Collaborative Innovation and Sustainability in the food supply chain- Evidence from Farmer Producer Organisations

1. Introduction

Innovation is defined as "a new product or service, a new production process technology, a new structure or administrative system or a new plan or program pertaining to organisational members" (Damanpour, 1991, p. 694). These days innovation is seen as an outcome of collaborative efforts rather than the outcome of a single entity (Bouncken, 2011; Soosay et al., 2008), it therefore demands a joint effort of stakeholders to work together. Thus, establishing a collaborative supply chain structure is a necessary condition in support of innovation, which in turn benefits all the stakeholders in the entire supply chain. Although innovation as a topic has been gaining increasing attention in the literature, there seems to be less emphasis on innovation in the supply chain context (Arlbjorn et al., 2011; Gao et al., 2017). Only few studies have linked innovation to supply chain, yet almost all of these studies have focused only on a particular type of innovation such as product, process or technological innovation (Arcese et al., 2015; Gao et al., 2017).

With changing customer behaviour and strict government regulations, it becomes important to consider the environmental and social impact of Food Supply Chain (FSC) operations (Gualandris and Kalchschmidt, 2014; Zhu et al., 2018). Though existing literature has investigated the impact of Supply Chain Innovation (SCI) on operational and financial performances (Ju et al., 2016; Lee et al., 2011; Nguyen and Harrison, 2019), studies exploring the impacts on sustainability dimensions are lacking. Sustainability is defined as "the design of human and industrial systems to ensure that humankind's use of natural resources and cycles do not lead to diminished quality of life due either to losses in future economic opportunities or to adverse impacts on social conditions, human health and the environment" (Crittenden et al., 2002, p. 2). Prior researches have explored the impact of innovation only on a particular dimension of sustainability (see Chen et al., (2017) & Zailani et al., (2015)). Accordingly, there is a gap in the existing literature on collaborative innovation influencing sustainability in the context of the FSC.

The FSC is characterised by perishability, long lead time for the production of food products, seasonality in production and consumption and variability of product quality and yield, making it complex to manage when compared with other supply chains (Amorim et al., 2014; Cagliano et al., 2016). In addition, in developing countries such as India, the presence of too many intermediaries, small average landholdings (approximately 1-2 hectares per farmer) and the fragmented nature of farmers, reduce the margins realised by the farmers and forces small landholding farmers to sell their products to the intermediaries at a much lower price than the going market price. Also, due to the inefficient agricultural practices and food waste, significant environmental and social impacts are being created (Krishnan et al., 2020). These challenges faced by the small farmers' highlight the necessity for collaborative innovation within the FSC to improve their livelihood and the sustainability of FSC.

In this regard, this study aims to investigate how collaboration among FSC entities leads to different types of innovations – product, process and technology and thus creates sustainable outcomes. The case of the Farmer Producer Organisation (FPO) is used for this investigation. The FPOs were introduced by the Indian Government in 2002 with the amendment on Companies Act 1956 (Dept. of Agriculture and Cooperation, 2013) to support farmers and reduce the number of intermediaries in the FSC. FPOs are formed by a group of small farm landholders with the initial capital generated from the members of the FPO. This collaborative network structure has resulted in various innovative practices that are benefiting the stakeholders (Bikkina et al., 2018).

The following research questions are addressed in this study:

RQ1: Does the formation of collaborative network structures promote innovation in the FSC?

RQ2: What are the innovative activities emanating from the process of collaboration that has been employed and distributed within the FSC?

RQ3: What are the impacts of these innovative activities and how do these innovative activities improve sustainability of the FSC?

In addition, the Supply Chain Operations Reference (SCOR) model (Supply-Chain Council, 2005) is used to analyse the FSC activities across different levels – plan, source, make, deliver and return. The novelty and key contribution of this study over existing studies are four-fold: First, this study provided an in-depth case analysis of different process levels of the farmer producer organisations using the SCOR model. Second, the innovative practices evolving out of the collaboration of FSC entities are identified and classified into product, process and technological innovations. Third, the outcomes of collaborative innovations are captured in terms of sustainability dimensions – economical, environmental and social. Fourth, an integrated framework of Supply Chain Collaboration (Figure 5), SCI and Supply Chain Sustainability (SCS) is proposed that shows at which level of the supply chain, the innovative practices are more prevalent and where it is lacking.

The remainder of this paper is structured as follows. In Section 2, we present a literature review while Section 3 presents the conceptual framework and economic models used in this research. Section 4 outlines the case study research method, the data collection process and details of the various case studies used. In Section 5, the research findings are presented, followed by a discussion of the results. In Section 6, the theoretical, managerial implications and policy recommendations derived out of this are discussed. In Section 7, we conclude and provide limitations of this study and possible future research directions.

2. Literature review

In this section, we review the literature related to SCI, SCC and SCS. The relationships between these different concepts are explained and this is followed by the research gaps.

