

Has Open Innovation Taken Root in India

Evidence from Startups working in Food Value Chains

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Abstract

Open innovation represents a paradigm shift in the technology development process from the advent of the New Millennium. Though evidenced mainly in technology-intensive sectors of developed countries, several ‘erosion factors’ and their interplay catalyse open innovation in relatively traditional sectors of developing countries. The rise of startups with supplementary venture capital industry is hypothesised to play this role in the Indian food system. This paper examines this hypothesis by leveraging a large database of startups. Several types of startups have come up in the last decade and are filling the gaps in the food value chains in infrastructure deficit regions and introducing innovations. 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, international institutions like the World Bank, various crop associations like the tea growers association, constitute a complex web. 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. These fast expanding knowledge flows have brought several innovations that could not be imagined just a few years back in developing countries. The emergence of open innovation in agriculture bodes well to food value chain flows and to harness the higher level of technologies. There is a need to internalise these innovations in the national food policy for addressing issues of inclusion. The paradigm shift also calls for rigorous research on the business models, and collaboration and licensing agreements between companies, universities, and governmental agencies

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1. Introduction

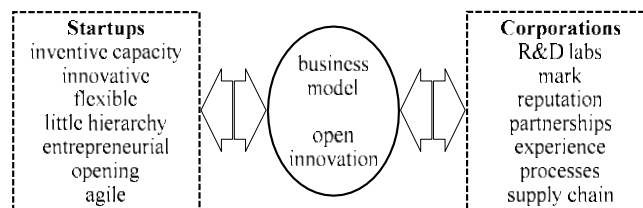
Open innovation has been permeating every field of economic activity all over the world in the last two decades. More consciously and as a planned development process, after the word ‘open innovation’ was coined and formalised as a new paradigm of creating and profiting from technology by Chesbrough (2003) in his celebrated book. Initially, he called it the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively (Chesbrough, 2006). As the learning curve moved up with intensive debates and extensive applications after the first decade, more details are added to say that open innovation is ‘a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business model’ (Chesbrough and Bogers, 2014). To start with, this kind of organisation of innovation is only possible in economic activities as the level of sophistication is high and the processes are complex. However, the evolving experience in disparate industries showed that this can have traction in relatively conventional industries too (Chesbrough and Crowther, 2006; Medeiros et al., 2016). The ramping up of technology with newer innovations has been spurring transitions in the food industry, especially as the midstream and downstream of food value chains reached two-thirds magnitude in most of the world (Reardon et al., 2019) including India (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 changing consumer demands (Bigliardi and Galati, 2013) all lead 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 diffusion of innovation across all the actors in the entire chain when the processing firms bring in new technologies (Zilberman, et al., 2019). However, the new paradigm goes beyond joint diffusion and involves disparate actors in both the development and diffusion of innovations.

The knowledge flows can be outside in or outbound depending on the needs of innovation and the business models of the respective actors. While initial evidence showed that primarily the large companies initiate and move the process forward, the subsequent experience proved that small and medium-sized companies including startups, non-profit foundations, collective community actions, and individual consumers can also catalyse significant transformations (Figure 1). Startups specifically need external knowledge sources given the scarcity of 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 the open innovation framework (De Bernardi and Azucar, 2020, pp 109-110).

Startups have been proliferating across the countries not only in the developed, but also in developing countries in Asia, Africa and Latin America (de Angelis, 2017). The last decade witnessed entry of a large number of these micro-firms in India with the rising confidence of the nation with large exports of software products and willingness to fail by venturing into innovative products (Subramanya, 2015; Korreck, 2019; Singh, 2020). The explosion of startups has made it possible to leverag the innovations of these startups for food system 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 on². It is by now well-known that entrepreneurial micro-firms called startups have the potential to bring in innovations to address the gaps in production and marketing of goods and services (Audretsch et al., 1999, Audretsch, 2009; Acs et al., 2004; Nanda and Rhodes-Kropf, 2013). These startups are hypothesized to bring open innovation through new business models in association with established companies and other players (Fabricio et al., 2015)

Figure 1: Startups and Large Companies Relationship



Source: Fabricio et al., (2015)

This paper employs an open innovation framework to understand the operations of a large number of agri-tech startups in India across various activities to fully make sense of their activities in totality. Being an exploratory study on this evolving ecosystem, this paper confines to the broad delineation of the functions and interoperability mechanisms without going deeper into the technological products and associated marketing strategies. It classifies the startups working in food value chains based on the main purpose of each of its functioning, though there can be several interventions at different nodes of the value chain and overlap of functions. Then, it analyses the innovations and brings out salient features including the level of investments. It harnesses a large database of startups from Traxcn and also collates with other published as well as news items in business dailies.

The rest of the paper is organised as follows. The next Section examines the nature of innovations of startups in regard to their functioning at various nodes of the value chain. The third Section brings out the discussion on open innovation knowledge flows leading to open innovation. The last Section concludes with policy suggestions.

