NABARD Research and Policy Series No. 3/2022

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Startups Digitising Indian Food System

Innovations, Survival and Investment

Chandra S R Nuthalapati

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NABARD Research and Policy Series No. 3/2022

भारतीय खाद्य प्रणाली का डिजिटलीकरण करने वाले स्टार्टअप्स
नवाचार, उत्तरजीविता और निवेश
Startups Digitising Indian Food System
Innovations, Survival and Investment

चन्द्र एस आर नूतलपाटि
Chandra S R Nuthalapati

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ISBN 978-93-5607-203-9

Published by
Department of Economic Analysis and Research
National Bank for Agriculture and Rural Development
Plot No. C-24. 'G' Block, Bandra-Kurla Complex
Bandra (E), Mumbai –400051

Printed at
Image Impression
Mumbai

Chairman's Message

Academic research can inform policy making. However, since each piece of research may cover certain aspects of an issue, a comprehensive review of research may help collate the findings that may lead to policy recommendations. Further, the research available may be often very technical and less communicative to the policy makers. NABARD commenced the "Research & Policy" series to commission review papers on various themes to bring research findings on a given theme in a capsule form.

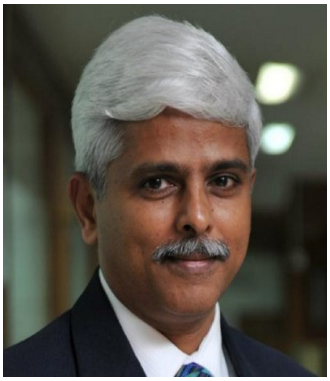
With this series, veteran scholars in different fields of specialisation have been requested to document research in their field highlighting various issues, policy relevance and prescriptions, and suggestions for future research. I am glad to present the paper on "Startups Digitising Indian Food System" by Dr. Chandra S. R. Nuthalapati who has been an authority on the subject.

The series will present more such authoritative papers on various issues ranging from climate change to agricultural policy in the coming months. I hope that series will be beneficial to academicians, researchers and policy makers for use at the ground level.

My best wishes to the authors and the Department of Economic Analysis and Research (DEAR) for initiating such wonderful series.

Dr. G. R. Chintala

Foreword



There is a vast body of research available on topics related to agriculture and rural development in the academic world. But, most of it is in the technical realm and not in a form which could feed into the policy. Research must first lead to better understanding of a subject and then into a robust policy, wherever it can, so that it touches the multitude of Indians across the length and breadth of our country through better public policy & efficient services. Discussion with my colleagues on this issue lead to this new series "Research & Policy". We wish that this series will provide the breadth & depth of research into an area topped up by a lucid presentation for the policy makers.

I am happy to present the third publication in this series on "Startups Digitising Indian Food System" written by Dr. Chandra S. R. Nuthalapati.

I wish this new series acts as a bridge between the researchers & policy makers.

P. V. S. Suryakumar
Deputy Managing Director

Preface

Agriculture sector proved a silver lining in the pandemic period registering a positive growth in the covid times. Yet it faces various structural challenges to be addressed to make it profitable. For, the majority of the population is still dependent on the sector. As we all know, investing in research is one of the best strategies to address problems of agriculture. Equally important is to communicate the research findings to policy makers to design and tweak policies that matter. During one of our meetings with Shri P. V. S. Suryakumar, our DMD, we had loud thinking if we can commission a few review papers on a select themes. We thought that it is appropriate to request veteran scholars who spent prime of their life on a given research theme to attempt such a work where they will distil their understanding and the research done on the theme in a short paper. Duly encouraged by DMD and Chairman, we wrote to a dozen eminent scholars. And the response was overwhelming resulting in Department of Economic Analysis and Research (DEAR), the research wing of NABARD, initiating the 'Research and Policy' series. The motivation is, thus, to get a few handles from research that can help effective policy intervention. This series will be useful to policy makers and researchers alike.

The 'Research and Policy' series is an attempt to get a glimpse of hardcore research findings in a capsule form thereby making it more effective and communicative to policy makers. The group of researchers who agreed to prepare a review of research have spent their life in the field of agricultural research. Our purpose here, as we communicated to them, was not just to get literature survey but to get researcher's heart and their experience which they gained during their long passionate innings. The paper is expected to highlight various issues, policy relevance, prescription, and suggestion for future papers on the themes of interest to NABARD.

India is the third country in the world in number of startups with 50,000 entities and 200 unicorns. Sizeable proportion of these startups are in food system. Thus, the present paper on "Startups Digitising Indian Food System" written by Dr. Chandra S. R. Nuthalapati, Professor, Institute of Economic Growth, New Delhi assumes importance. Dr. Rao has an illustrious academic career, and his research interests

are modernisation of agriculture, employment, open innovation paradigm and food systems, contract farming, direct procurement, digitalisation, and food value chains and innovations through startups.

The present paper aims to analyse the ongoing digitisation of the Indian food system, nature of innovations in agricultural startups using an open innovation framework, spatial and sectoral distribution and factors that influence their survival, investment, and revenue. The paper also provides examples of how startups at different levels in food value chain are leveraging technology to provide services which enables the actors in the chain to make informed decision ranging from what, when and how to grow to delivery of their produce till the last mile of consumption for better price realisation. The author highlights the need for research and policy framework to create necessary enabling environment for the development of the startup ecosystem in the country, at the same time raising the concerns of welfare loss implication, if the smallholders are bypassed by these digital innovations. Overall, the paper is a food for thought to the readers.

In bringing this series as planned, I would like to express our sincere gratitude to Dr. G. R. Chintala, Chairman, NABARD for his inspiring leadership, unstinted support and guidance. We also wish to express our sincere thanks to Shri P. V. S. Suryakumar, DMD, for being the inspiration and the driving force behind the publication of this first of its kind series. We are grateful to the authors of this series who agreed to write on themes relevant to NABARD in such a short period of time. Indeed, it has been a great privilege for us.

I also acknowledge the contributions of the officers of DEAR, NABARD especially Dr. Ashutosh Kumar, DGM; Mrs. Geeta Acharya, Manager; Ms Neha Gupta, Shri Vinay Jadhav, Asst. Managers, and others who coordinated with the authors and the editor to bring out the series as envisaged.

Thanks are due to Dr. J. Dennis Rajakumar, Director, EPWRF and his team for their contribution in copy editing and bringing uniformity to the document.

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Acknowledgement

We are grateful to the National Bank for Agriculture and Rural Development (NABARD) for the encouragement and funding support for research on food value chains. We are indebted to Dr. K. J. Satyasai, Chief General Manager, Department of Economic Analysis and Research (DEAR), NABARD for his critical comments and useful insights. Visionary thoughts and observations of Dr. G. R. Chintala, Chairman and Dr. P. V. S. Surya Kumar, Deputy Managing Director, NABARD, were particularly useful in taking forward this research. The constant persuasion and help by Ms. Pankaja Borah, Ms. Kaur and Dr. Ashutosh Kumar is gratefully acknowledged.

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Abbreviations

$	US Dollar
AIF	Alternative Investment Funds
AIP	Agribusiness and Innovation Platform
B2B	Business-to-Business
B2C	Business-to-Customers
CEO	Chief Executive Officer
FaaS	Farming as a service
FMCG	Fast-Moving Consumer Goods
FPO	Farmer Producer Organisation
GIB	Greenhouse-in-a-Box
GVA	Gross Value Added
IARI	Indian Agricultural Research Institute
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IoT	Internet of Things
ISRO	Indian Space Research Organisation
MFD	Maximising Finance for Development
MIP	Mission-oriented Innovation Policy
NABARD	National Bank for Agriculture and Rural Development
NCR	National Capital Region
NDRI	National Dairy Research Institute of India

(Contd.....)

Abbreviations *(Concluded)*

SaaS	Software as a Service
SLACC	Sustainable Livelihoods and Adaptation to Climate Change
SMEs	Small and Medium Enterprises
SOLVED	Social Objectives-Led Volunteer Enterprise Development
UG	Undergraduate
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture

Executive Summary

The concept of food value chain to understand the food system in its entirety has been gaining popularity among development economists during the last decade. The rapidly developing digital technologies have been radically altering production and marketing as well as consumption in all the sectors of the economy, including the supposedly low-tech sector like agriculture in the last few years. Interestingly, food systems in developing countries like India have been witnessing this phenomenon mainly due to the innovative endeavours of the new generation startups. The explosion of startups in the developing countries of Asia, Latin America and Africa has been making it possible to digitise food value chains through innovations and by use of cutting edge technologies in the information and communication revolution, such as machine learning, internet of things (IoT), deep learning, big data analytics, blockchain technologies and so on. This paper examines this rapidly ongoing digitisation of Indian food system by harnessing a large database of startups data, explores the nature of innovations in the startups by using an open innovation framework, and analyses sector-wise and geographical distribution of these startups and determinants of their survival, investment and revenue. The six broad categories of digitisation by startups are identified, namely, providing output market linkages, facilitating input supply, enabling mechanisation, irrigation control and financial support, helping in quality maintenance, monitoring, traceability and output predictions (SaaS), postharvest management and farming as a service (FaaS), and supporting animal husbandry farmers. Being an exploratory study on this evolving digitisation of food system, this paper confines to broad delineation of the functions and interoperability mechanisms of startups, without going deeper into the technological products and associated marketing strategies.

Evidence shows that 50% of the startups are from tier 1 and tier 2 cities, and therefore the stylised fact that the most of the startups are located in the three major cities of Delhi National Capital Region (NCR), Bangalore and Mumbai does not represent ground realities. On an average, only one in ten startups manage to get funding, which makes it difficult for them to survive and launch their innovations successfully. The analyses of funding deals reveal that 90% of the total amount of funding accrued in Bangalore, Delhi NCR and Mumbai, despite these cities accounting for only 60% of

the deals. Consequently, startups located in other cities find it extremely difficult to get financial support. Most of the funding is in seed and Series A stage, and late-stage funding is negligible. Only 6.4% and 1.7% of the startups receive funding at the seed stage and Series A stage, respectively, while funding at late-stages is negligible. The food and agriculture segment attracted a considerable number of startups in recent years, despite lacklustre initiatives until 2016. They are located mainly in places other than these three cities. There are several types of startups that have come in the last decade, and they are filling the gap in the food value chains in infrastructure deficit regions through use of various digital technologies.

A large number and proportion of agtech startups focus on innovations for linking the farmers in far-flung areas with the buyers of their produce. The important players among them include Udaan, BigBasket, Swiggy, Zomato, Grofers, Ninjacart, WayCool, ZopNow, ShopKirana, Jumbotail, DeHaat, AgriBazaar, Bijak, Farmpal and MilkBasket. The first five of these startups are unicorns. Despite being the direct sellers of food, most of these startups engage directly with farming community and procure their produce. By September 2020, a large amount of investment to the tune of $6.96 billion was attracted by these startups, and they were invested in the long-neglected modernisation of the value chains as well as for innovations.

Several startups like Agrostar, BigHaat, Khetinext and Gramophone have been offering digital solutions to enable delivery of assured quality inputs to farmers and to optimise their use. These online services have been of particular help in the times of pandemic to follow social distancing and purchase inputs from home using smart phones. Some of them provide mechanisation services on rent (MITRA, EM3, Sickle innovations), digitise irrigation through the use of sensors (Flybird and Kisanraja), and render financial services such as credit (Jai Kisan, SG Agtech and SafalFasal) and insurance (GramCover) in a transparent and hassle-free manner.

Several innovative digital products have been developed and popularised by startups in the area for quality assaying, quality maintenance by advisories, traceability and yield predictions through mobile imagery, digitisation and advanced software. One of the most popular startups in this category is CropIn that has clients in 30 countries, and was chosen by the World Bank for Sustainable Livelihoods and Adaptation to Climate Change (SLACC) Project. The SaaS startups such as Intello Labs, Agricxlab, QZense and RAAV Techlabs focus on quality assessment of

agri-commodities. Precision agriculture solutions are provided by software platforms of Amnex, AS Agri Systems, BKC Aggregator and NeerXTechnovation. Agricultural information sharing has few startups, including RML Agtech, FarmBee, MyCrop Technologies, Agrojay and NammaUzhavan. Crop yield predictions are facilitated by Fasal, Yuktix, Bloom and Skymet. Likely to be unicorn soon is SourceTrace that operates in 26 countries with a digital platform that helps to capture information regarding agriculture, financial services and retail through existing mobile and wireless networks in developing economies and also a two-way interactive digital platform.

Startups have become crucial in the segment of logistics, with several of them acting as third-party logistic partners for other startups as well as for established food companies like Britannia. Apart from that, a few startups have made innovative products for cold storage, saving the produce from postharvest damage before being transported. The solar-powered small size cold storage unit of Ecozen Solutions and low-cost storage-cum-transportation solution called Sabjikothi, developed by Saptakrishi, for extending shelf life of vegetables from 7-30 days have tremendous potential to cover the shortcomings for smallholder farmers. Another area many startups have been playing a considerable role is storage of agri-produce with the likes of A2Z Godaam of Arya Collateral. The FaaS has gained currency, with several urban people wishing to engage in cultivation of fruits and vegetables often in organic modes and with several smallholders wishing to have support for their farming profitability.

