-style-type: none"> <li>Commonly agreed structured framework for joint activities</li> <li>Creation and transmission of information using contemporary multimedia resources.</li> <li>Sharing of failures and lesson learning.</li> <li>Regular meetings in person; quarterly webinars.</li> <li>Virtual dissemination of Data Information Statistics and Knowledge (DISK).</li> <li>Creating champions for systematic coaching of the sectors taking into account equally successes and failures.</li> <li>Make use of middle-level executives. For example, LinkedIn creator accelerator programme (CAP).</li> </ul>
<b>Better awareness of policy terminology (SSI) across system actors</b>	<p>Across the board, understanding of terminology provides a framework for actors understanding each other and their respective roles.</p>	<p>Have a standard definition in all documentation.</p> <ul style="list-style-type: none"> <li>Present definition in national government bulletin.</li> <li>Standardization of terminology used in policy/national documentation.</li> <li>Outreach to industry via industry associations.</li> <li>Development of impact driven byte size content dealing with core terminology and widely disseminated using multimedia in multi languages.</li> </ul>
<b>Lack of understanding by actors of each other's role within the IASSI</b>	<p>On clear understanding of actor roles and responsibilities within a system there is the increased ability for them to reach out to each other. With the focus being impact on the directionality of actor relationships to become more bi-directional.</p>	<ul style="list-style-type: none"> <li>SSI should be an integrated component of national events, i.e., "Partner's forum" or the "Food tech conclave".</li> <li>National innovation event (every 2 years bringing together users, producers and service providers for innovation). It can be linked to National Science Week (10 best projects).</li> <li>An integrated platform linking institutions and their services</li> <li>Developing actor level content using multimedia - easily accessible and easily digestible. For example, fail fast fail safe (moral of the story).</li> <li>Learn, un-learn, and thinkers and be future relevant.</li> <li>Culture of innovation (create a mascot).</li> <li>Promotion in adoption of ISO 56002 (2019).</li> <li>Incorporation of Theory of Inventive Problem Solving (TRIZ) within the sector.</li> <li>Creation of an innovation indicator assessment scheme for all contributing actors. Participation and access to assessment score can be used to leverage benefits. Catching them young (tinkering labs, start-up kits).</li> </ul>
<p><b>Industry modes of interaction that require attention:</b></p> <p><b>Intra:</b></p>	<p>Lack of knowledge exchange between industry actors. Need to make them more collaborative rather than competitive which is particularly important in areas of new technology adoption.</p>	<p><b>Intra</b></p> <ul style="list-style-type: none"> <li>Specific policy interventions to create a robust supplier development ecosystem. (i.e., technology-based linkages between large companies &amp; MSME's).</li> </ul>