2. Nature of Innovations in Food Value Chains with Startups and Implications

Several types of startups have come up in the last decade that are filling the gaps in the food value chains in infrastructure deficit regions of the country. Farmers in developing countries face multiple risks on several fronts (Komarek et al., 2020) and these startups endeavor to address them using new generation IT tools such as the internet of things (IoT), big data analytics, blockchain technology, and so on. Many of these startups in India operate in tandem with various other related companies in downstream with 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. It is here the open innovation framework is employed 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 is made to classify them based on their main line of activity, though they can have other initiatives too so that the nature of arising startup initiatives can be analysed to unravel the mechanisms of knowledge flows for innovation. The six broad categories of startup innovations identified are- those providing output market linkages; facilitating input supply; enabling mechanisation, irrigation control, and financial support; helping in quality

² Detailed expositions of these technologies and their applications in agriculture can be seen from Deichmann et al (2016), Tripoli and Schmidhuber (2018), Jha et al (2019), Anand and Raj (2019) and WB (2019).

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 more details and analysis with interconnections. Finally, the nature of knowledge flows leading to the complicated web of open innovation networks is examined.

2.1. Output market linkages: Accumulated evidence shows that reducing the chain of intermediaries between the farmer-producer and consumer can benefit the former through higher price realisation (Chand, 2017; Nuthalapati et al., 2020; Pingali et al., 2019). A large number of startups focus on innovations for linking the farmers in far-flung areas with the buyers of their produce (Table 1). The important players among them include- *Udaan*, *BigBasket*, *Swiggy*, *Zomato*, *Grofers Ninjacart*, *WayCool*, *ZopNow*, *ShopKirana*, *Jumbotail*, *DeHaat*, *AgriBazaar*, *Bijak*, *FarmPal*, and *MilkBasket*. The first four of these startups are unicorns involved in direct procurement from farmers and selling to other supermarket chains and other downstream actors. *Udaan* is the fastest-growing 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 viz., *BigBasket*, *Swiggy*, and *Zomato* engage directly with the farming community and procure through viz., like are direct sellers of food. By September 2020, large investments are attracted by these startups to the tune of 6.96 billion USD, which is invested in building the long-neglected modernisation of the value chains as well as for innovations. Significant investments are in *Swiggy* (1.6 billion), *Zomato* (972 million), *BigBasket* (1.02 billion), and *Udaan* (900 million). Some of the other startups raising considerable investments include *Grofers* (548 million USD), *Ninjacart* (163 million), *WayCool* (66 million), *Jumbotail* (25 mn), and *Bijak* (15 mn).

While *BigBasket* has been procuring directly from the farmers for the last several years (Nuthalapati et al., 2017), several 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 5000 tons of staples (Poojary, 2019). *Ninjacart* supplies fresh produce to *Flipkart* for its *Flipkart Quick* and deals with 1500 tons a day (Velayanikal, 2020). *Zomato* acquired Bangalore-based *WOTU* in 2018 and renamed 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 also procuring from farmers directly (Garg, 2020). Leveraging e-*mandi* model, *Agribazaar* works with 200,000 farmers and connects them with procurement agencies and food processing companies like *Britannia*, *AgroPure*, and others at no cost, though it collects transaction fees from buyers (Mitter, 2020). *DeHaat*, based on the franchise model connects farmers with traders, institutional financiers, and buyers like *Reliance Fresh*, *Zomato*, *Udaan*, etc 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 the states with poor agricultural marketing infrastructure in central and north India. Further, they provide several related services to which we return towards the end of this Section. While several startups fail to survive or make it to the bigger leagues, some are acquired by bigger companies. For example, *ZopNow* was acquired by More and later Amazon; *FarmTaaza* by *WayCool*; and *DailyNinja* by *BigBasket*. Pivoting from B2C to B2B, as done by *Ninjacart*, *WayCool*, has been a trend recently and B2B startups seem to get higher funding chances relatively (Sheth et al., 2020).