The animal husbandry sector, with one-third of agriculture gross value added (GVA) in the country, does attract startup ventures, though not in proportion to its contribution to the country's GVA. The leaders in this segment are Licious and Fresh-to-Home that engage in farm-to-fork model and supply to the consumers directly. Other significance presence is by dairy sector startups such as CountryDelight and Stellaps, and fishery startup, that is, Aquaconnect.

Women are also taking an active role in founding startups, though a large number of the startups is founded by men. The paper has identified startups like Intello Labs, QZense, PureScan AI, AgShift, BharatAgri, NEERx Technovation, Kheyti, Green Venture, Farmizen, Herbivore Farm, Smartbell, Mooo Farms, and a few others with women founders.

Startups have played a critical role in mitigating COVID-19 related food supply chain disruptions in a variety of ways. Widespread supply disruptions that came in the way of primary production as well as processing and distribution of food were experienced in the initial stages of the lockdown. Several innovative technological and marketing strategies, leveraging on the cutting edge information technologies, of the startups helped to overcome these problems, and this strengthened the resilience of food supply chains, and at the same time, accelerated their growth.

A regression analysis indicates that food and agriculture startups are not short-lived vis-a-vis those in other sectors. Also, they earn a significant and relatively higher revenue. However, their Achilles Heel is in attracting investments. Venture capital enhances the chances of survival of the startups, probably due to their continued mentoring. Women successfully start innovative micro firms, and their stewardship enables the startups to thrive for a long period of time.

Our estimates show that startups attracted investment to the tune of $10 billion into the food and agriculture sector – in this sector, there emerged six unicorns and three soonicorns. Most of these startups operate digitally in tandem with various other companies in the downstream like supermarkets, retailers and hoteliers; in the midstream with processors, wholesalers and logistic firms; and, in the upstream with input companies and so on. The entry of startups has accelerated the flows amongst food chain actors in regard to making and diffusing innovations to the end users. The knowledge flows are both outbound from the startups to the companies and other actors, and sometimes in the opposite direction as well as bi-directional.

The interconnections between startups themselves and their business partnerships with input companies, processors, aggregators, traders, hotels and restaurants, supermarkets, ecommerce companies, research organisations, various governments (centre and states), international institutions like World Bank and various crop associations like tea growers' association, constitute a complex web.

This fast-expanding digitalisation has brought in several innovations, which could not be imagined just a few years back. To the ready access of farming community, the startups ecosystem has been bringing several innovative products such as online marketing of farmers produce, precision agriculture solutions for crop and animal husbandry, traceability solutions, storage solutions, online financing, innovative field

level cold storages, irrigation control, customised mechanisation solutions on rent, rapid quality assessment and grading, and third-party logistics solutions. These innovations are from the startups to other actors in the value chain, which itself has been accelerated and invigorated, with covering up of the missing links.

Most of the factors leading to open innovation, termed as erosion factors by Chesbrough and Bogers (2014), such as startups getting venture capital, rising number of internet users, widespread use of social media, universities becoming innovation hubs and inter-firm mobility of employees are present in the country, and they combine to create this open innovation system.

After a long period of stagnation and technology fatigue, Indian agriculture is in transition and moving towards higher level of digital technologies with better and faster linkages amongst various food chain actors. The government needs to develop a policy framework to create necessary enabling environment for the development of the startups ecosystem that include venture capital industry and associated policy changes. While addressing the ecosystem, due considerations should be given to the early-stage support through seed fund, encouraging angel investors, mass incubators, level playing field for non-technical startups and occasional conduct of regional food system challenges. Startups and chain actors interact with others keeping their own interests rather than wider interests, and therefore, this innovation system has to be internalised and mainstreamed into the agricultural development planning, but at the same time, being mindful of the twin objectives of growth and equity. The Mission-oriented Innovation Policy (MIP) under Horizon Europe programme in the European Union is an interesting model in this regard. As noted by the World Bank, the Maximising Finance for Development (MFD) framework can help to identify public actions needed to the inclusive digitalisation process. The initiative of National Bank for Agriculture and Rural Development (NABARD) to establish an exclusive fund through Nabventures is a right step in this direction and is likely to go a long way.

The nascent stage of development of this digital innovation system needs dispassionate research from the equity point of view and for exploring the possibility of scaling up these ventures. Also, required is research focus on the type of business models, collaborations and licensing agreements between companies, universities and governmental agencies. Social scientists may also examine scale bias, possible

risks and redressal mechanisms for digitisation risks that include exclusion, lack of data privacy, cybersecurity breaches and over-concentration of service provider market power. This is all the more important because of the welfare loss implications, if the smallholders are bypassed by these digital innovations.

Startups Digitising Indian Food System
Innovations, Survival and Investment

1. Introduction

There is a growing consensus among development economists that food system has to be considered in its totality as it reaches the consumers from the farmer-producers (Pingali *et al.* 2019; Swinnen and Kujipers 2019; Zilberman *et al.* 2019). This system is better represented by the concept of food value chain and the interactions among numerous actors at different nodes of these value chains (Gomez *et al.* 2011; Nuthalapati *et al.* 2017). Digitisation is the new trend in the food system and has the potential to transform the food system through better informed and engaged consumers, smarter farms and improved delivery of public services (World Bank 2019; Birner *et al.* 2021; Reardon *et al.* 2021). Until a few years ago, it was assumed to take a long time to digitise the smallholder dominated food system of developing countries, as the big companies do not have sufficient market incentive to undertake the same (Lianos *et al.* 2016). The explosion of startups in developing countries of Asia, Latin America and Africa has changed this notion, with digitisation of several activities in the food system taking root through the innovations of these startups using cutting edge technologies in the information and communication revolution, including machine learning, internet of things (IoT), deep learning, big data analytics, blockchain technologies and so on (Jha *et al.* 2019; Tripoli and Schmidhuber 2018; Deichmann *et al.* 2016; Anand and Raj 2019).

It is well-known that entrepreneurial micro-firms, called startups, have the potential to bring in new innovations to address the gap in production and marketing of goods and services (Audretsch *et al.* 1999; Acs *et al.* 2004; Baumol 2004; Nanda and Rhodes-Kropf 2013).[1] Startups have been proliferating across the countries not only in the developed world, but also in the developing countries in Asia, Africa and Latin America (de Angelis 2017). The last decade witnessed the entry of a large number of these micro-firms in India with a willingness to fail by venturing into innovative products (Subrahmanya 2015; Korreck 2019; Singh 2020). While the banking system in India has been conservative in financing proven technologies and products, nascent venture capital promoted by central government nurtured budding innovators

(Mazumdar-Shaw 2017). Concerted efforts by the government to promote a venture capital industry on the lines of the successful United States (US) model fructified, and India became one of the largest recipients of venture capital in the world after the US and China (Nuthalapati and Singh 2019). This availability of venture capital has further encouraged risk-taking innovators to set up startups in the country.

Interestingly, these startups have entered into both hitech sectors and traditional sectors like agriculture (Fabrico *et al.* 2015; de Bernardi and Azucar 2020). Though some initiatives were taken to encourage startups in agriculture a decade back by the Godrej group through an exclusive fund, it got accelerated only after 2015 (Putrevu 2020). The food system is in need of transition with the paradigm shift in thinking from growth to welfare (Satyasai *et al.* 2021). The remarkable resilience of food value chains and higher agriculture growth during the pandemic (Chintala, 2021) brought to the fore the crucial role of startups (Suryakumar 2021). Notwithstanding the proliferation of startups and a flurry of innovations to digitise operations in various segments of the value chain, the extant literature does not analyse these developments in developing countries' context and integrate these developments into the overall growth process. This paper endeavours to address this research gap.

This paper is organised as follows. Section 2 expounds the analytical framework along with a discussion on data source and methods. Section 3 brings out the basic structural characteristics of the agri-startups vis-à-vis others. Section 4 examines the nature of digitisation by startups in regard to their functioning of the various nodes of the food value chain. Section 5 and 6 examine the nature of innovations in women-founded startups and startups mechanisms for ameliorating COVID-19 induced disruptions, respectively. Section 7 analyses the determinants of survival, funding and revenue of agri-startups. The last section has the concluding remarks with some policy suggestions.

2. Analytical Framework

This paper uses a dataset of more than 11,000 startups in various sectors to find out the defining features of agri-tech startups vis-à-vis those in the rest of the sectors, and to identify the determinants of their survival, funding and income. This has been supplemented with details of functioning of several startups based on the information collected from business newspapers and magazines. The database on

startups from Tracxn was resorted to for collecting firm level information of 11,583 startups covering seven key sectors such as food and agriculture, financial technology, logistic, health technology, educational technology, real estate and artificial intelligence. Besides providing a firm's characteristics such as employment, location and year of establishment, Tracxn database also provides details of the firm's financial performance such as revenue, profit, assets, liabilities and valuation. Separate efforts were made to collect the founders and co-founders related information like their gender, qualifications and so on. Both datasets were combined for all these sectors to make a comprehensive database. Despite the best attempts to collect variables of interest, key information for several firms was found missing in the combined datasets. Multiple imputation method was used to deal with missing observations. The impact of firm size and total funding on the growth of Indian startups are examined, while controlling for potential confounding factors such as gender, educational qualification of Chief Executive Officer (CEO) and number of founders as well as a host of other factors. We measure performance of a firm through its gross revenue, and a firm's size is proxied by the number of its employees. Simple linear regression method has been used to determine the relationship between survival duration, funding received and revenue of startups, along with founders' characteristics, sectors of operation and geographical locations and related factors. All the investment figures reported in this paper are in US Dollar ($).

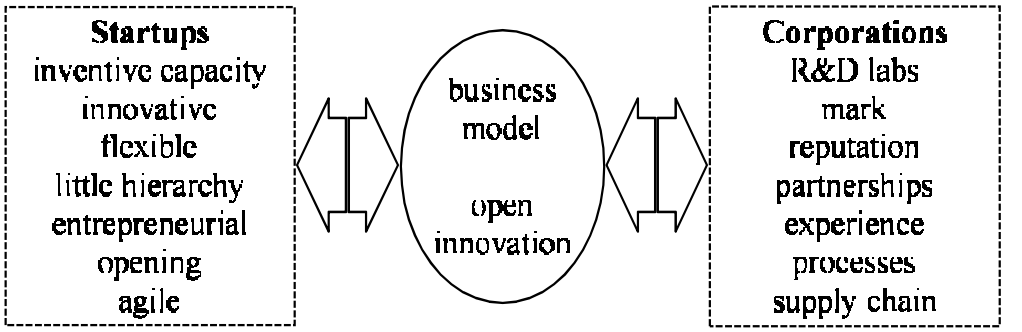
This paper employs the open innovation framework to understand the operations of a large number of agri-tech startups in India across various activities to understand their activities in totality. Being an exploratory study on this evolving digitising food system, this paper confines to the broad outline of the functions and interoperability mechanisms of the startups without going deeper into their technological products and marketing strategies. It classifies the startups working in food value chains based on the main purpose of their functioning, though they may be engaged in a wide range of activities at different nodes of the value chain.

Open innovation has been permeating every field of economic activity all over the world in the last two decades, particularly after this was formalised as a new paradigm for creating and profiting from technology by Chesbrough (2003). Initially, he called it the use of purposive inflows of knowledge to accelerate internal innovation and outflows of knowledge to expand the markets for external use of inno-

vation (Chebrough 2006). The open innovation has been recognised as 'a distributed innovation process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model' (Chesbrough and Bogers 2014). To start with, this kind of organisation of innovation was seen as possible only in the economic activities where the level of sophistication was high and the processes were complex. However, the evolving experience in disparate industries showed that this could have traction in relatively conventional sectors too (Chesbrough and Crowther 2006; Medeiros *et al.* 2016). The ramping up of technology with new innovations has been spurring transitions in the food industry, with the mid-stream and downstream of food value chains increasing their share in the total value added of the supply chains (Reardon *et al.* 2019; Reardon *et al.* 2020). Research has shown that diverse actors in the long chains with heterogeneous needs (Sarkar and Costa 2008) and an assortment of technologies required to produce in accordance with changing consumer demands (Bigliardi and Galati 2013) have led to the open innovation paradigm for faster technology development and diffusion. The convergence of findings can also be seen in studies in agricultural economics, showing the entire chain innovations when the processing firms bring in new technologies (Zilberman *et al.* 2019).