<p>Despite user-producer relationship between IND actors there are few linkages in terms of tacit knowledge transfer &amp; joint research activities</p> <p><b>Inter:</b> <b>IND - GOV</b> Poor public financing for the food sector.</p> <p><b>IND - KBI</b> Low conversion of joint research activities into innovation output.</p> <p>Need for increased knowledge sharing through secondments.</p> <p><b>IND-ARB</b> Few linkages in terms of formal meetings, informal meetings &amp; seminar/training.</p>	<p>Low innovation activity in the food and beverages sector due to lack of public funds for the industry. Government to better disseminate information on funds amongst industry players, in particular MSMEs.</p>	<ul style="list-style-type: none"> <li>Creation of knowledge exchange platforms in the form of annual buyer-supplier summits stressing on outsourcing strategies, sustainability, new market opportunities, etc.</li> </ul> <p><b>IND-GOV</b></p> <ul style="list-style-type: none"> <li>Improve easy &amp; accessible formal credit facilitations.</li> <li>Reduce procedural bottlenecks for availing finance at macro, meso &amp; micro level (simplified compliance structure).</li> </ul> <p><b>IND-KBI</b></p> <ul style="list-style-type: none"> <li>Initiate KPI tracking linked research &amp; development projects.</li> <li>Replicate the FITT Foundation for Information and Technology Transfer (IIT-D) model in other tertiary education institutions.</li> <li>Providing adequate resources for functional spaces like dean of corporate relations for higher educational institutes.</li> <li>Involving industry in content and design of curriculum.</li> <li>Introduction of convergence of disciplines at the beginning of postgraduate level.</li> <li>Promote &amp; enable secondment policy to bring flexibility for academia to work in Industry.</li> </ul> <p><b>IND-ARB</b></p> <ul style="list-style-type: none"> <li>Educating financial institutions and their assessors in line with new technological trends as well as changing industry needs. Industry associations can act as the conduit for such initiatives.</li> </ul>
<p><b>Knowledge-based institutions modes of interaction that require attention:</b></p> <p><b>Intra:</b> Conversion of joint research activities into innovation output is negligible.</p> <p><b>Inter:</b> <b>KBI-IND</b> Few linkages in the form of tacit knowledge transfer. Low conversion of joint research activities into innovation output.</p> <p><b>KBI-INT</b> Tacit knowledge transfer is limited.</p> <p><b>KBI-ARB</b> Minor interactions in form of seminars/training activities and limited flow of funds.</p>	<p>Limits commercial adoption and application of new technology</p> <p>Strengthen linkages in order to facilitate ideation to market.</p>	<p><b>Intra</b></p> <ul style="list-style-type: none"> <li>Hub &amp; Spoke Model to connect regional/local institutions with national institutions. (CSIR/NIFTEM/CFTRI).</li> <li>Create forums where KBIs come together on a regular basis.</li> <li>Create formal forums for joint research, meetings, seminars and training with respect to the food and beverages sector.</li> <li>Align local KBIs with central R&amp;D institutes.</li> <li>Promote faculty exchange programs with leading global universities.</li> <li>Boost joint research between knowledge-based institutions, including T2 and T3 institutions.</li> </ul> <p><b>KBI-IND</b></p> <ul style="list-style-type: none"> <li>Establish Centre of Excellence (CoE's) through academia-industry partnership fostering training programs for different functional roles and providing farm extension services.</li> <li>Institutionalize R&amp;D funds to increase academia-industry collaboration.</li> <li>Rigorous joint training &amp; up skilling programs.</li> <li>Facilitating publishing of industrial research from the point of view of IPR and other legalities.</li> <li>Involving industry in content and design of curriculum.</li> </ul> <p><b>KBI-INT</b></p> <ul style="list-style-type: none"> <li>Providing technical advisory/consultation on productivity improvement, machinery selection and adopting standardized processes.</li> <li>Initiate workplace training programs to improve private sector participation through industry associations.</li> <li>Boost Results-based project collaborations.</li> <li>National/regional Innovation Summits on Nutrition/Functional foods &amp; drinks processing.</li> </ul> <p><b>KBI-ARB</b></p> <ul style="list-style-type: none"> <li>Educating financial institutions and their assessors in line with new technological trends as well as changing industry needs. Industry associations can act as the conduit for such initiatives.</li> </ul>
<p><b>Intermediary modes of interaction that require attention:</b></p> <p><b>Intra:</b> Limited joint research and co-publishing activities.</p> <p><b>Inter:</b> <b>INT-IND</b> Few joint research and co-publishing activities.</p> <p><b>INT-KBI</b> No secondments between intermediaries and the</p>	<p>Lack of codification of knowledge with industry</p>	<p><b>Intra</b></p> <ul style="list-style-type: none"> <li>Focus on circular business model &amp; practices, use of alternate materials, cost-effective recycling technologies.</li> <li>Enable research in packaging technology to improve export competitiveness.</li> </ul> <p><b>INT-IND</b></p> <ul style="list-style-type: none"> <li>Increasing &amp; strengthening the food testing labs across the country with latest technology &amp; equipment and manpower.</li> <li>Uptake &amp; implementation of food safety standards in the unorganized/informal sector.</li> <li>Engage in technological innovations related to food safety, traceability, and sustainability</li> <li>Create awareness &amp; extend consultancy support in global sustainability norms and compliance.</li> </ul>