Table 1: Startups connecting farmers with output markets

| Company Name | Overview | Founded year | City | Funding | Funding Mn. USD | Company stage | Revenue Mn. USD |
|-----------------------|--|--------------|------------|---------|-----------------|---------------|-----------------|
| Bigbasket (Unicorn) | Online marketplace of grocery products | 2011 | Bangalore | Yes | 1020.000 | Series F | 366.077 |
| Zomato (Unicorn) | Online platform enabling food ordering and delivery | 2008 | Gurgaon | Yes | 975.000 | Series J | 169.140 |
| Swiggy (Unicorn) | Online platform for food ordering and delivery | 2014 | Bangalore | Yes | 1620.000 | Series I | 159.332 |
| Udaan | Online B2B marketplace for multi-category products | 2016 | Bangalore | Yes | 900.000 | Series D | 7.760 |
| Grofers (Soonicorn) | Online retail store offering groceries | 2013 | Gurgaon | Yes | 548.000 | Series F | 11.121 |
| Ninjacart (Soonicorn) | App-based B2B platform offering vegetables and fruits | 2015 | Bangalore | Yes | 163.000 | Series C | 17.110 |
| WayCool (Soonicorn) | E-distributor of farm products | 2015 | Chennai | Yes | 65.737 | Series C | 22.693 |
| ZopNow (Soonicorn) | Online grocery platform with a three-hour delivery promise (Acquired by More and Amazon) | 2011 | Bangalore | Yes | 12.045 | Series A | 2.943 |
| Agrevolution (DeHaat) | Provider of end-to-end farming services to the farming communities | 2012 | Patna | Yes | 16.508 | Series A | 5.417 |
| Bijak | Online B2B marketplace to trade agriculture commodities | 2019 | Gurgaon | Yes | 14.592 | Series A | |
| Jumbotail | Online B2B platform for packaged food, fruits and vegetables | 2015 | Bangalore | Yes | 25.361 | Series B | 29.233 |
| ShopKirana | Mobile-based B2B marketplace for groceries | 2015 | Indore | Yes | 12.472 | Series B | 3.011 |
| Otipy | App-based platform offering fruits and vegetables | 2019 | Delhi | Yes | 2.500 | Seed | 0.000 |
| Kisan Network | B2B marketplace for farmers, bulk buyers | 2015 | Delhi | Yes | 3.493 | Seed | 0.867 |
| Crofarm | Digital supply chain of fruits and vegetables from farm to business | 2016 | Gurgaon | Yes | 5.867 | Seed | 1.476 |
| Aibono | Services for farm data collection & analytics and mobile application for farm management | 2013 | Bangalore | Yes | 6.489 | Seed | 0.244 |
| Clover Ventures | Provider of supply chain solution for fruits and vegetables | 2017 | Bangalore | Yes | 6.931 | Series A | 0.148 |
| Teabox | Online retailer of tea | 2012 | Bangalore | Yes | 19.000 | Series B | 2.689 |
| Satvacart | Online platform offering multi-category grocery products | 2014 | Gurgaon | Yes | 2.324 | Seed | 0.184 |
| Tokri | Online platform to buy fresh produce and groceries | 2014 | Pune | Yes | 2.500 | Seed | 0.056 |
| Milkbasket | Subscription based daily need items delivery (Milk and F&V) | 2015 | Gurgaon | Yes | 40.575 | Series B | 10.349 |
| Farmpal | Online platform delivering farm produce to businesses | 2017 | Pune | Yes | 0.136 | Seed | 0.179 |
| MeraKisan | Online marketplace that connects consumers with local farmers | 2014 | Pune | Yes | 1.000 | Seed | 0.819 |
| VnF | Online platform to purchase fruits and vegetables | 2018 | Mumbai | Yes | 2.000 | Seed | 0.423 |
| InI Farms | Provider of farming services to horticulture industries | 2009 | Mumbai | Yes | 14.635 | Series A | 14.404 |
| FarmTaaza | Manages supply chain of fruits and vegetables from farm to business (Acquired by Way Cool) | 2015 | Bangalore | Yes | 10.693 | Series A | |
| Daily Ninja | Hyper-local subscription based delivery service (Acquired by Big Basket) | 2015 | Bangalore | Yes | 10.744 | Acquired | 0.414 |
| Smerkato | Online B2B platform offering multi-category grocery products | 2016 | Bangalore | Yes | na | Funded | |
| GeeCom | Online E-commerce platform offering agricultural products and supplies | 2018 | Indore | No | na | Unfunded | |
| Farmley | Online platform linking farmers with customers (Earlier called Technify Biz) | 2016 | Delhi | Yes | na | Funded | 1.683 |
| KiranaMonk | App-based B2B marketplace offering farm produce | 2018 | Sonipat | No | na | Unfunded | 0.000 |
| Atomaday | App-based video shopping platform offering fruits and vegetables | 2017 | Bangalore | No | na | Unfunded | |
| GreenNGood | Online retailer of organic products | 2012 | Jaipur | Yes | na | Funded | |
| Organofresh Solutions | B2B wholesaler of fruits and vegetables | 2017 | Chandigarh | No | na | Unfunded | |
| Farmcon | Online B2B marketplace for agriculture products | 2017 | Pune | No | na | Unfunded | 0.874 |
| LivLush | B2B platform to procure fresh fruits and vegetables(Sabziwala and LivLush merged as Kamatan) | 2016 | Bangalore | Yes | na | Series A | |
| Brownsoil | Online B2B platform offering farm produce | 2018 | Bangalore | No | na | Unfunded | 5.531 |

Source: Compiled from Traxen database as of February 2020

2.2. Startups Facilitating Input Supply: Several studies showed that availability and quality of inputs to the farmers is a serious problem impinging productivity and profitability of farmers, where flyby night operators make quick money by selling spurious seeds, fertilisers, and pesticides (Parthasarathi and Shameem, 1998). 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 the delivery of assured quality inputs to farmers (Table 2). These online services have been of particular help in the times of pandemic to follow social distancing and purchase inputs from home using smartphone. *Agrostar* is the largest startup in input supply to farmers and is expected to be a unicorn soon. It has mobilised 47 million USD 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 in buying 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.