The knowledge flows can be inbound or outbound depending on the needs of innovation and the business models of the actors. While evidence show that the large companies primarily initiated and moved the process forward, subsequent experience proved that small and medium sized companies as well as startups, non-profit foundations, collective community actions and individual consumers could also

Figure 1: Relationship Between Startups and Corporations



Source: Fabrico et al (2015).

catalyse significant transformations (Figure 1). Startups specifically need external knowledge sources because of the inadequate internal resources and competencies (Di Pietro *et al.* 2018). The food system is ideally suited to combine the knowledge specificities of many actors, including startups in open innovation framework (de Bernardi and Azucar 2020).

3. Basic Characteristics of Startups

In this section, we examine the distribution of startups across different regions, sectors, funding and stages of development.

The Table 1 provides sector-wise and location-wise distribution of the sample of 11,412 startups. Over one-fifth of startups are located in Delhi National Capital Region (NCR) (21.19%), followed by Bangalore (17.14%) and Mumbai (11.31%). Half of all the startups in the country are located in these three cities. The other half of

Table 1: Sector-wise and Geographical Distribution of Startups

Sector	Number of Startups					Percentage of Startups in				
	Bang-alore	Mum-bai	Delhi NCR	Other	Total	Bang-alore	Mum-bai	Delhi NCR	Others	Total
Artificial intelligence	42 (2.2)	8 (0.6)	17 (0.7)	29 (0.5)	96 (0.8)	43.8	8.3	17.7	30.2	100
EdTech	753 (38.5)	464 (35.9)	1,096 (45.3)	2,326 (40.5)	4,639 (40.7)	16.2	10	23.6	50.1	100
Fintech	42 (2.2)	33 (2. 6)	25 (1.0)	24 (0.4)	124 (1.1)	33.9	26.6	20.2	19.4	100
FoodAgri	397 (20.3)	266 (20.6)	446 (18. 4)	1,418 (24. 7)	2,527 (22.1)	15.7	10.5	17.7	56.1	100
HealthTech	525 (26.8)	360 (27.9)	600 (24.8)	1,382 (24.1)	2,867 (25.1)	18.3	12.6	20.9	48.2	100
Logistic	186 (9.5)	156 (12.1)	227 (9.4)	563 (9.8)	1,132 (9.9)	16	13.8	20.1	49.7	100
RealEstate	11 (0.6)	4 (0.3)	7 (0.3)	5 (0.1)	27 (0.2)	40.7	14.8	25.9	18.5	100
Total	1,956 (100)	1,291 (100)	2,418 (100)	5,747 (100)	11,412 (100)	17.1	11.3	21.2	50.4	100

Note: Figures in parenthesis are percentage to the total number of firms till 2019.
Source: Author's calculations based on data from Tracxn (2019).

the startups are located in cities like Hyderabad, Pune and Ahmedabad, and tier 2 cities. The education sector has the largest share of startups of 40.7%, followed by healthtech (25.1%) and foodagri (22.1%). The food and agriculture segment attracted a large number of startups in recent years (Anand and Raj 2019; NASSCOM 2019), despite lacklustre initiatives until 2016 (Nuthalapati *et al.* 2017). Food and agriculture startups are located mainly in other cities, which together account for 56.1% of their total. Only 22.1% of all the startups are food and agricultural startups. The startups are low in artificial intelligence (AI) (0.8% of the total), real estate (0.2%) and fintech (1.1%), although the startups in these sectors have a disproportionately larger share in turnover.

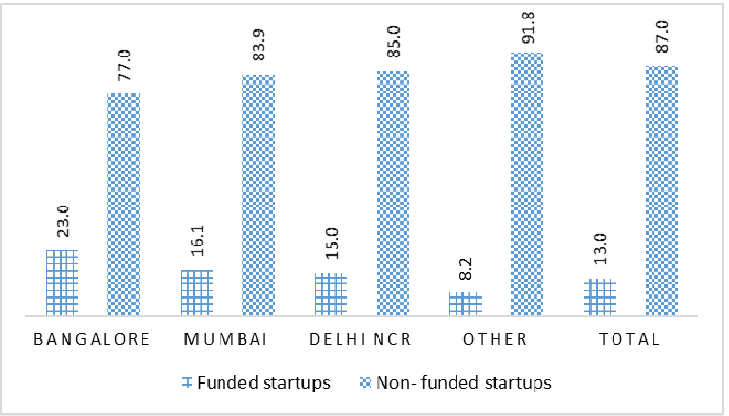
Venture capital funding helps the survival of startups by providing the most needed investments as well as mentoring with regard to marketing, finances and governance issues (Kortum and Lerner 2000). The Table 2 shows that only 12% of all the startups manage to get this vital funding support. After using a large sample, Sheth *et al.* (2020) observed that only 8% of the startups are funded.

Table 2: Sector-wise Distribution of Startups that Received Funding

Sector	Startups			Percentage of Startups		
	Funded	Non-funded	Total	Funded	Non-funded	Total
Artificial intelligence	87 (5.8)	9 (0.1)	96 (0.8)	90.6	9.4	100
EdTech	465 (31.2)	4,231 (41.9)	4,696 (40.6)	9.9	90.1	100
Fintech	105 (7.1)	19 (0.2)	124 (1.1)	84.7	15.3	100
Food and agriculture	279 (18.7)	2,264 (22.4)	2,543 (22.0)	11.0	89.0	100
HealthTech	372 (25.0)	2,583 (25.6)	2,955 (25.5)	12.6	87.4	100
Logistic	158 (10.6)	980 (9.7)	1,138 (9.8)	13.9	86.1	100
Real estate	24 (1.6)	3 (0.0)	27 (0.2)	88.9	11.1	100
Total	1,490 (100)	10,089 (100)	11,579 (100)	12.0	87.1	100

Note: Figures in parenthesis are percentage to the total number of firms till 2019.
Source: Author's calculations based on data from Tracxn (2019).

Figure 2: City-wise Distribution of Startups that Received Funding



Startups in food and agriculture sector are relatively worse off with only 11% of them getting funding, while the situation is better in the case of firms in AI (90.6% of them), real estate (88.9%) and fintech (84.7%). Among the firms funded, startups in edutech firms accounts for a lion's share (31.2%), followed by healthtech (25%), food and agriculture (18.7%), and logistic sector (10.6%). The startups that received relatively more funding are in Bangalore (23%), Mumbai (16.1%) and Delhi NCR (14.97%). In contrast, only 8.3% of the startups in tier 2 and 3 cities are funded (Figure 2).

Table 3: Educational Attainments of Startups' Founders

Sector	Shares of Startups with Founders having Degree					
	UG and below	Master and above	Total	UG and below	Master and above	Total
Artificial Intelligence	72 (6.3)	220 (10.0)	292 (8.7)	24.7	75.3	100
Fintech	49 (4.3)	263 (11.9)	312 (9.3)	15.7	84.3	100
Food Agri	63 (5.5)	116 (5.3)	179 (5.3)	35.2	64.8	100
Health Tech	926 (80.6)	1,548 (70.2)	2,474 (73.8)	37.4	62.6	100
Real Estate	39 (3.4)	58 (2.6)	97 (2.9)	40.2	59.8	100
Total	1,149 (100)	2,205 (100)	3,354 (100)	34.3	65.7	100

Note: Figures in parenthesis are percentage to the total number of firms till 2019.
Source: Author's calculations based on data from Tracxn (2019).

Two-thirds of the startups' founders had attained educational qualifications of a master's degree and above (Table 3). The percentage of founders with a masters and above degree is higher in fintech (84%) and AI (75%). Understandably, founders of firms in real estate sector are mostly with undergraduate (UG) degree and below.

Startups are often categorised based on their valuation by venture capitalists as minicorns, soonicorns and unicorns, starting with the coining of the word 'unicorn' in 2013 by Aileen Lee to mean a startup with a net worth of $1.0 billion. Among the startups in the country, three-fourths are in the minicorn category with a net worth of $1.0 million or more (Table 4). One-fifth of them are soonicorns ready to mature to

Table 4: Sector-wise and Geographical Distribution of Startups by their Status

Startups	Minicorn	Soonicorn	Unicorn	Total
		Sectors		
Artificial intelligence	34	4		38
	(89.5)	(10.5)	-	(100)
EdTech	45	4	1	50
	1(90.0)	(8.0)	(2.0)	(100)
Fintech	43	17		60
	(71. 7)	(28.3)	-	(100)
FoodAgri	40	10	3	53
	(75.5)	(18.0)	(5.7)	(100)
HealthTech	31	9		40
	(77.5)	(22.5)	-	(100)
Logistic	25	9	5	39
	(64.1)	(23.1)	(12.8)	(100)
RealEstate	4	5		9
	(44.4)	(55.6)	-	(100)
		Geographical Distribution		
Bangalore	80	30	5	115
	(69.5)	(26.1)	(4.4)	(100)
Mumbai	37	5		42
	(88.1)	(11.9)	-	(100)
Delhi NCR	64	9	4	77
	(83.1)	(11.7)	(5.2)	(100)
Other	41	14		55
	(74.6)	(25.5)	-	(100)
Total	222	58	9	289
	(76.8)	(20.1)	(3.1)	(100)

Note: Figures in parenthesis are percentage to the total number of firms till 2019.
Source: Author's calculations based on data from Tracxn (2019).

Table 5: Sector-wise and Geographical Distribution of Number of Deals and Funding

City	Sector	Number of Deals	Total Funding	
			Amount in $ mn.	Share in %
Bangalore	AI	37	327.59	1.6
	EdTech	58	1936.09	9.6
	Fintech	38	1123.60	5.6
	FoodAgri	68	3313.24	16.4
	HealthTech	69	879.62	4.4
	Logistic	35	2252.94	11.2
	RealEstate	11	369.39	1.8
	Sub-total	316	10202.46	50.6
Mumbai	AI	6	98.15	0.5
	EdTech	38	199.49	1.0
	Fintech	24	598.43	3.0
	FoodAgri	13	72.00	0.4
	HealthTech	39	550.44	2.7
	Logistic	25	67.20	0.3
	RealEstate	3	155.57	0.8
	Sub-total	148	1741.28	8.6
Delhi NCR	AI	13	198.62	1.0
	EdTech	75	167.12	0.8
	Fintech	19	366.12	1.8
	FoodAgri	46	2292.10	11.4
	HealthTech	49	398.38	2.0
	Logistic	29	2544.73	12.6
	RealEstate	6	234.87	1.2
	Sub-total	237	6201.94	30.8
Other	AI	22	207.42	1.0
	EdTech	72	213.12	1.1
	Fintech	15	563.82	2.8
	FoodAgri	49	513.76	2.6
	HealthTech	61	326.87	1.6
	Logistic	19	144.48	0.7
	RealEstate	3	39.04	0.2
	Sub-total	241	2008.51	10.0
All-India	AI	78	831.78	4.1
	EdTech	243	2515.82	12.5
	Fintech	96	2651.97	13.2
	FoodAgri	176	6191.1	30.7
	HealthTech	218	2155.31	10.7
	Logistic	108	5009.35	24.9
	RealEstate	23	798.87	4.0
	Grand total	942	20154.18	100

Source: Author's calculations based on data from Tracxn (2019).

unicorn status. Only a small percentage of them are unicorns. As of September 2021, India had 66 unicorns. Bangalore had the highest percentage of minicorn, soonicorn and unicorn (36.0%, 51.7% and 55.6%, respectively).

The investment deals of these startups are analysed, both location-wise and sector-wise (Table 5). Sectors that accounted for a large share of investment include foodtech (30.7%) and logistic startups (24.9%), followed by fintech (13.2%), edtech (12.5%) and healthtech (10.7%). Of all the deals in food and agriculture startups, Bangalore accounted for a major share (53.5%), followed by Delhi NCR (37.0%). There were not many investment deals for the food and agriculture startups in Mumbai. On the whole, more than a half of funding was received by startups located in Bangalore (50.6%), followed by Delhi NCR (30.8%) and Mumbai (8.6%). Thus, the startups located in tier 2 and 3 cities may find it difficult to get funders and associated supportive ecosystem. Several studies have also pointed out the geographical concentration and unbalanced nature of this ecosystem in India (Nuthalapati and Singh 2019; Rault and Mathew 2019). It may, however, be noted that the fast-paced initiatives and investment in startups across all sectors make it difficult to indicate the pattern of investment. During the COVID-19 lockdown period, there has been a huge surge in the flow of investment into edtech, fintech and e-commerce ventures.