<p>knowledgebase. Limited flow of funds.</p> <p><b>INT-ARB</b> Limited Joint Research Activities</p>		<ul style="list-style-type: none"> <li>Collaborative efforts to develop business models on best farm practices &amp; enabling technology cum quality interventions to improve productivity. E.g., crop-specific PPP Model of Andhra Pradesh for banana production.</li> </ul> <p><b>INT-KBI</b></p> <ul style="list-style-type: none"> <li>Incentivize ISTC's to establish strategic cells in KBIs for facilitation of knowledge sharing and provision of business support services for ideation to market.</li> <li>Scaling up of schemes like International Co-operation schemes for deputation of MSME business delegations to foreign countries for exploring new technology infusion.</li> <li>Institute financial aid for creating more GI brands.</li> </ul> <p><b>INT-ARB</b></p> <ul style="list-style-type: none"> <li>Promote joint studies based on changes in technology and market research linked to funding opportunities.</li> </ul>
<p><b>Arbitrageurs' modes of interaction that require attention:</b></p> <p><b>Intra:</b> Few interactions through tacit knowledge transfer coupled with joint research activities.</p> <p><b>Inter:</b> Overall, there are few linkages with other actors.</p> <p><b>ARB-IND</b> Limited tacit knowledge transfer</p> <p><b>ARB-KBI</b> Few joint research activities.</p> <p><b>ARB-INT</b> Limited flow of funding.</p>		<ul style="list-style-type: none"> <li>Have regular fora addressing the areas of future technology trends skills and with inclusion of other system actors.</li> </ul> <p><b>ARB-IND</b></p> <ul style="list-style-type: none"> <li>Promoting use of FinTech technologies in trading &amp; communication with consumers. (foreign &amp; domestic).</li> </ul> <p><b>ARB-KBI</b></p> <ul style="list-style-type: none"> <li>Encourage similar initiatives like IIT-Bombay &amp; SBI Signed MoU for developing FinTech innovations in ICT sector.</li> <li>Scaling up of programmes like "Startup Investopreneur" by IIM Lucknow Incubator for training new investors on early-stage investments.</li> </ul> <p><b>ARB-INT</b></p> <ul style="list-style-type: none"> <li>Provide financial assistance to industry associations for strengthening local chapters.</li> </ul>
<p><b>Latent barriers - All Actors</b></p> <ul style="list-style-type: none"> <li>Market Structure &amp; Dynamics (Lack of innovative customers; lack of clear national innovation strategy; lack of demanding customers; lack of explicit policy support (government); lack of traditional infrastructure; and excessive perceived economic risk)</li> <li>Industry 4.0 (Lack of understanding of I4.0 technologies; cost of I4.0 technologies; lack of access to I4.0 technologies; and lack of infrastructure for I4.0)</li> <li>ICT and Knowledge flows (ICT Capacity, Rate of access to ICT, Lack of Willingness to Share the Knowledge)</li> <li>Human Capital and Organization (Brain Drain, Lack of Competition, Hierarchical Organizations).</li> </ul>		<p><b>Market Structure &amp; Dynamics</b></p> <ul style="list-style-type: none"> <li>Effective mechanism to regulate commercial viability of food production through contract farming. (Precision Agriculture).</li> <li>Policy initiatives for improving market infrastructure at basic processing &amp; post-harvesting stage for agro commodities.</li> </ul> <p><b>Industry 4.0</b></p> <ul style="list-style-type: none"> <li>Initiate developing technological/scientific processes to improve value addition in food products through Industry 4.0 (Like Dairy Industry)</li> <li>Strengthening of supply chain by deploying Block chain/AI based technologies. (Improving Monitoring &amp; Traceability)</li> <li>Incentivizing MSME's for faster adoption of 'Smart Production' related technologies like Smart Predictive Maintenance, Energy Management Systems, Industrial Internet of Things (IIoT).</li> </ul> <p><b>ICT and Knowledge flows</b></p> <ul style="list-style-type: none"> <li>Cross-functional interactions with IT companies for leveraging cloud computing/analytic technologies to understand consumer behaviour &amp; preferences. <ul style="list-style-type: none"> <li>Enhance joint research/exchange programs between public sector KBI's &amp; MSMEs.</li> <li>Need of automation-driven strategy coupled with setting up of infrastructural facilities for micro &amp; household level enterprises.</li> </ul> </li> </ul> <p><b>Human Capital and Organization</b></p> <ul style="list-style-type: none"> <li>Establish mechanism to monitor firms as well as incentivize for adopting occupational &amp; health safety standards. (Enabling hygienic food practices)</li> <li>Create consumer awareness for processed food (processed food enhances shelf-life).</li> <li>Encourage MSME's to adopt product-diversification strategy to improve economies of scale.</li> </ul>
<p><b>Unsuccessful policy instruments from the perspective of Industry:</b></p> <ul style="list-style-type: none"> <li>Explicit firm innovation policy support.</li> <li>Focused skill development initiatives.</li> </ul>		<ul style="list-style-type: none"> <li>Distilled versions of policies and strategies need to be articulated and disseminated.</li> <li>Specific-policy intervention for diffusion of high-end technologies in MSME.</li> </ul>