Table 2: Startups enabling online procuring of quality inputs

| Company Name | Overview | Founded year | City | Funding | Total funding MnUSD | Company stage | Annual revenue Mn USD |
|----------------------|---|--------------|-----------|---------|---------------------|---------------|-----------------------|
| Agrostar (Soonicorn) | Online platform offering agri-inputs, content, and advice | 2008 | Pune | Yes | 47.183 | Series C | 11.618 |
| Khethinext | Mobile app that enables procurement of farm inputs and provides information | 2017 | Hyderabad | Yes | 5.386 | Series A | na |
| Gramophone | App-based platform providing farm input products and information to the farmers | 2016 | Indore | Yes | 8.062 | Series A | 0.578 |
| Marut Drones | Provides drone-based precision agriculture services | 2019 | Guwahati | Yes | 0.100 | Seed | na |
| LeanAgri | Technology solutions providers for farmers | 2017 | Pune | Yes | 0.567 | Seed | 0.093 |
| BharatAgri | Platform that provides crop management solutions for farmers | 2017 | Pune | Yes | 1.292 | Seed | 0.093 |
| BigHaat | Online marketplace offering farm inputs | 2015 | Bangalore | Yes | 2.570 | Seed | 0.104 |
| A-One Seed Wholesale | Online B2B marketplace 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 for agriculture farm inputs | 2016 | Bangalore | Yes | na | Funded | na |
| SmartFarms | Online B2B distributor 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 | Unnati | 2016 | Noida | Yes | 0.452 | Seed | 10.129 |

Source: Compiled from Traxcn database as of February 2020

2.3. Startups for Mechanisation, Irrigation, and Financial Services: Farming in the Indian context has been becoming difficult for lack of suitable equipment especially for small farmers, enormous drudgery in irrigation fields, wastage of water and lack of financial services. Startups have been finding these gaps and operating efficient services across the length and breadth of the country (Table 3). Some of them focus on the accurate and timely assessment of soil moisture and developing data-driven controlled irrigation models. *Kisan Raja* is an innovative device that allows farmers to remotely control the agricultural motor using their mobile or landline and used by 34200 farmers in India (Gogoi, 2019), apart from being harnessed by the World Bank for a project on saving water in rice. Bangalore-based *FlyBird* installs sensors in the soil to detect moisture content and 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 and *Sense It Out*, *Kritssnam*, *Agirain*, *Manna Irrigation*.

Table 3: Startups helping in efficient mechanisation, irrigation, and financial services

| Company Name | Overview | Founded year | City | Funding | Total funding Mn.USD | Company stage | Annual revenue Mn.USD |
|---------------------------|--|--------------|-----------|---------|----------------------|---------------|-----------------------|
| Mechanisation | | | | | | | |
| FarMart | Web and mobile-based application for renting farm equipment | 2015 | Gurgaon | Yes | 0.740 | Seed | 0.035 |
| EM3 Agri Services | Provider of farming services to the farming communities | 2013 | Noida | Yes | 17.022 | Series B | 1.174 |
| RAVGO | Digital farm and construction equipment rentals marketplace | 2015 | Gurgaon | No | na | Unfunded | na |
| JFarm Services | Online marketplace platform for equipment rental | 2017 | Chennai | No | na | Unfunded | na |
| Trringo | Mobile based app offering farming equipment on rent | 2016 | Mumbai | No | na | Unfunded | 0.240 |
| Irrigation | | | | | | | |
| FlyBird Innovations | Manufactures irrigation controllers | 2013 | Bangalore | Yes | 0.223 | Seed | 0.066 |
| Intech Harness | Provider of an IoT-based automated water pump controller | 2018 | Pune | Yes | na | Funded | na |
| Sense It Out (F6s) | IoT controller for greenhouse management deployed as a service | 2015 | Pune | Yes | na | Funded | na |
| KisanRaja | Technology Solutions for Agriculture | 2006 | Bangalore | No | na | Unfunded | na |
| Satyukt | Data and analytics solutions for earth observations | 2018 | Bangalore | No | na | Unfunded | na |
| Kritssnam Technologies | IOT-based solutions for water monitoring and management | 2015 | Kanpur | Yes | 0.0701 | Seed | na |
| Financial services | | | | | | | |
| Jai Kisan | Online supply chain platform for farmers | 2017 | Mumbai | Yes | 6.0140 | Seed | 0.098 |
| SG Agtech Innovations | Online platform for providing digital & financial solutions to farmers | 2018 | Chennai | No | na | Unfunded | na |
| Safal Fasal | Online marketplace for agricultural products | 2019 | Mumbai | No | na | Unfunded | na |
| Jai Kisan | Online supply chain platform for farmers | 2017 | Mumbai | Yes | 6.014 | Seed | 0.098 |
| Niruthi technology | Location-specific crop monitoring and yield prediction solution provider | 2005 | Hyderabad | No | na | Unfunded | 0.341 |
| Gramcover | Insurance marketplace focused on rural areas | 2015 | Noida | Yes | 1.181 | Seed | 0.318 |
| SatSure | Data services for crop health monitoring and assessment | 2016 | Bangalore | Yes | na | Funded | 0.03 |
| PayAgri | Online platform to bring cashless ecosystem in Agriculture | 2017 | Chennai | Yes | 0.348 | Seed | 0.01 |
| Farmguide | Digitizing agri supply chain and services | 2014 | Gurgaon | Yes | 15.708 | Seed | 0.157 |
| AgRisk Tech | Core banking, payments, transaction banking, and financial inclusion solution provider | 2009 | Mumbai | No | na | Unfunded | na |