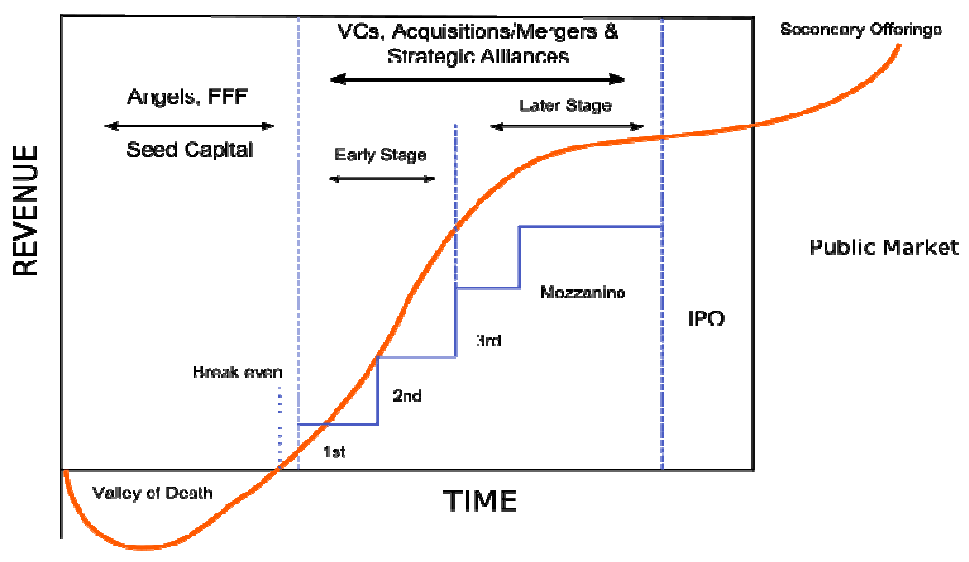
The startups that manage to get some funding account for only 12.9% of the total startups. While funding is crucial for the survival and successful launch and marketing of its innovative product, the stages of funding are also critical. The early stages until it launches the product are critical for the survival of a startup (Suryakumar 2021) and often this phase is termed as the valley of death (Figure 3). Because of difficulties in getting funding as well as uncertainties associated with innovations, only a few micro firms reach advanced stages of development like Stage C, D and so on. Table 6 shows the number and share of the startups that are in various stages of development. Most of the startups that attract funding are funded in seed stage (49.5%) and Series A (12.7%). Funding support is received by only 5% startups in Series B stage and 3% in Series C stage. For 27.1% of those firms receiving funding, the stage at which they received support could not be clearly determined. However, it is possible that these firms might have got funding in the seed and early-stage funding. A few startups in fintech, logistic, foodtech and health have received late-stage funding. Distribution of firms by cities reveals that those firms situated in Bangalore got early-stage funding,

Table 6: Sector-wise Distribution of Startups by their Stages

Stage/Sector	Sectors							Total	
	AI	Ed-Tech	Fin-Tech	Food Agri	Health Tech	Logi-stic	Real Estate	Num-ber	As % of the Total Funded
Acquired	0	0	9	0	0	0	8	17	1.1
Deadpooled	0	0	1	0	0	0	1	2	0.1
Seed	34	238	35	141	203	83	5	739	49.5
Series A	33	50	25	25	33	19	4	189	12.7
Series B	11	8	19	14	13	9	0	74	5.0
Series C	3	3	12	8	6	5	4	41	2.8
Series D	0	0	2	1	2	5	2	12	0.8
Series E	0	1	0	2	1	0	0	4	0.3
Series F	0	0	0	2	0	2	0	4	0.3
Series G	0	1	0	0	1	0	0	2	0.1
Series I	0	0	0	1	0	1	0	2	0.1
Series J	0	0	0	1	0	1	0	2	0.1
Funded but stage is unknown	6	164	4	84	113	33	0	404	27.1
Unfunded	9	4,231	17	2,264	2,583	980	3	10,087	
Total	96	4,696	124	2,543	2,955	1,138	27	11,579	

Source: Author's calculation based on the data extracted from Tracxn (2019).

Figure 3: Startup Financing Cycle



Source: Cardullo (1999).

followed by Delhi NCR and Mumbai. On the other hand, firms in Mumbai got the highest number of late-stage funding compared to Bangalore and Delhi.

4. Digitisation of Food Value Chains

There are several types of startups that have emerged in the last decade that are filling the gap in the food value chains in infrastructure deficit regions of the country through various digital technologies. Many of these startups operate in tandem with various other related companies in the downstream like the supermarkets, retailers, hoteliers; in the midstream with the processors, wholesalers and logistic firms; and, in the upstream with the input companies and so on. The open innovation framework is employed here to discern the nature of emerging innovations and their diffusion through inbound and outbound as well as bi-directional knowledge flows as shown by Bogers *et al.* (2018). An effort has been made to classify them based on their main line of activities, though they can have other initiatives too, so as to unravel the mechanisms of knowledge flows for innovation. The six broad categories of startup innovations identified include: those providing output market linkages; facilitating input supply; enabling mechanisation, irrigation control and financial support; helping in quality maintenance, monitoring, traceability and output predictions (SaaS); post-harvest management and farming as a service (FaaS); and, those supporting animal husbandry farmers. All these groups are discussed below with an analysis of their interconnections. Finally, the nature of knowledge flows leading to the complicated web of open innovation network is examined.

4.1 Digitising Output Market Linkages

Evidences show that reducing the chain of intermediaries between the farmer-producer and consumer can benefit the former through a better price realisation (Chand 2017; Nuthalapati *et al.* 2020). A large number and proportion of startups focus on innovations for linking the farmers in far-flung areas with the buyers of their produce (Table 7). The important players among them include *Udaan, BigBasket, Swiggy, Zomato, Grofers, Ninjacart, WayCool, ZopNow, ShopKirana, Jumbotail, DeHaat, AgriBazaar, Bijak, Farmpal* and *MilkBasket*. The first five of these startups are unicorns involved in direct procurement from farmers and selling to other supermarket chains and other downstream actors. *Udaan* is a fastest

Table 7: Startups Connecting Farmers with Output Markets

Startup Name	Overview	Founded in	City	Funding	Total Funding ($)	Company Stage	Annual Revenue ($)
Bigbasket (Unicorn)	Online marketplace of grocery products	2011	Bangalore	Yes	78,80,00,000	Series F	36,60,77,300
Zomato (Unicorn)	Online platform enabling food ordering and delivery	2008	Gurgaon	Yes	97,50,00,000	Series J	16,91,40,273
Swiggy (Unicorn)	Online platform for food ordering and delivery	2014	Bangalore	Yes	1,62,00,00,000	Series I	15,93,31,500
Udaan	Online B2B marketplace for multi-category products	2016	Bangalore	Yes	90,00,00,000	Series D	77,60,117
Grofers (Soonicorn)	Online retail store offering groceries	2013	Gurgaon	Yes	54,80,00,000	Series F	1,11,21,000
Ninjacart (Soonicorn)	App-based B2B platform offering vegetables and fruits	2015	Bangalore	Yes	16,30,00,000	Series C	1,71,09,500
WayCool (Soonicorn)	E-distributor of farm products	2015	Chennai	Yes	6,57,36,870	Series C	2,26,92,800
ZopNow (Soonicorn)	Online grocery platform with a three-hour delivery promise (Acquired by More and Amazon)	2011	Bangalore	Yes	1,20,45,360	Series A	29,42,600
Agrevolution (DeHaat)	Provider of end-to-end farming services to the farming communities	2012	Patna	Yes	1,65,07,907	Series A	54,17,400
Bijak	Online B2B market place to trade agriculture commodities	2019	Gurgaon	Yes	1,45,91,780	Series A	na
Jumbotail	Online B2B platform for packaged food, fruits and vegetables	2015	Bangalore	Yes	2,53,61,400	Series B	2,92,33,300
Shop Kirana	Mobile-based B2B marketplace for groceries	2015	Indore	Yes	1,24,72,215	Series B	30,11,000
Otipy	App-based platform offering fruits and vegetables	2019	Delhi	Yes	25,00,000	Seed	na

(Contd....)

Table 7: Startups Connecting Farmers with Output Markets *(Contd....)*

Startup Name	Overview	Found-ed in	City	Fun-ding	Total Fun-ding ($)	Company Stage	Annual Revenue ($)
Kisan Network	B2B marketplace for farmers, bulk buyers	2015	Delhi	Yes	34,93,115	Seed	8,66,700
Crofarm	Digital supply chain of fruits and vegetables from farm to business	2016	Gurgaon	Yes	58,66,696	Seed	14,76,300
Aibono	Services for farm data collection & analytics and mobile application for farm management	2013	Bangalore	Yes	64,88,656	Seed	2,44,200
Clover Ventures	Provider of supply chain solution for fruits and vegetables	2017	Bangalore	Yes	69,30,813	Series A	1,48,400
Teabox	Online retailer of tea	2012	Bangalore	Yes	1,90,00,000	Series B	26,89,100
Satvacart	Online platform offering multi-category grocery products	2014	Gurgaon	Yes	23,24,241	Seed	1,83,700
Tokri	Online platform to buy fresh produce and groceries	2014	Pune	Yes	25,00,000	Seed	55,500
Milkbasket	Subscription based daily need items delivery (Milk and F&V)	2015	Gurgaon	Yes	4,05,75,340	Series B	1,03,48,500
Farmpal	Online platform delivering farm produce to businesses	2017	Pune	Yes	1,36,390	Seed	1,79,463
MeraKisan	Online marketplace that connects consumers with local farmers	2014	Pune	Yes	10,00,000	Seed	8,19,100
VnF	Online platform to purchase fruits and vegetables	2018	Mumbai	Yes	20,00,000	Seed	4,22,900
InI Farms	Provider of farming services to horticulture industries	2009	Mumbai	Yes	1,46,34,837	Series A	1,44,04,300

(Contd....)

Table 7: Startups Connecting Farmers with Output Markets *(Concluded)*

Startup Name	Overview	Found-ed in	City	Fun-ding	Total Fun-ding ($)	Company Stage	Annual Revenue ($)
FarmTaaza	Manages supply chain of fruits and vegetables from farm to business (Acquired by WayCool)	2015	Bangalore	Yes	1,06,93,115	Series A	na
Daily Ninja	Hyper-local subscription based delivery service (Acquired by Big Basket)	2015	Bangalore	Yes	1,07,44,109	Acquired	4,13,969
Smerkato	Online B2B platform offering multi-category grocery products	2016	Bangalore	Yes	na	Funded	na
GeeCom	Online E-commerce platform offering agricul-tural products and supplies	2018	Indore	No	na	Unfunded	na
Farmley	Online platform linking farmers with customers (Earlier called TechnifyBiz)	2016	Delhi	Yes	na	Funded	16,83,221
KiranaMonk	App-based B2B marketplace offering farm produce	2018	Sonipat	No	na	Unfunded	na
Atomaday	App-based video shop-ping platform offering fruits and vegetables	2017	Bangalore	No	na	Unfunded	na
GreenNGood	Online retailer of organic products	2012	Jaipur	Yes	na	Funded	na
Organofresh Solutions	B2B wholesaler of fruits and vegetables	2017	Chandigarh	No	na	Unfunded	8,74,200
Farmcon	Online B2B marketplace for agriculture products	2017	Pune	No	na	Unfunded	na
LivLush	B2B platform to procure fresh fruits and vegetables (Sabziwala and LivLush merged as Kamatan)	2016	Bangalore	Yes	na	Series A	55,30,600
Brownsoil	Online B2B platform offering farm produce	2018	Bangalore	No	na	Unfunded	na

Note: na means not available.

Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

growing business-to-business (B2B) full stack platform, dealing in several items like electronics, garments, footwear, kitchen and home appliances, along with staples and fruit and vegetables (Poojary 2019). Despite being the direct sellers of food, the other three unicorns, namely, *BigBasket, Swiggy* and *Zomato* engage directly with farming community and procure from the sellers of food. By September 2020, investment to the tune of $6.96 billion was attracted by these startups, which invested them for building the long neglected modernisation of the value chains as well as for innovations. The significant investments were in *Swiggy* ($1.6 billion), *Zomato* ($972 million), *BigBasket* ($1.02 billion) and *Udaan* ($900 million). Some of the other startups that raised a considerable amount of fund include *Grofers* ($535 million), *Ninjacart* ($164 million), *WayCool* ($65 million), *Jumbotail* ($25 million) and *Bijak* ($15 million).

While *BigBasket* has been procuring directly from farmers since the last several years (Nuthalapati *et al*. 2017), several other startups embarked on direct procurement in recent years, and the quantities are significant and increasing. For example, *Udaan* is procuring fruits and vegetables in Delhi and Karnataka and dealing with a quantity of 500 tons per day, apart from 5,000 tons of staples (Poojary 2019). *Ninjacart* supplies fresh produce to *Flipkart* for its *Flipkart Quick* and deals with 1,500 tons a day (Velayanikal 2020). *Zomato* acquired Bangalore-based *WOTU* in 2018 and renamed it as *Hyperpure* for starting direct procurement from farmers through operations in B2B foodtech space (Kashyap 2019, 2020), while *Swiggy* entered hyperlocal grocery delivery recently, and is also procuring from farmers directly (Garg 2020). Leveraging e-*mandi* model, *Agribazaar* works with 2,00,000 farmers and connects them with procurement agencies and food processing companies like Britannia, *AgroPure* and others at no cost, though it collects transaction fee from buyers (Mitter 2020). *DeHaat*, based on the franchise model, connects farmers with traders, institutional financers and buyers like *Reliance Fresh, Zomato* and *Udaan* on one platform in 20 regional hubs in eastern India and serves 210,000 farmers (Singh 2020a). It is noteworthy that several of the active startups work in central and north India, which suffer from poor agricultural marketing infrastructure. Further, they provide several related services, which are discussed later. While several startups fail to survive or make it to the bigger leagues, some of them are acquired by big companies. For example, *ZopNow* was acquired by *More* and later by *Amazon*, *FarmTaaza* by *WayCool* and *DailyNinja* by *BigBasket*. Pivoting from business-to-customers (B2C) to B2B, as has been done

by *Ninjacart* and *WayCool,* has been a recent trend, and B2B startups have relatively better chances for receiving investment (Sheth *et al.* 2020).