<ul style="list-style-type: none"> <li>Spatial Policies.</li> </ul>		<ul style="list-style-type: none"> <li>Strengthening of regional KBIs by adopting apprenticeship programs catering to industry-needs. (Like Meghalaya Institute of Entrepreneurship)</li> <li>Like Mega Food Parks, institutionalize Logistics Parks to encourage specialized distribution or export facilities.</li> <li>Enable fair sharing mechanism to create common logistics infrastructure.</li> </ul>
<b>Unsuccessful policy instruments from the perspective of KBI:</b> <ul style="list-style-type: none"> <li>Govt. backed venture capital</li> <li>Labor Mobility &amp; Laws</li> <li>Explicit firm innovation policy support</li> </ul>		<ul style="list-style-type: none"> <li>Instituting funds for skill development missions.</li> <li>Need for creation of a performance index measuring worker-wellbeing at enterprise level and incentivizing high performing firms.</li> <li>Undertaking sector-specific wages reforms.</li> </ul>
<b>Unsuccessful policy instruments from the perspective of Intermediary:</b> <ul style="list-style-type: none"> <li>Explicit firm innovation policy support</li> <li>Donor Funds</li> <li>Government Procurement</li> </ul>	Strengthen and focus delivery of policy to address specific gaps.	<ul style="list-style-type: none"> <li>Need for developing international standards for Indian traditional food-products.</li> <li>Initiate collaborative accelerator programs at regional level with donor-funding agencies and State governments (like CIIE - IIM Ahmedabad &amp; Rockefeller Foundation jointly launched 'Last Mile Accelerator Program')</li> <li>Exemption from duty structure for incubators to purchase &amp; import high-end equipment.</li> <li>Provision of quality inspection of products on GEM Portal.</li> <li>Aim for sustainable public procurement (use of recycled materials).</li> <li>Improve the coverage of organized procurement.</li> </ul>
<b>Unsuccessful policy instruments from the perspective of Arbitrageurs:</b> <ul style="list-style-type: none"> <li>Regulation</li> <li>Govt. backed venture capital</li> <li>Spatial Policies</li> </ul>	Strengthen and focus delivery of policy to address specific gaps	<ul style="list-style-type: none"> <li>Establish a standard set of industrial licenses across all the states.</li> <li>Institutionalize R&amp;D investment funds to upgrade regional-level incubators.</li> <li>Establish venture capital fund for market intelligence &amp; brand building support for MSMEs.</li> <li>Enable low-cost financing options to set-up cold chain infrastructure.</li> <li>Setting-up of sector-specific venture capital fund for supporting start-ups.</li> </ul>

A person wearing a white lab coat and gloves is holding a small green plant with multiple stems and leaves. A vertical ruler is placed next to the plant for scale. The background is a laboratory with a computer monitor displaying a green image and various lab equipment. The entire scene is overlaid with a semi-transparent yellow filter.

8.

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# 9.

## Annexes

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## Annexes

### 9.1 Annex 1 – Sample size calculation

- **Overall sample sizes** for both firm level and sectorial system of innovation surveys are determined by the degree of stratification of the sample. The overall sample size depends on the decision of the sample size for each level of stratification.
- **Determining the desired sample size:** Desired sample size from a particular state, which will represent the population (total production units), is calculated through the formula developed by Cochran (1963).

$$SS = \frac{Z^2 * p * (1 - p)}{e^2}$$

Where:

Z = Z value (e.g., 1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal (.5 used for sample size needed)

e = margin of error, expressed as decimal (e.g., .05 = ± 5%)

- **Margin of Error** – It is defined as the range of values below and above the sample statistic in a confidence interval. It is a measure of the variability of sample statistics, and it is used to indicate the level of precision

of the sample estimate. It is typically expressed as a percentage of the total sample size and is calculated by taking the standard deviation of the sample and dividing it by the square root of the sample size. Margin of error for the sectorial survey sampling is ± 5%.

- **Confidence Level** – It is the proportion of sample, which will represent the population, given the level of precision or confidence interval. A 95% level of confidence has been taken, which shows that 95 out of every 100 samples will have true population value within the level of precision.
- **Correction for Finite Population:** If the population is small then the sample size can be reduced slightly. This is because a given sample size provides proportionately more information for a small population than for a large population. The sample size obtained for different states is based on the formula –

$$New\ SS = \frac{SS}{1 + \frac{SS - 1}{pop}}$$

Where: pop = is the number of production units in a state (finite population)

A convenient sample was chosen for each actor category and contact details were verified through the ASI and CMIE databases.

### 9.2 Annex 2 – NIC code classification

NIC 2008 Codes & Its Description (Divisions and Groups)	
<b>Division 29</b>	<b>Manufacture of motor vehicles, trailers, and semi-trailers</b>
Group 101	Processing and preserving of meat
Group 102	Processing and preserving of fish, crustaceans and molluscs
Group 103	Processing and preserving of fruit and vegetables
Group 104	Manufacture of vegetable and animal oils and fats
Group 105	Manufacture of dairy products
Group 106	Manufacture of grain mill products, starches and starch products
Group 107	Manufacture of other food products
Group 108	Manufacture of prepared animal feeds
<b>Division 11</b>	<b>Manufacture of beverages</b>
Group 110	Manufacture of beverages



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