Source: Compiled from Traxcn database as of February 2020

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, *M.I.T.R.A.*, and others have been providing these services at a lower cost and some of them are finding good traction among farmers (Singh, 2017). *Sickle innovations*, *Distinct Horizon*, *Tractor Junction*, *Khetibadi*, and *J Farm service* are some of the other startups in mechanisation services. *Kamal Kisan* 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 modern marketing channels, the 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 lower rates of interest, along with other services. Apart from *Jai Kisan*, *SG Agtech*, and *Safal Fasal* shown in Table 3, there are others like *Samunnati*, *FarMart*, *PayAgri*, *Kissh*, *SatSure*, *Farmguide*, *Niruthi*, and so on. *GramCover* acts an insurtech platform too. Some of

the startups with market linkage also provide loans. For example, there are the startups like *Udaan*, *Bijak*, and *Clover*.

Table 4: Startups for quality monitoring and maintenance and predictions of crop health and output

| Company Name | Overview | Found ed year | City | Fun ding | Total funding Mn.USD | Company stage | Annual revenue Mn.USD |
|---------------------|---|---------------|-------------|----------|----------------------|---------------|-----------------------|
| CropIn | Provider of saas-based farming solutions to agribusinesses | 2010 | Bangalore | Yes | 15.624 | Series B | 1.623 |
| Intello Labs | Image recognition based solutions for multiple industries | 2016 | Bangalore | Yes | 8.751 | Series A | 0.157 |
| FarmERP | Software suite for control over farm operations and traceability | 2005 | Pune | Yes | 14.389 | Series A | 0.312 |
| Jivabhumi | Connecting consumers to farmer groups/cooperatives. Uses Blockchain technology for traceability | 2015 | Bangalore | Yes | na | Funded | 0.316 |
| Agricx | Provider of AI-based stack solutions for grading | 2016 | Thane | Yes | 0.775 | Seed | 0.0411 |
| qZense Labs | Provider of an IoT device for food quality check for grading | 2019 | Bangalore | Yes | 0.254 | Seed | na |
| AgNext | Platform for monitoring and improving agricultural food quality for grading | 2016 | Mohali | Yes | 4.337 | Seed | 0.097 |
| RAAV Techlabs | Provider of AI-powered food quality analysers | 2018 | Delhi | Yes | na | Funded | 0.001 |
| OneWater | Soil and groundwater sensing and analytics product | 2015 | Ahmedabad | No | na | Unfunded | na |
| 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 | 18.783 |
| AS Agri Systems | Develops integrated hardware and software platform for precision agriculture | 2017 | Bangalore | No | na | Unfunded | na |
| BKC Aggregator | Precision agriculture solutions provider | 2018 | Delhi | No | na | Unfunded | na |
| NEERx Technovation | Provides smart agriculture solutions | 2019 | Gandhinagar | Yes | na | Funded | na |
| RML Agtech | Online portal for agriculture information sharing | 2007 | Mumbai | Yes | 4.000 | Series A | 0.779 |
| FarmBee | Online platform providing data-driven agricultural solutions | 2006 | Pune | Yes | 9.099 | Seed | 0.760 |
| MyCrop Technologies | Provider of information, 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 dissemination platform for farmers | 2018 | Coimbatore | No | na | Unfunded | na |
| Nebulaa's Matt | Crop quality assessment system | 2016 | Jaipur | Yes | 0.295 | Seed | 0.141 |
| TartanSense | Analyzing health of plants using drones | 2015 | Bangalore | Yes | 2.139 | Seed | 0.002 |
| Yuktix | Technology sensor products for remote monitoring and control of devices | 2013 | Bangalore | Yes | 0.133 | Seed | 0.077 |
| Fasal | AI-powered IoT platform for precision agriculture | 2018 | Bangalore | Yes | 1.720 | Seed | na |
| Bloom | Online mobile-based platform for agriculture risk prediction and mitigation | 2009 | Delhi | No | na | Unfunded | na |
| Skymet Weather | Crop insurance and weather forecasting data services | 2003 | Noida | Yes | 11.768 | Series C | 5.827 |