4.2 Digitising Input Supply

Several studies have shown that availability and quality of inputs to the farmers is a serious problem that adversely affects farm productivity and profitability, where fly-by-night operators make quick money by selling spurious seeds, fertilisers and pesticides (Parthasarathi and Shameem 1998). And so, the transformation of input industries and delivery systems is critical in this regard (Pray and Nagarajan 2014). Several startups have been offering solutions to optimise the use and enable delivery of assured quality inputs to farmers (Table 8). These online services that facilitated the purchase inputs from home using smart phones have been of particular help in the times of pandemic. *Agrostar* is the largest startup offering input supply to farmers and is expected to be an unicorn soon. It has mobilised $47 million in funding and reached Series C funding so far. It has been serving farmers in Gujarat, Maharashtra and Rajasthan with 400, 000 active users and one million downloads of its app. By partnering with leading national and multinational companies to sell their products through *AgroStar*, it enables farmers to buy seeds, nutrients, crop protection, as well as hardware products from its platform and app (Apoorva 2019). Similar services are provided by *BigHaat, Khetinext*, *Gramophone*, and several others. Many of them combine input provision with agri-advisory and other services.

4.3 Mechanisation, Digitising Irrigation and Financial Services

Farming in India is increasingly becoming difficult due to lack of suitable equipment, especially for small farmers, enormous drudgery in irrigating fields and wastage of water and lack of financial services. In order to fulfil these needs, startups have been offering efficient services across the length and breadth of the country (Table 9). Some of them focus on accurate and timely assessment of soil moisture and on developing data-driven controlled irrigation models. *Kisan Raja* is an innovative device that allows farmers to remotely control irrigation pumps using their mobile or landline, and their service has been used by 34,200 farmers in India (Gogoi 2019). This was hailed by the World Bank as a project on saving water in rice cultivation. The Bangalore-based *FlyBird* installs sensors in the soil to detect moisture content and

Table 8: Startups Enabling Online Procuring of Quality Inputs

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Agrostar (Soonicorn)	Online platform offering agri-inputs, content, and advice	2008	Pune	Yes	4,71,82,672	Series C	1,16,18,100
Khethinext	Mobile app that enables procurement of farm inputs and provides information	2017	Hyderabad	Yes	53,86,498	Series A	na
Gramo phone	App-based platform providing farm input products and inform-ation to the farmers	2016	Indore	Yes	80,62,080	Series A	5,78,400
Marut Drones	Provides drone-based precision agriculture services	2019	Guwahati	Yes	1,00,085	Seed	na
LeanAgri	Technology solutions providers for farmers	2017	Pune	Yes	5,67,108	Seed	93,300
BharatAgri	Platform that provides crop management solutions for farmers	2017	Pune	Yes	12,91,537	Seed	93,300
BigHaat	Online marketplace offering farm inputs	2015	Bangalore	Yes	25,69,628	Seed	1,03,894
A-One Seed Wholesale	Online B2B market-place of seeds	2019	Hisar	No	na	Unfunded	na
Terra Agro biotech	Manufacturer and supplier of biological farm inputs	2016	Jaipur	No	na	Unfunded	na
AgriApp	Online marketplace place for agriculture farm inputs	2016	Bangalore	Yes	na	Funded	na
Smart Farms	Online B2B distri-butor of agricultural input products	2019	Gurgaon	Yes	na	Seed	na
FarmGuru	Online platform for group buying of farm inputs	2015	Pune	No	na	Unfunded	na
Behtar Zindagi	Online marketplace for agricultural supplies	2016	Delhi	No	na	Unfunded	na
Unnati	Online platform that helps Indian workers find jobs across emplo-yers all over the country	2016	Noida	Yes	4,52,321	Seed	1,01,28,605

Note: na means not available.

Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

Table 9: Startups Offering Efficient Mechanisation, Irrigation and Financial Services

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Mechanisation							
FarMart	Web and mobile-based application for renting farm equipment	2015	Gurgaon	Yes	7,39,765	Seed	35,000
EM3 Agri Services	Provider of farming services to the farming communities	2013	Noida	Yes	1,70,22,002	Series B	11,73,648
RAVGO	Digital farm and construction equi-pment rentals market place	2015	Gurgaon	No		Unfunded	na
JFarm Services	Online market-place platform for equipment rental	2017	Chennai	No		Unfunded	na
Trringo	Mobile based app offering farming equip-ment on rent	2016	Mumbai	No		Unfunded	2,40,000
Irrigation							
FlyBird Innovations	Manufactures irrigation controllers	2013	Bangalore	Yes	2,23,330	Seed	66,400
Intech Harness	Provider of an IoT-based auto-mated water pump controller	2018	Pune	Yes		Funded	na
Sense It Out (F6s)	IoT controller for greenhouse management deployed as a service	2015	Pune	Yes		Funded	na
KisanRaja	Technology Solutions for Agriculture	2006	Bangalore	No		Unfunded	na
Satyukt	Data and analytics solutions for earth observations	2018	Bangalore	No		Unfunded	na
Kritsnam Technologies	IOT-based solutions for water monitoring and management	2015	Kanpur	Yes	70,119	Seed	na

(Contd....)

Table 9: Startups Offering Efficient Mechanisation, Irrigation and Financial Services *(Concluded)*

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Financial Services							
Jai Kisan	Online supply chain platform for farmers	2017	Mumbai	Yes	60,14,060	Seed	97,900
SG Agtech Innovations	Online platform for providing digital & financial solutions to farmers	2018	Chennai	No		Unfunded	na
SafalFasal	Online market-place for agricul-tural products	2019	Mumbai	No		Unfunded	na
Jai Kisan	Online supply chain platform for farmers	2017	Mumbai	Yes	60,14,060	Seed	97,900
Niruthi technology	Location-specific crop monitoring and yield prediction solution provider	2005	Hyderabad	No		Unfunded	3,40,900
Gramcover	Insurance market place focused on rural areas	2015	Noida	Yes	11,81,090	Seed	3,17,500
E	Data services for crop health monitoring and assessment	2016	Bangalore	Yes		Funded	30,400
PayAgri	Online platform to bring cashless ecosystem in Agriculture	2017	Chennai	Yes	3,48,442	Seed	9,775
Farmguide	Digitising agri-supply chain and services	2014	Gurgaon	Yes	15,70,818	Seed	1,57,200
AgRisk Tech	Core banking, payments, trans-action banking, and financial inclusion solu-tion provider	2009	Mumbai	No		Unfunded	na

Note: na means not available.

Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

controls irrigation at a low cost to the farmers, and this can be of use especially for high value crops (Ayyar and Desikan 2016). There are others like *Intech Harness* that provides solutions for water pump controller.

Several startups focus on mechanisation of farming activities through renting easy-to-use machines or aggregating companies that can rent machines. *FarMart, EM3 Agri Services, MITRA* and others have been providing these services at a low cost, and some of them are finding good traction among farmers (Singh 2017). *Sickle innovations, Distinct Horizon, TractorJunction, Khetibadi* and *J Farm service* are some of the other startups in mechanisation services. *KamlKisan* develops farm equipment for small farm owners to reduce labour dependence, and has rental services in Karnataka, Jharkhand and Andhra Pradesh (Ravi 2017).

As we move from traditional marketing services to the modern marketing channels, lack of support structures to provide handholding through credit is a handicap for the farmers. Some of the startups resolve this issue by making credit available in a transparent online procedure at a low rate of interest, along with other services. *GramCover* acts as an insurtech platform. Some of the startups like *Udaan, Bijak* and *Clover* with market linkage also provide loans.

4.4 Quality Maintenance, Monitoring, Traceability and Output Predictions

Several innovative products have been developed and popularised by startups in the area for quality assaying, quality maintenance through advisories, traceability, and yield predictions through mobile imagery, digitisation and advanced software (Table 10). One of the most popular startups in this category is *CropIn* that has clients in 30 countries, and was chosen by the World Bank for its Sustainable Livelihoods and Adaptation to Climate Change (SLACC) Project. As a farm-to-fork traceability business model, it collects information from various sources like weather, satellite and ground data and delivers targeted solutions to the agribusinesses on a B2B model, and at the same time, it has a unique farmer application for the companies to interact directly with the farmers (Anand and Raj 2019). The Government of India has also roped in *CropIn* to streamline crop cutting experiments and their accuracy.

The SaaS startups such as *Intello Labs, Agricxlab, QZense* and *RAAV Techlabs* focus on quality assessment of agri-commodities. *Intello Labs* developed an app to test,

Table 10: Startups for Quality Monitoring, Maintenance and Predictions of Crop Health and Output

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
CropIn	Provider of saas-based farming solutions to agribusinesses	2010	Bangalore	Yes	1,56,23,458	Series B	16,22,700
Intello Labs	Image recognition based solutions for multiple industries	2016	Bangalore	Yes	87,50,809	Series A	1,57,400
FarmERP	Software suite for control over farm operations and traceability	2005	Pune	Yes	14,38,880	Series A	3,11,600
Jivabhumi	Connecting consu-mers to farmer groups/cooperatives. Uses Blockchain technology for traceability	2015	Bangalore	Yes	na	Funded	3,16,400
Agricx	Provider of AI-based stack solu-tions for grading	2016	Thane	Yes	7,74,776	Seed	40,700
qZense Labs	Provider of an IoT device for food quality check for grading	2019	Bangalore	Yes	2,53,386	Seed	na
AgNext	Platform for monitoring and improving agricul-tural food quality for grading	2016	Mohali	Yes	43,36,741	Seed	97,000
RAAV Techlabs	Provider of AI-powered food quality analysers	2018	Delhi	Yes	na	Funded	9,200
OneWater	Soil and ground-water sensing and analytics product	2015	Ahmedabad	No	na	Unfunded	na

(Contd....)

Table 10: Startups for Quality Monitoring, Maintenance and Predictions of Crop Health and Output *(Contd....)*

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
AmviCube	Developer of paddy quality tester for rice mills	2014	Raichur	Yes	na	Funded	na
Amnex	Provider of precision agriculture solutions	2008	Ahmedabad	Yes	na	Funded	1,87,83,400
AS Agri Systems	Develops integrated hardware and soft-ware platform for precision agriculture	2017	Bangalore	No	na	Unfunded	na
BKC Aggregator	Precision agriculture solutions provider	2018	Delhi	No	na	Unfunded	na
NEERx Techno-vation	Provides smart agriculture solutions	2019	Gandhinagar	Yes	na	Funded	na
RML Agtech	Online portal for agriculture information sharing	2007	Mumbai	Yes	40,00,000	Series A	7,79,068
FarmBee	Online platform providing data-driven agricul-tural solutions	2006	Pune	Yes	90,99,055	Seed	7,60,200
MyCrop Techno-logies	Provider of infor-mation, expertise, and resources for agriculture sector	2016	Ahmedabad	Yes	na	Funded	na
Agrojay	Online information dissemination platform for agriculture farmers	2019	Nashik	No	na	Unfunded	na
Namma Uzhavan	Online agriculture information disse-mination platform for farmers	2018	Coimbatore	No	na	Unfunded	na
Nebulaa's Matt	Crop quality assessment system	2016	Jaipur	Yes	2,94,730	Seed	1,41,400

(Contd....)

Table 10: Startups for Quality Monitoring, Maintenance and Predictions of Crop Health and Output *(Concluded)*

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Tartan Sense	Analyzing health of plants using drones	2015	Bangalore	Yes	21,39,340	Seed	1,800
Yuktix	Technology sensor products for remote monitoring and control of devices	2013	Bangalore	Yes	1,33,229	Seed	76,500
Fasal	AI-powered IoT platform for precision agriculture	2018	Bangalore	Yes	17,20,000	Seed	na
Bloom	Online mobile-based platform for agricul-ture risk prediction and mitigation	2009	Delhi	No	na	Unfunded	na
Skymet Weather	Crop insurance and weather forecast-ing data services	2003	Noida	Yes	1,17,68,115	Series C	5,82,7100

Note: na means not available.

Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

grade and analyse the visual quality parameters of agri-commodities in order to enable better prices for the farming community, and had been working with the Government of Rajasthan to grade grains in *mandis* (Prasad 2018). *Agricxlab* harnessed deep learning technology to grade agri-commodity and certify them in 30 seconds, and acts as a bridge between cold storages and procurement companies (Patil 2018). The *QZense,* founded by women, employs a unique combination of near-infrared spectral sensors and olfactory sensors for analysis of internal spoilage, ripeness, sweetness and shelf life that can be used at any stage of the supply chain, though initially deployed by retailers to gauge and maintain quality for driving down inventory losses and spur up margins (Balakrishnan 2020). Soil and groundwater sensing and analytics products have been introduced by *OneWater*, while an innovative paddy quality tester for rice mills came out from *AmviCube*. Another useful innovation is by *Krishitantra* from Udupi, Karnataka, for rapid soil testing in 35 minutes, and this can be shared in cloud and short message service (SMS) with advisory. *Cheruvu* also enables soil testing facilities and advisory in comparison to the neighbour's field. *TartanSense* has developed technologies to assess health of plants.

Precision agriculture, using advanced analytics and prediction platforms, are supposed to be the game changing technologies. In the past, they would be the exclusive preserve of top six companies, and were likely to be bypassed for the smallholder farmers of the developing world (Lianos *et al.* 2016; Nuthalapati 2017). However, startups entered this segment of the value chain and made it possible through their innovations at a cost-effective manner for the smallholder farmers in developing countries like India (Nuthalapati *et al.* 2020; Birner *et al.* 2021).

Precision agriculture solutions are provided by software platforms of *Amnex, AS Agri Systems, BKC Aggregator* and *NeerXTechnovation*. Agricultural information sharing has few startups, and they include *RML Agtech, FArmBee, MyCrop Technologies, Agrojay* and *NammaUzhavan*. Crop yield predictions are facilitated by *Fasal, Yuktix, Bloom* and *Skymet*. Many of these startups leverage satellite images to geotag farms, assess crop health and estimate output. *Fasal* captures real-time data on growing conditions from on-farm sensors and delivers farm-specific, crop-specific actionable advisories to farmers through mobile in vernacular languages. Likely to be an unicorn soon is *SourceTrace* that operates in 26 countries with a digital platform that helps capture information regarding agriculture, financial services and retail through existing mobile and wireless networks in developing economies and also a two-way interactive digital platform (NASSCOM 2019).

4.5 Digital Solutions for Postharvest Management and Farming as a Service

Over the past decades, the food value chain has become elongated with nearly two-thirds of food being consumed in urban areas in India (Reardon *et al.* 2020), and side by side, the requirements for processing, logistics, wholesaling and associated services have been increasing. Startups have become crucial in the segment of logistics with several of them acting as third-party logistic partners for other startups as well as for established food companies like Britannia. Apart from that, a few startups have made innovative products for cold storage, saving the produce from postharvest damage before being transported. Table 11 presents the startups in the midstream of the value chain.

The solar-powered small size cold storage unit of *Ecozen Solutions* and low-cost storage-cum-transportation solution called *Sabjikothi,* developed by *Saptakrishi*, for extending shelf life of vegetables by 7 to 30 days have tremendous potential to

Table 11: Startups Helping in Postharvest Management and Farming as a Service (FaaS)

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Postharvest Management							
Ecozen Solutions	Manufactures and supplies solar-powered irrigation pump controllers	2009	Pune	Yes	1,05,90,520	Series A	97,99,600
SaptaKrishi (Sabjikothi)	Provider of a micro-climate storage solution for farmers	2018	Kanpur	Yes	Na	Funded	na
New Leaf Dynamic Technologies	Off-grid refrigeration	2012	Delhi	Yes	Na	Funded	na
AgriGator	Provider of agri-cultural logistics platform conne-cting grain ship-pers and carriers	2019	Bhopal	Yes	na	Funded	na
Star Agriware Housing and Collateral Management	Agricultural ware-housing and post-harvest supply chain solutions	2006	Mumbai	Yes	7,20,00,000	Series C	10,93,00,000
Arya Collateral Warehousing Services	Warehousing and collateral management services for agri commodities	1982	Noida	Yes	93,33,310	Series A	1,19,55,900
Farming as a Service (FaaS)							
Farmizen	Develops and operates digital application for community supp-orted farming	2017	Bangalore	Yes	2,96,585	Seed	47,300
Triton Foodworks	Integrated business for soil-less culti-vation of fruits & vegetables and supply of produce	2014	Delhi	Yes	na	Seed	na

(Contd....)

Table 11: Startups Helping in Postharvest Management and Farming as a Service (FaaS) *(Concluded)*

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Agro20	Manufacturer and supplier of indoor hydroponics system	2017	Delhi	Yes	na	Seed	na
Kheyti	Greenhouse and end-to-end farm enabling services	2015	Hyderabad	Yes	na	Seed	1,05,300
Khetify	DIY rooftop farming and gardening kits	2016	Delhi	No	na	Unfunded	na
Farmizen	Develops and operates digital application for community supported farming	2017	Bangalore	Yes	2,96,585	Seed	47,300
Hosa Chiguru	Agri Infrastructure and developer	2006	Bangalore	No		Unfunded	na
Vegrow	Provider of tech-enabled farming services to farmers	2020	Hyderabad	Yes	25,00,000	Seed	na

Note: na means not available.
Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

cover the shortcomings for smallholder farmers. Many startups have been playing a considerable role in the storage of agri-produce. In a country where it is estimated that there is storage gap of around 35%, these startups can play a crucial role in reducing food damage. *A2Z Godaam* of *Arya Collateral* is the foremost among them. It is a digital platform for search, discovery and fulfilment of warehousing for farmers, Farmer Producer Organisations (FPOs), corporate and other stakeholders. It goes beyond storage by integrating with other services like financial and market linkages (Kashyap 2020a). Similar postharvest services are provided by another startup called *Origo* with 3.5 million tons of storage capacity in 500 warehouses across 15 states.

Farming as a service (FaaS) has been growing, with several urban people wishing to engage in cultivation of fruits and vegetables often in organic modes and several

smallholders wishing to have support in several related services to make their farming profitable. Several startups have been testing this area and seem to be getting good response. *Farmizen* and *Hoshachiguru* provide mini-farms that could be rented by prospective cultivators, who could also opt to take services from them for technically sound and cost effective cultivation (Hariharan 2018). These startups collect rent and also fee for their services. Startups like *Vegrow* and *EMB* partner with smallholders for profitable cultivation that might also lead to aggregation of fragmented farms for achieving economies of scale (Sangwan 2020). Rooftop gardening by *Khetify*, indoor hydroponics by *Agro20* and end-to-end farm enabling services for greenhouses by *Kheyti* represent the other emerging areas for startup ventures.

4.6 Digital Solutions for Animal Husbandry

The animal husbandry sector, with a relative share of one-third of GVA of the agriculture sector, does attract startup ventures (Table 12). The leaders in this segment are *Licious* and *Fresh-to-Home* that engage in farm-to-fork model and supply to the consumers directly. They received funding to the tune of $95 million (Series E funding) and $47 million (Series B funding), respectively. Apart from them, the large ticket investments are in dairy sector startups like *CountryDelight* ($20 million) and *Stellaps* ($19 million) and fishery startups *Aquaconnect* ($11 million). *Licious* has attained the status of unicorn very recently. Both *Licious* and *Fresh-to-Home* procure directly from farmers. While *Caprabook* is for goat farm management, *PoultryMon* is for hatchery management solutions. Dairy sector has few startups in *Stellaps, Country Delight, Prompt AMCS, Meri Dairy* and *Farmery*. *Eruvaka* and *Krimanshi* deal with sustainable feed solutions, while *Eruvaka* has developed AI based on-farm diagnostic equipment.

Listed as one of the 100 Technology Pioneers of 2020 by the World Economic Forum 2020, *Stellaps* digitises farm-to-consumer chains and enables dairy ecosystem partnerships, including facilitating digital payments, hassle-free credit and insurance to marginal dairy farmers, apart from better milk quality and traceability (Kashyap 2020b). It works with its innovative software solutions for dairies to enable contactless procurement and for adhering to sanitary guidelines. It has been managing 10 million litres of milk per day and covers two million farmers in 30,000 villages.

Table 12: Startups Digitising Animal Husbandry

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue($)
Licious (Soonicorn)	Online platform for delivery of meat and seafood	2015	Bangalore	Yes	9,45,00,000	Series E	91,33,000
Fresh to home (Soonicorn)	Manages supply chain of meat and seafood from farm/ fishermen to home	2012	Bangalore	Yes	4,72,00,000	Series B	9,29,567
ZappFresh	Online fresh meat delivery service	2015	Delhi	Yes	90,59,375	Series A	40,87,400
Caprabook	Software for goat farm management	2015	Satara	No	na	Unfunded	na
Eggoz	Full-stack egg producer using advanced technology, IoT based poultry farming techniques	2017	Bihar Sharif	Yes	7,51,549	Seed	3,62,900
Poultry Mon	Hatchery manage-ment solutions for poultry farms	2018	Hyderabad	Yes	na	Funded	na
Aqua-connect	Developer of products for data-driven farming in shrimp ecosystem	2017	Chennai	Yes	11,01,687	Seed	2,04,300
INCEVE	Provider of SONARs for catching fish	2016	Bangalore	Yes	na	Funded	na
Stellapps	Provider of farm optimisation and monitoring support for milk	2011	Bangalore	Yes	1,90,09,146	Series B	68,95,700
Country Delight	Online retailer of dairy products	2015	Gurgaon	Yes	1,96,36,337	Series B	79,64,500
Prompt AMCS	Automatic milk collection system for dairy industry	2011	Ahmedabad	No	na	Unfunded	na

(Contd....)

Table 12: Startups Digitising Animal Husbandry *(Concluded)*

Startup Name	Over view	Founded in	City	Fund-ing	Total Fund-ing ($)	Company Stage	Annual Revenue ($)
Meri Dairy	Provider of dairy management software for milk collection centers	2008	Jaipur	No	na	Unfunded	na
Farmery	Production, marke-ting and delivery of raw cow milk	2015	Delhi	No	na	Unfunded	7,65,800
Eruvaka	Provider of IoT based on-farm diag-nostic equipment. Animal nutrition and aqua feed	2012	Vijayawada	Yes	67,80,764	Series B	13,60,200
Krimanshi	Developer & supplier of sustainable feed for livestock animals	2018	Bangalore	Yes	na	Seed	na
Tropical Animal Gen-etics (TAG)	Developer of in-vitro animal breeding platform	2014	Gurgaon	Yes	na	Seed	2,62,000
Aqua connect	Developer of products for data-driven farming in shrimp ecosystem	2017	Chennai	Yes	11,01,687	Seed	2,04,300

Note: na means not available.
Source: Compiled by the author based on information extracted from Traxcn database as of February 2020.

4.7 Open Knowledge Flows

The entry of startups has accelerated flows between food chain actors in regard to making and diffusing innovations to the end users, as the foregoing analysis shows. The knowledge flows are both outbound from the startups to the companies and other actors, and sometimes in the opposite direction as well as bi-directional, as brought out in the cases above. Some of the companies have founded their own startups for various knowledge generation and use. For example, *Godrej Agrovet* instituted a venture capital fund in the name of *Omnivore* as an anchor investor for investing in startups. It is a leading agribusiness company in poultry feed, dairy products, vegetable

oil and processed foods (Joint venture with Tyson Foods of USA for processed foods). This company has so far completed two funds with $97 million and is about to start the third one (Putrevu 2020). Among its investment are startups working in various segments of food value chain and include *DeHaat* (full-stack market place), *Stellaps* (dairy platform), *GramCover* (rural fintech and farm finance) and *Bijak* (B2B agricultural commodity platform). The company has also acquired two startups for digital supply chain solutions for farm business (Chaudhary 2012).

The ITC, one of the largest processing companies, has upgraded its *eChoupal* to a more collaborative mobile platform in the name of *eChoupal* 4.0, and other companies like Bayer is harnessing the same (Anand 2020). The ITC has invested in alternative investment funds (AIF) that fund startups, and is also investing directly in startups to aid in improving the business (Naik 2019). Reliance, that started the JioMart ecommerce company recently, has backed or acquired startups like *Grab A Grub* (last-mile logistics company), *C-Square Info Solutions* (software for managing logistics of distribution and retail operations), *Fynd* (e-commerce company), Reverie Language Technologies (language localisation technology platform), *Haptik* (AI-backed B2B chatbot maker) and *Netradyne* (driver and commercial vehicle safety). Reliance continues to scout for many more startups as partners in innovations for the food chain (Soni 2020). Walmart-owned *Flipkart* launched a venture fund with $100 million to support early-stage startups and also a startup accelerator called *Flipkart Leap* for deep engagement with B2C and B2B startups with supply chain solutions (Poojary 2020). It has also been leveraging supply solutions of *Ninjacart* for its grocery delivery initiative *Flipkart Quick* to procure directly from farmers, and is committed to invest $50 million to strengthen *Ninjacart* (Velayanikal 2020). Similarly, Amazon acquired the ecommerce grocery startups *ZopNow* in 2018. The *StarAgri* floated its own initiative *Agrobazaar* for better market linkages.

The interconnections between startups themselves and their business partnerships with input companies, processors, aggregators, traders, hotels and restaurants, supermarkets, ecommerce companies, research organisations, various governments (centre and state), international institutions like the World Bank, various crop associations like tea growers' association, constitute a complex web. These fast-expanding knowledge flows have brought several innovations that could not be imagined just a few years back. The vibrancy of the food value chains in India during the pandemic

can be attributed to some extent to the activities of the startups (Medhi 2020; Mitter 2020; Narain 2020). The ecosystem has been bringing to the ready access of farming community several innovative products, such as online marketing of farmers produce (leading to shortening of the food value chain), precision agriculture solutions for crop and animal husbandry, traceability solutions, storage solutions, online financing, innovative field level cold storages, irrigation control, customised mechanisation solutions on rent, rapid quality assessment and grading, and third-party logistics solutions. Most of the innovations explained above are innovations flowing from the startups to other actors in the value chain, which itself has been accelerated and invigorated, with missing links getting covered up.

5. Women-led Startups

Women are also taking an active role in founding startups, though a large share of the startups is founded by men. We trace some of them here, though it is by no means an exhaustive list.

Intello Labs, co-founded in 2017 by Himani Shah, is a Delhi-based agritech startup that uses image learning and machine learning to gauge the quality of produce and to grade them. It works on a B2B model with food growers, processors, retailers, food service companies, and other stakeholders in the food supply and production chain. It is expanding beyond the Indian market to the US, China, Thailand and other countries. In 2019, women entrepreneurs Rubal Chib and Srishti Batra founded *QZense* that employs a unique combination of near-infrared spectral sensors and olfactory sensors for analysis of internal spoilage, ripeness, sweetness and shelf life, and they can be used at any stage of the supply chain, though initially deployed by retailers to gauge and maintain quality for driving down inventory losses and spur up margins. Manasa Gonchigar from Bengaluru is one of the 10 young winning entrepreneur teams of the agri-enterprise challenge SOLVED (Social Objectives-Led Volunteer Enterprise Development). She won the challenge for her startup company *PureScan AI,* a technology startup that helps players in the food supply chain, and also assists them in making informed decisions on food safety. Her company is preparing an optical device- Afla Scan- which does rapid aflatoxin assessment of maize, chilies and peanuts. Miku Jha founded *AgShift* to address global food waste through more accurate and standardised produce inspection. The

system works by employing deep learning models to inspect produce, using United States Department of Agriculture (USDA) quality requirements to make a judgment on the product's quality leading to a more efficient and consistent process. The insights from the automated process have led to a reduction of losses and waste.

BharatAgri, co-founded by Sai Gole in 2017, helps farmers to maximise production and income using their algorithm to tell farmers what, when and how to grow. Nikita Tiwari is the Co-founder of Ahmedabad-based *NEERx Technovation*, an agritech startup that develops sensors to help farmers to get real-time data about farming conditions, using a sensor called 'SHOOL: Smart Sensor for Hydrology and Land Application'. This can help prevent pest infestation, improve water and fertiliser retention, drought prevention and soil degradation. It also helps in water harvesting, reduces agri-input cost and improves productivity. Its products are currently used by the Indian Space Research Organisation (ISRO), Indian Agricultural Research Institute (IARI) and National Crop Forecasting Centre. It provides solutions to farmers in Gujarat, Haryana, Lucknow, Delhi, Jaisalmer and Hyderabad.

Saumya co-founded *Kheyti,* which has developed and introduced Greenhouse-in-a-Box (GIB) – a low-cost, modular greenhouse integrated with end-to-end support to battle income variability. *Kheyti* enables a community of farmers who are independent yet interdependent, by giving each on their own mini-greenhouse on their land. *Kheyti* trains, advises and helps farmers with their marketing. To financially empower them, the organisation has partnered with firms such as *Big Basket*, Northwestern Institute for Sustainability and Energy, T-Hub, AgriPlast, Agribusiness and Innovation Platform (AIP) of ICRISAT and Acumen Funderscircle.

Founded by Kavya Chandra, *Green Venture* is a Bengaluru-based eco-enterprise that curates experiences to connect people with natural, chemical-free food at farms through workshops, camps and trips for both children and adults. Kavya believes in '..supporting small groups, collectives or a system, which gives us a window to learn how organic farming is practised, ... (and allowing) buyers to make more informed choices about their fruits and veggies'. Gitanjali Raman co-founded *Farmizen* in 2017. It is a startup that allows anyone to rent a community farmland outside the city to grow produce of one's choice safely and organically. It was started with two goals in mind. One was to give city-dwellers fresh and chemical-free produce through the farming experience. The other was to help improve the

livelihoods of farmers. Sakina Rajkotwala is the co-founder of *Herbivore Farm*. It is Mumbai's first hyperlocal and hydroponic farm that grows nutritious, premium quality, pesticide-free greens like Swiss chard, kale, rocket and lettuce. The environmental benefits of the way *Herbivore Farm* operates include using up to 80% less water for growth through a recirculating irrigation system and growing the plants in a vertical format, which allows it to grow five times more than it would have been able to otherwise.

Veena Adityan is the co-founder and CEO of the United Kingdom (UK)-based startup *Smartbell,* an animal health monitoring solutions platform. The startup has developed sensors that can be mounted on collars or ears of cattle to monitor their movement and health. Founded in 2016, its wearable technology provides farmers with information about cattle's activity, temperature, feeding habits and their surroundings such as air quality and humidity. Its intelligence platform analyses the data to pick up early signs of disease, days before any visible symptoms can be observed, to help farmers to get early medical assistance. Aashna Singh co-founded *Mooo Farms* to address the challenges of rural dairy farmers, providing an app that allows them to manage their farm and access an e-commerce marketplace to connect with buyers. Shilpi Sinha, founder of *Milk India Company*, is on a mission to deliver pure and unadulterated cow milk to help improve the health of children. Based in Bengaluru, *Milk India Company* aims to deliver pure cow milk that is raw and unpasteurised, and has zero processing involved. It is certified by the National Dairy Research Institute of India (NDRI) and delivered in glass bottles. She uses a machine to calculate somatic cells in the milk, before it is sent to the customers. The lesser the somatic cells, the healthier is the milk. She delivers milk to parents, whose children are aged between one and eight years old.

6. Startups Mitigating COVID-19 Disruptions

Startups have been playing a crucial role to mitigate the COVID-19 driven disruptions in food supply chains in various ways (Nuthalapati *et al.* 2020; Reardon *et al.* 2020, 2021, 2021a). Widespread supply disruptions, due to the most stringent lock-down in the country that came in the way of primary production as well as processing and distribution of food, were experienced in the initial stages of the lockdown. Studies have noted that the market informality and pre-pandemic conditions lead to heteroge-

neous impacts across households, regions and producer groups (Swinnen and Vos 2021). Acute difficulties were faced by the regions located far off from the places of production (Mahajan and Tomar 2020), farmers growing crops not having public support like vegetables (Ceballos *et al.* 2021) and highly vulnerable women farmers and smallholders (Harris *et al.* 2021). However, several innovative technological and marketing strategies by startups helped to overcome these problems and strengthened the resilience of food supply chains, and at the same time, accelerated their growth (Singh 2020).

This crisis has created high transaction costs and uncertainty in food supply chains, putting food security at risk, as 92% of food consumed is purchased predominantly from the private sector. Also, the social distancing norms and movement restrictions meant that the midstream and downstream of the value chains are affected, and need pivoting by firms and support from policymakers (Reardon *et al.* 2020). Food firms in the downstream have adapted by switching to e-commerce and e-procurement to connect with other actors in the midstream and upstream. Several startups connected all these actors. Startups in the logistic sector co-pivoted with food firms to help them deliver and procure (Reardon *et al.* 2021a). E-commerce firms in developing regions have fast tracked their adaptation to these challenges by bundling services as well as partnering with retail small and medium enterprises (SMEs) and delivery intermediaries (Reardon *et al.* 2021).

Several Indian tech startups, whose core business has nothing to do with food, have started dabbling with this essential item to stay afloat amid the COVID-19 lockdown, which has either halted or slowed down most businesses (Bhattacharya 2020; Ganju 2020). From online travel agent *MakeMyTrip* to property portal *NoBroker*, startups are either coming up with new service lines or tied up with food-related businesses. While survival in these times is the main motive behind this new shift, this also helped in making food value chains resilient, while the pandemic has been wreaking havoc with normal life in several unforeseen ways. Examples of this development include car rental company *Zoomcar* partnering with *BigBasket*, *Grofers* and *Milk Basket* for last mile delivery. Cab aggregator *Uber India* has launched a last mile delivery service and has partnered with online grocery firm *BigBasket*. Social commerce company *Meesho* has launched essentials delivery called *MeeshoMandi*. Social commerce startup *Coutloot* has launched delivery of essential items such as food, groceries, medicines and health/personal care by working with *Ninjacart, Indusfresh, Villageagro* and

Farm Fresh. Fintech player, *PayNearby,* managed to aggregate over 400,000 kirana shops across the country for its newly-introduced grocery segment *BuyNearby*. Real estate and property management startup *NoBroker* has introduced grocery delivery in Bengaluru on its community management app by entering into tie-up with ITC and *BigBasket*. Swiggy and Zomato, the nation's largest food delivery startups, began delivering grocery items in the country and alcohol in select parts. Health and fitness startup *Cure.fit* added grocery to its platform for patrons in Bengaluru, Hyderabad and Delhi. *ClubFactory*, the seller of beauty items, switched to grocery delivery service. Online travel agent startup *MakeMytrip* launched a new stores feature that facilitates grocery delivery by showing customers store inventories, opening hours and contact information among others. Mobile wallet company *PhonePe* launched a new store feature that, among others, facilitates grocery delivery by showing customers store inventories and contact information.

Another e-commerce player *BigBasket* adopted multiple approaches towards last-mile fulfilment, like delivering in bulk and combining neighbourhoods. It moved to a community selling model, whereby it asks apartment complexes to put orders together for their residents. This helps the company to meet consumers' demand, despite having a lower-than-usual workforce.

Several startups collaborated with processed food fast-moving consumer goods (FMCG) companies to sell. While Marico launched *Saffola Store* on *Swiggy* and *Zomato*, ITC has joined hands with them along with community centric apps such as Apna Complex, My gate, No broker and Azgo. ITC Hotels has partnered with *Swiggy* to offer fresh and seasonal selections as part of a delivery-only menu. The Godrej Consumer Product, has tied up with *Zomato* and *Dunzo* along with B2B supply chain start-up *Shop Kirana* and car rental company Zoomcar. The Nestle continues to deepen its partnership with e-commerce retailers, as online sales jumped manifold. In May 2020, PepsiCo India partnered with *Dunzo* for its snack food brands that include Lay's, Kurkure, Doritos and Quaker. They have no wherewithal to do the logistics, and so they use the services of logistics startups like GATI, Ecom express, Delhivery, Bluedart and FedEx, and hyperlocal logistics companies. Startups have been accelerating digitalisation and last-mile delivery of small businesses and kiranas. B2B ecommerce *Udaan* and Metro Cash and Carry have been popular in enabling kiranas to operate with COVID protocols. *Udaan, ShopX, Jumbotail, NinjaKart* and others have been pivoting kiranas

in a big way towards last-mile deliveries, supply chain management, effective inventory management, credit and more. Several B2C e-commerce companies have been shaping up their models to include kirana stores in their business. In all this, the entire kirana inventory is getting digitised (Bhalla 2020).

Licious, an online meat supplier, switched to an alternative delivery model as it could not maintain its staff during the pandemic by tying-up with third-party logistics providers like *Yulu* and *Shadowfax*. E-commerce firms *Snapdeal* and *DealShare* began grocery delivery service. *ID Fresh* adopted the online sales model within four days after the lockdown to make its products available to consumers. The company also started taking consolidated orders from residential welfare societies, instead of making individual deliveries. Similarly, Udaan started to accept bulk orders from housing societies, and is exploring more opportunities in the B2C space.

To ensure timely supply of seeds ahead of the kharif planting season in the pandemic time, agri-input companies had to redraw their distribution networks and consider alternate business models such as startup collaborations to facilitate home-delivery of seeds and crop protection products to farmers (Narain 2020). In the absence of the local *mandi*, digital tools created new market linkages by connecting farmers directly to bulk buyers across the country. Several small players (startups) set up collection centers at the farm level for direct procurement of produce (Nuthalapati *et al.* 2017). *AgriBazaar,* a startup functioning in Rajasthan, Madya Pradesh, Punjab, Haryana, Maharashtra, Gujarat, West Bengal and few others, connects around 10,000 traders and processors and over 100 FPOs with its network of over 200,000 farmers. Aggregation of farm produce is a key missing link in the supply chain. Start-ups who are catching up in this area include *Ninjacart*, *Jumbotail*, *Bigbasket*, *ShopKirana*, *SuperZop*, *WayCool*, *MeraKisan*, *Kamatan*, *DeHaat*, *KrishiHub*, *Agrowave*, *Loop*, *Crofarm*, *FreshoKartz*, *Agribolo*, *Himkara* and *Kisan Network*.