Source: Compiled from Traxcn database as of February 2020

2.4. Startups for Quality maintenance, monitoring, traceability and output predictions:

Several innovative products have been developed and popularised by startups in this area for quality assaying, quality maintenance through advisories, traceability, and yield predictions through mobile imagery, digitisation, and advanced software (Table 4). One of the most popular startups in this category seems to be *CropIn* that has clients in 30 countries and chosen by the World Bank as a project on sustainable livelihoods and adaptation to climate change. Basically 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 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.

SaaS startups such as *Intellolabs*, *Agricxlab* and *QZense*, and *Raav Techlabs* focus on quality assessment of agri-commodities. *Intellolabs* developed an app to test, grade, and analyse the visual quality parameters of agri-commodities 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 in 30 seconds and acts as a bridge between cold storages and procurement companies (Patil, 2018). On the other hand, women entrepreneurs who founded *QZense* 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. However, it was initially deployed by retailers to gauge and maintain quality for driving down inventory losses and spur margins (Balakrishnan, 2020). Soil and groundwater sensing and analytics products is brought out 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 that can be shared in cloud and SMS with advisory. *Cheruvu* also enables soil testing facilities and advisory along with comparisons to neighbour’s field. *TartanSense* developed technologies to assess the health of plants through drone imageries.

Table 5: Startups helping in post-harvest management, and engaging in farming as a service (FaaS)

| Company Name | Overview | Founded year | City | Funding | Total funding Mn. USD | Company stage | Annual revenue Mn. USD |
|--|--|--------------|-----------|---------|-----------------------|---------------|------------------------|
| Post-harvest management | | | | | | | |
| Ecozen Solutions | Manufactures and supplies solar-powered irrigation pump controllers | 2009 | Pune | Yes | 10.591 | Series A | 9.800 |
| 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 agricultural logistics platform connecting grain shippers and carriers | 2019 | Bhopal | Yes | na | Funded | na |
| Star Agriwarehousing & Collateral Management | Agricultural warehousing and post-harvest supply chain solutions | 2006 | Mumbai | Yes | 72.000 | Series C | 42.600 |
| Arya Collateral Warehousing Services | Warehousing and collateral management services for agri commodities | 1982 | Noida | Yes | 9.333 | Series A | 11.956 |
| Farming- as-a-service (FaaS) | | | | | | | |
| Farmizen | Develops and operates digital application for community supported farming | 2017 | Bangalore | Yes | 0.297 | Seed | 0.047 |
| Triton Foodworks | Integrated business for soil-less cultivation of fruits & vegetables and supply of produce | 2014 | Delhi | Yes | na | Seed | na |
| Agro2o | 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 | 0.105 |
| 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 | 0.297 | Seed | 0.047 |
| Hosa Chiguru | Agri Infrastructure and developer | 2006 | Bangalore | No | na | Unfunded | na |
| Vegrow | Provider of tech-enabled farming services to farmers | 2020 | Hyderabad | Yes | 2.500 | Seed | na |

Source: Compiled from Traxcn database as of February 2020

Precision agriculture using advanced analytics and prediction platforms are supposed to be the game-changing technologies and exclusive preserve of top six companies and likely to be bypassed for the developing world (Lianos et al., 2016). However, startups enter this segment of the value chain and make them possible through their innovations at a cost-effective manner for the smallholder farmers in developing country contexts such as in India. Precision agriculture solutions are provided by software platforms of *Annex*, *AS Agri Systems*, *BKC Aggregator*, and *NeerX Technovation*. Agricultural information sharing has few startups attending and they include *RML Agtech*, *FARMbee*, *MyCrop Technologies*, *Agrojay*, and

Namma Uzhavan. 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 via mobile in vernacular languages. Likely to be 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).

2.5. Startups for Postharvest Management and Farming-as-a Service: As the value chains become elongated with nearly two-thirds of food being consumed in urban areas in India (Reardon et al., 2020), the requirements for processing, logistics, wholesaling, and associated services have been increasing over the past few decades. Startups have been crucial in the segment of logistics with several of them acting as third party logistic partners for other startups as well as established food companies like Britannia and several others. Apart from that, few startups made innovative products for cold storage and saving the produce from post-harvest damage before being transported. Table 5 examines the startups in midstream of the value chain.

The solar-powered small-size cold storage unit of *Ecozen Solutions*; and low-cost storage cum transportation solution called *Sabjikothe*, 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 in is storage of agri-produce. In a country where it is estimated that there is storage gap of around 35%, their role can play a crucial role in reducing food damage. *A2Z Godaam* of *Arya Collateral* is foremost among them. It is a digital platform for the search, discovery, and fulfilment of warehousing for farmers, FPOs, corporate and other stakeholders. It goes beyond storage by integrating with other services like financial and market linkages (Kashyap, 2020a). Similar post-harvest 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 the cultivation of fruits and vegetables often in organic modes on the one hand and on the other 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 get a good response. *Farmizen*, and *Hoshachiguru* provide min-farms to be rented by prospective cultivators and can 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. On the other hand, startups like *Vegrow* and *EMB* partner with smallholders for profitable cultivation that might also lead to the aggregation of fragmented farms for achieving economies of scale (Sangwan, 2020). Rooftop gardening by *Khetify*, indoor hydroponics by *Agro2o*, and end to end farm enabling services for greenhouses by *Kheyti* represent the other emerging areas for startup ventures.

2.6. Startups for Farmers in Animal Husbandry: The animal husbandry sector, with one-third of the gross value added in the agriculture, does attract startup ventures though not in proportion to its contribution to value-added and support to smallholder cultivators (Table 6). The leaders in this segment are *Licious* and *FreshToHome* that engage in a 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, large ticket

investments are in dairy sector startups *CountryDelight* (20 million) and *Stellaps* (19 million) and fishery startup *Aquaconnect* (11 million). Both *Licious* and *FreshToHome* procure directly from farmers. While *Caprabook* is for goat farm management, *PoultryMon* is for hatchery management solutions. The 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.

Table 6: Startups in animal husbandry

| Company Name | Overview | Founded year | City | Funding | Total funding Mn. USD | Company stage | Annual revenue Mn. USD |
|--------------------------------|---|--------------|--------------|---------|-----------------------|---------------|------------------------|
| Licious (Soonicom) | Online platform for delivery of meat and seafood | 2015 | Bangalore | Yes | 94.500 | Series E | 9.133 |
| Fresh to home (Soonicom) | Manages supply chain of meat and seafood from farm / fishermen to home | 2012 | Bangalore | Yes | 47.200 | Series B | 0.930 |
| ZappFresh | Online fresh meat delivery service | 2015 | Delhi | Yes | 9.059 | Series A | 4.087 |
| 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 | 0.752 | Seed | 0.363 |
| PoultryMon | Hatchery management solutions for poultry farms | 2018 | Hyderabad | Yes | na | Funded | na |
| Aquaconnect | Developer of products for data-driven farming in shrimp ecosystem | 2017 | Chennai | Yes | 1.102 | Seed | 0.204 |
| INCEVE | Provider of SONARs for catching fishes | 2016 | Bangalore | Yes | na | Funded | na |
| Stellaps | Provider of farm optimization and monitoring support for milk | 2011 | Bangalore | Yes | 19.009 | Series B | 6.896 |
| Country Delight | Online retailer of dairy products | 2015 | Gurgaon | Yes | 19.636 | Series B | 7.965 |
| Prompt AMCS | Automatic milk collection system for dairy industry | 2011 | Ahmedabad | No | na | Unfunded | na |
| Meri Dairy | Provider of dairy management software for milk collection centers | 2008 | Jaipur | No | na | Unfunded | na |
| Farmery | Production, marketing and delivery of raw cow milk | 2015 | Delhi | No | na | Unfunded | 0.766 |
| Eruvaka | Provider of IoT based on-farm diagnostic equipment. Animal nutrition and aqua feed | 2012 | Vijayawada | Yes | 6.781 | Series B | 1.360 |
| Krimanshi | Developer & supplier of sustainable feed for livestock animals | 2018 | Bangalore | Yes | na | Seed | na |
| Tropical Animal Genetics (TAG) | Developer of in-vitro animal breeding platform | 2014 | Gurgaon | Yes | na | Seed | 0.262 |
| Aquaconnect | Developer of products for data-driven farming in shrimp ecosystem | 2017 | Chennai | Yes | 1.102 | Seed | 0.204 |

Source: Compiled from Traxcn database as of February 2020

Listed as one of the 100 Technology Pioneers of 2020 by the World Economic Forum 2020, *Stellaps* digitizes farm-to-consumer chain and enables dairy ecosystem partnerships including facilitating digital payments and 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 30000 villages.