The Punjab government tied-up with cab-hailing platform *Ola* for deploying its location tracking and geo-fencing technology- *Ola CONNECTS*- at over 3,800 *mandis* in Punjab to track the movement of farmers and ensure social distancing in the state. Currently, the technology has covered around 1.7 million farmers in Punjab. The government on its own started *KisanRath* and facilitated *KisanMitr* through special purpose vehicle to mitigate the crisis. *KisanRath,* mobile app of Government of India, connects farmers and traders with vehicles for movement of pro-

duce to ensure seamless supply linkages between farmers, FPOs, mandis and intra-state and inter-state buyers. *KisanMitr*is is yet another digital platform that was created to connect various actors involved in the agriculture technology innovation, business and entrepreneurship and extension activities, and integrate them into an agtech ecosystem.

7. Determinants of Survival, Investment and Revenue of Startups

The capacity of a startup to survive beyond the valley of death, market the product and become profitable critically hinges on its survival for sufficiently longer period of time. Research elsewhere has focused much on this aspect and analysed the causal factors (Hyytinen *et al.* 2015). This study harnessed the Traxcn database of 3,964 startups to find the crucial factors in the Indian setting (Table 13).

Table 13: Determinants of Survival of Startups

Variables	Coefficient	SE	t value	P> | t |
Number of founders	0.0283	0.0322	0.88	0.380
Number of female founders	0.2722***	0.0866	3.14	0.002
Highest educational degree of founders	-0.2787***	0.0924	-3.01	0.003
Editors rating	-0.9196**	0.0498	-1.85	0.065
Total funding	0.3542***	0.0345	10.28	0.000
Gross revenue	0.3392***	0.0228	14.91	0.000
Negative net returns	0.1873***	0.0292	6.41	0.000
Employment (Numbers)	-0.6344***	0.0360	-17.61	0.000
Fintech sector dummy	-1.2224***	0.2122	-5.76	0.000
Food & agri sector dummy	0.1960	0.2495	0.79	0.432
Healthtech sector dummy	-0.5671***	0.1752	-3.24	0.001
Logistic sector dummy	0.1845	0.1727	1.07	0.285
Delhi NCR dummy	-0.1209	0.1080	-1.12	0.263
Mumbai dummy	0.4585***	0.1106	4.15	0.000
Hyderabad dummy	1.2131***	0.1729	7.01	0.000
Venture funding dummy (Yes=1)	0.6675***	0.1151	5.80	0.000
Constant	-4.2223***	0.3839	-11.00	0.000
Number of observations			3964	
F value			86.70	
Prob> F			0.000	
Adj R-Squared			0.2571	
Root MSE			2.62	

Source: Author's estimates based on data extracted from Tracxn data base.

The startups located in Hyderabad and Mumbai, and with female founders, higher gross revenue and venture capital funding tend to strive for a long period. The food and agriculture startups are not short-lived. Positive and significant coefficient values reveals that venture capital funding propels startups to survive longer, probably with their guidance and mentoring. Similar result was reported in several studies (Gompers *et al.* 1998). Women successfully start innovative micro firms, and their stewardship enables the startups to survive for longer periods. The coefficient for negative net returns is positive and significant, and this suggests that the startups aim to survive despite their initial losses. It reflects the risk-taking attitude of the startups with an expectation of posting profits in course of time, as they expect to gain more markets for their innovative products and services.

Startups that have a large number of employees, founders with advanced educational qualifications and activities in fintech and healthtech may not be able to sustain for long. Similar negative association between team size and success of the startups, due to difficulties in communication and decision making is reported in studies in the US and other western countries (Bruton and Rubanik 2002). Specifically, the failing of Gibrat' law in the case of Indian startups, leading to a low survival period with large teams, has a precedent in Italy (Audretch *et al.* 1999). Higher innovation intensity can stifle firms' survival due to difficulties in accessing finance and elevated risk profile, as found in a study on Finnish startups (Hyytinen *et al.* 2015). There are also studies that show that college graduates founded startups perform better than the spinoffs by their faculties in the US (Astebro *et al.* 2012). Innovation intensity dragging down survival rates can also be attributed to the low survival of fintech startups. However, it needs to be probed further to understand the quick winding up of healthtech firms. The number of women founders spurring longer survival periods is also reported in the US (Gillard, 2016).

The unprecedented rise of startups, which are inherently risky due to innovations and reluctance of the formal financial institutions to fund them, raises the questions as to the pathways that can enable flow of more investment into their ventures and revenue augmenting capacity. Analyses of these issues using startups data throw up several policy relevant results (Table 14). The food and agriculture startups income is significantly positive, as also those in the logistic sector. However, they do not attract significantly higher investment, but innovative firms in fintech and AI are gather-

Table 14: Determinants of Revenue and Investment of Startups in India

Variables	Revenue		Investment	
	Coefficient	SE	Coefficient	SE
Firm age in years	0.1740***	0.0106	0.0251	0.0192
Highest degree of founders dummy	0.1821***	0.0639	-0.3499***	0.0747
Number of founders	-	-	-0.1242	0.1250
Number of female founders	-0.1226**	0.0577	-	-
Percent of female founders	-	-	0.0053	0.0036
Number of male founders	0.0082	0.0223	0.1736	0.1327
Editors rating	0.0081	0.0344	-	-
Employment (Numbers)	0.6887***	0.0230	1.0081***	0.0233
Total funding (in crores)	0.3177***	0.0197	-	-
Bengaluru dummy	-0.1054	0.8501	-0.0313	0.0820
Mumbai	0.2811	0.902	-	-
NCR dummy	0.2564***	0.0891	-0.0599	0.0974
Hyderabad dummy	-0.0398	0.1291	-	-
AI sector dummy	-	-	0.4272***	0.1290
Fintech sector dummy	0.2223	0.1471	0.6289***	0.1181
Food & agri sector dummy	0.3880**	0.1722	-0.0226	0.1505
Health tech dummy	0.0217	0.1212	-	-
Logistic dummy	0.4831***	0.1190	-	-
Real estate sector dummy	-	-	-0.0134	0.2083
Venture funding dummy (Yes=1)	0.0768	0.0807	-0.2749***	0.0856
Constant	3.9485***	0.2646	10.7607	0.1465
Number of observations		3964		1933
F value		376.53		172.63
Prob> F		0.000		0.000
Adj R-Squared		0.6026		0.5359
Root MSE		1.8099		1.4774

Source: Author's estimates based on data extracted from Tracxn data base.

ing more traction. Highest educational degree spurs revenue, but is negatively related to investment. Employment is associated with both revenue and investment. Firms located in Delhi NCR earn a significantly higher revenue, while locations do not seem to matter in attracting investment. Venture capital funding does not influence revenue in the background of its negative association with investment. Female founders do not get significantly higher investment, and they earn significantly lower revenue vis-à-vis those founded by their male counterparts. Both startups' age and funding received lead to higher revenue, but these factors do not influence investment.

8. Summary and Conclusions

The concept of food value chain to understand the food system in its entirety has been gaining popularity among development economists during the last decade. The rapidly developing digital technologies have been permeating the supposedly low-tech sector like agriculture in the last few years. Interestingly, food systems in developing countries like India have been witnessing this phenomenon, mainly due to the innovative endeavours of the new generation startups. This paper tries to analyse this ongoing digitisation of the Indian food system by exploring the nature of innovations in the startups working in agriculture using an open innovation framework and by analysing the sector-wise and location-wise distribution of the startups, and the determinants of their survival, investment and revenue.

Evidence shows that over 50% of the startups are located in tier 1 and tier 2 cities, and therefore, the stylised fact that most of the startups are located in the three major cities of Delhi NCR, Bangalore and Mumbai (Korreck 2019; Singh 2020) does not represent ground realities. On an average, only one in ten startups manage to get funding, which makes it difficult for them to survive and launch their innovations successfully. The analysis of funding deals reveals that 90% of the total amount of funding accrued in Bangalore, Delhi NCR and Mumbai, despite having only 60% of the deals. Consequently, startups located in other cities would find it extremely difficult to get financial support. Most of the funding is in seed and Series A stage, and late-stage funding is negligible. A regression analysis indicates that food and agriculture startups are not short-lived vis-à-vis those in other sectors. And food and agriculture startups also earn revenue significantly higher than other sectors. However, their Achilles Heel is in attracting investment. Venture capital enhances the chances of survival of the startups, probably due to their continued mentoring. Interestingly, the startups founded by women do well in terms of survival, though do not get much funding.

There are several types of startups that have come up in the last decade that are filling the gap in the food value chains in infrastructure deficit regions of the country and introducing innovations. Our estimates show that the startups in food and agriculture sector mobilised funds to the tune of $8 billion. Most of these startups operate in tandem with various other related companies in the downstream like the supermarkets, retailers, hoteliers; in the midstream with the processors, wholesalers and logistic firms; and, in the upstream with the input companies and so on. The

entry of startups has accelerated flows amongst food chain actors in regard to making and diffusing innovations to the end users. The knowledge flows are both outbound from the startups to the companies and other actors, and sometimes, in the opposite direction as well as bi-directional.

The interconnections between startups themselves and their business partnerships with input companies, processors, aggregators, traders, hotels and restaurants, supermarkets, e-commerce companies, research organisations, various governments (centre and states), international institutions like the World Bank, various crop associations like tea growers' association, constitute a complex web. This expanding knowledge flows has brought several innovations, which could not be imagined just a few years ago. The ecosystem has been bringing to the ready access of farming community several innovative products, such as online marketing of farmers produce, precision agriculture solutions for crop and animal husbandry, traceability solutions, storage solutions, online financing, innovative field level cold storages, irrigation control, customised mechanisation solutions on rent, rapid quality assessment and grading and third-party logistics solutions.

Most of the factors leading to open innovation, termed as erosion factors by Chesbrough and Bogers (2014), such as startups getting venture capital, rising number of internet users, widespread use of social media, universities becoming innovation hubs and inter-firm mobility of employees, are present in India, and they combine to create this open innovation system. Venture capital has grown over the years, and India has become one of the favoured destinations (Dossani and Kearney 2002; Nuthalapati and Singh 2019). After a long period of stagnation and technology fatigue (Narayanamoorthy 2007), Indian agriculture is in transition and moving towards higher level of technologies with better and faster linkages among various food chain actors. As experience in other countries demonstrated, open innovation is required during the transition stage to higher level of technologies, and the innovations would be less radical without knowledge flows (Medeiros *et al.* 2016). The government needs to develop a policy framework to create the necessary enabling environment for the development of the startups ecosystem that include venture capital industry and associated policy changes. The early-stage support through seed fund, encouragement to angel investors and mass incubators, level playing field for non-technical startups and occasional conduct of the regional food system are important.

The nascent stage of development of this innovation system needs dispassionate research on these developments from the purview of equity and the possibility of scaling up these ventures. Also required is the research focus on the type of business models, collaboration and licensing agreements between companies, universities and governmental agencies. Available evidences point out that the startups' innovations are more accessible to large farmers (Singh 2016). The World Bank (2019) underlines that the digitisation poses several risks like exclusion, lack of data privacy, cybersecurity breaches and over concentration of service providers' market power. Food chain actors resisting these open flows would be worse off in terms of net welfare gains; and it would be more problematic, if the farming community are bypassed by these innovations.

Policymakers in Europe have internalised three core principles (open science, open innovation and open to the world) for their innovation and research. Preliminary studies in the Netherlands show that corporate-startup collaborations could improve innovation performance and enhance competitive advantage, and at the same time, mediating and moderating factors are important to be kept in mind (van der Boezem *et al.* 2015). This is warranted as startups and chain actors interact with each other keeping their own interests rather than the wider interests, and therefore, this innovation system has to be internalised and mainstreamed into the agricultural development planning, while being mindful of the twin objectives of growth and equity. As noted by World Bank (2019), the Maximising Finance for Development (MFD) framework could help to identify public actions that are needed to make the digitalisation process more inclusive. The initiative of NABARD by establishing exclusive fund through Nabventures (NABARD 2019) is a right step in this direction and is likely to go a long way ahead.

Notes

1. While entrepreneurial societies have been taking risks and replacing managerial economies everywhere in the world (Audretsch 2009), the knowledge spill theory of entrepreneurship by Acs *et al.* (1994) shows how the knowledge created in the public institutions and universities as well as those in the corporate sector gets converted into innovative products through entrepreneurship.

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