3. Open Innovation knowledge flows

The foregoing analysis reveals that open innovation as explained by Chesbrough (2003) has been taking root in Indian agriculture by joint development and diffusion of innovations by startups and other actors in the food value chain. 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 the USA for processed foods). This company has so far completed two funds with 40 million and 97 million and about to start the third one (Putrevu, 2020). Among its investments are startups working in various segments of the food value chain and include *DeHaat* (Full-stack marketplace), *Stellaps* (Dairy platform), *GramCover* (Rural fintech and farm finance), *Bijak* (B2B agricultural commodity platform). The company has also acquired two startups for digital supply chain solutions for farm business (Chaudhari, 2012).

One of the largest processing company *ITC* has upgraded its *eChoupal* to a more collaborative mobile platform in the name of *eChoupal 4.0* and other companies like Bayer are harnessing the same (Anand, 2020). *ITC* has invested in alternative investment funds (AIF) those that fund startups and is also investing directly in startups to aid in improving the business (Naik, 2019). Reliance, which started *JioMart* e-commerce 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 committed to investing 50 million to strengthen *Ninjacart* (Velayanikal, 2020). Similarly, Amazon acquired the e-commerce grocery startup *ZopNow* in 2018. On the other hand, a startup by name *StarAgri* floated its own initiative for market linkages in the form of *Agrobazaar*.

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 (federal as well as provincial), 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 these startups (Medhi, 2020; Mitter, 2020; Narain, 2020). The ecosystem has been bringing to the ready access of the farming community several innovative products including 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, third party logistic 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 covered up. It needs to

be highlighted here that innovations in value chain organisation can accelerate technology adoption by the farming community (Swinnen and Kujipers, 2019).

4. Summary and Conclusions

Open innovation is a paradigm shift in technology development and benefit sharing in the New Millennium. This kind of organisation of innovation starts with the kind of economic activities with a high level of sophistication and complex processes. The rapid evolution of the food system with diverse actors and an assortment of technologies makes open innovation possible in agriculture. This paper harnesses a large database of startup data in India and examines the nature of innovations in the startups working in food and agriculture in open innovation framework, analyses startups according to their roles in the value chain, funding, and investment, and revenue.

Several types of startups have come up in the last decade and are filling the gaps in the food value chains in infrastructure deficit regions of the country and introducing innovations. Our estimates show that they mobilised investments to the tune of six billion USD into the food and agriculture sector producing four unicorns and three soonicorns by the end of 2020. Most of these startups operate in tandem with various other related companies in downstream with 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 between 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 (federal as well as provincial), 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 in developing countries. The ecosystem has been bringing to the ready access of the farming community several innovative products including 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, third party logistic solutions. These innovations are from the startups to other actors in the value chain, which itself has been accelerated and invigorated with the missing links covered up.

The food value chain emergence of open innovation in agriculture augurs well to flows and to harness higher levels of technologies. The factors leading to open innovation, termed erosion factors by Chesbrough and Bogers (2014), significantly influence the evolution of this innovation system. Most of these erosion factors including startups getting venture capital, the rise of the internet with 700 million internet users, the widespread use of social media, universities becoming innovation hubs, and 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 Kenney, 2002; Nuthalapati and Singh, 2019). After a long period of stagnation and ‘technology fatigue’ (Narayanmoorthy, 2007), Indian food system is in transition and moving towards a 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 a higher level of technologies and the innovations will 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 startup ecosystem that includes venture capital industry, and associated policy changes. It is worth highlighting few key measures like early-stage support through seed fund, encouragement to angel investors, mass incubators, and a level playing field for non-technical startups.

The nascent stage of development of this open innovation needs dispassionate research on these developments from the purview of equity and the possibility of scaling up these ventures. Also required is a research focus on the type of business models, collaboration and licensing agreements between companies, universities and governmental agencies. Food chain actors resisting these open flows will be worse off in terms of net welfare gains and this will be much more problematic if the smallholders are bypassed by these innovations. The limited and available evidence points to the startup innovations accessible more to the larger farmers (Singh, 2016; Hennessy et al., 2016).

Also, preliminary studies in the Netherlands show that corporate-startup collaborations can improve innovation performance and enhance competitive advantage and at the same time mediating and moderating factors are important to be kept in mind³ (van der Boezem et al., 2015). Enabling these factors is warranted as startups and chain actors interact with others keeping their interests rather than the wider interests and therefore this innovation has to be internalised and mainstreamed into the agricultural development planning, mindful of the twin objectives of growth and equity (Korreck, 2019; Singh, 2020). The entry of open innovation in food value chain actor bodes well for the food system and its disparate actors and it calls for wider engagement by economists in research related to the factors leading to this innovation in terms of business mechanisms, socioeconomic contexts, technological drivers, and both supply and demand-side factors.

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³ The policymakers in Europe have internalised the three core principles of open innovation (Open science, open innovation and open to the world) in its Mission-oriented Innovation Policy (MIP) as the core of the *Horizon Europe* programme.

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