2.1 Supply chain innovation

Most firms today engage in innovative practices to establish themselves in the market, ensure their on-going survival, contribute to value creation and enhance their competitiveness (Jangga et al., 2015; Jung et al., 2003). Innovation has been increasingly described as an outcome of a collaborative process that involves the participation of various stakeholders not only within but also outside the supply chain (Arlbjorn et al., 2011; Ozman, 2009). This leads to the notion of SCI, which has been increasingly invoked in both academic and practical spheres in recent years. Gao et al., (2017) proposed a holistic definition of SCI as: "an integrated change from incremental to radical changes in product, process, marketing, technology, resource and/or organisation, which are associated with all related parties, covering all related functions in supply chain and creating value for all its stakeholders" (Gao et al., 2017, p. 13). A complete SCI comprises of a set of innovative organisational activities that are associated with all stakeholders and includes all related functions of the supply chain. Our study adopts this integrated definition of innovation yet concentrates on the three most common types of innovation that includes product, process and technological innovation as addressed in the literature.

The literature on SCI has evolved over time. Over the past decades, SCI has been applied to various aspects related to supply chain management including (i) introducing new products and service (Flint et al., 2005); (ii) implementing new technology (Smith and Dos Santos, 2008; Tang et al., 2003; Wu and Chuang, 2010); (iii) optimising supply chain business process (Bello et al., 2004); (iv) innovations in supply chain networks (Autry and Griffis, 2008; Caniëls and Romijn, 2008) and (v) value networks (Agarwal and Selen, 2011, 2009; Sharpe and Agarwal, 2014). More recently, SCI research has focused on sustainability-oriented innovations such as green or ecological innovations (Abu Seman et al., 2019; Gualandris and Kalchschmidt, 2014; Tong et al., 2012; Zailani et al., 2015).

2.2 Supply chain collaboration leads to supply chain innovation

Firms are striving to attain greater SCC in order to reduce cost, increase revenue and operational flexibility (Bowersox et al., 2003; Mandal, 2017; Vereecke and Muylle, 2006), access complementary resources (Park et al., 2004), as well as enhance competitive advantage over time (Mentzer et al., 2000). SCC is defined as a close and long-term relationship in which supply chain partners work together to share resources, information and risk (Barratt and Oliveira, 2001; Bowersox et al., 2003) using different co-ordination mechanisms (Agarwal and Subramani, 2013) as well as solve problems and make joint decisions (Spekman et al., 1998) to achieve mutual objectives.

Collaboration is not only associated with innovation, but it can also enhance innovation (de Paula et al., 2019; Mittal et al., 2018). A large part of a firm's innovation capability lies in its external relationship network. Collaboration helps to dismantle learning barriers and enables better understanding and communication between/among supply chain partners, thereby facilitating reliable information sharing and improving process efficiency that collectively promotes innovativeness across the supply chain (Bouncken, 2011). As such, we use Dynamic Capability Theory (DCT) (Teece et al., 1997) lens to support this linkage for this empirical enquiry of how SCC supports SCI. DCT seeks to explain how firms can build, extend, integrate, and modify their internal and external resources while simultaneously effectuating necessary transformations (Teece et al., 1997; Teece, 2017). The dynamic capability building aspect such as resource complementary, knowledge sharing, co-value creation can enable firms to reconfigure resources and apply them to innovate further to become more profitable (Gruchmann et al., 2019; Teece, 2017), resulting in sustainable innovations and outcomes (Aguinis and Glavas, 2012; Gruchmann et al., 2019). For example, the collaboration between suppliers and producers in their procurement process helps to reduce the use of raw materials and waste generation, or collaboration among entities within a closed-loop SC mitigates the wastes through utilising returned used products as inputs for another manufacturing process (Ray and Mondal, 2017).

The influences of collaboration on innovation have also been detailed in previous studies. For example, Soosay et al., (2008) identified a number of innovation outcomes derived from collaborations, including maintaining standardised operations, joint planning, sharing knowledge, sharing processes, joint investing, synchronising and interfacing with customers and suppliers. Agarwal and Selen (2009) found that supply chain members who have a higher level of collaboration can achieve better operational performance and innovation practices, leading to service innovations through the building of dynamic capabilities. Based on their empirical study on collaboration and product innovation, (Haus-Reve et al., 2019) concluded that firms who collaborate with their supply chain partners are more likely to innovate than those that do not. Similarly, SCC, in particular, information sharing, risks and benefits sharing and joint decision making, promotes radical and incremental innovations (Nguyen et al., 2019).

2.3 Supply chain innovation contributes to supply chain sustainability

SCI has been widely accepted as a vital instrument for improving both organisational and supply chain performances (El-Kassar and Singh, 2019; Kwak et al., 2018; Lee et al., 2011; Vereecke and Muylle, 2006). The literature has highlighted the contributions of innovation to firms' performance in terms of financial performance (El-Kassar and Singh, 2019; Kwak et al., 2018) such as growth in sales or profits, market share, return on investments (see Nguyen and Harrison, 2019; Piening and Salge, 2015)) and operational performance such as improvement in operational flexibility, operational responsiveness, operational service quality (see (Ju et al., 2016; Lee et al., 2011; Richey et al., 2005)). To benefit from innovations, firms are usually required to involve their key supply chain partners, such as suppliers and customers into their innovation strategies and practices (Acar and Atadeniz, 2015; Storer et al., 2014). Such co-innovators are expected to contribute to improving the performance of the entire supply chain. Moreover, innovations focused on attaining sustainability goals of firms have come under increasing pressure to move towards a more sustainable economic system (Nosratabadi et al., 2019). Gattorna (2015) argues that innovations that lead to high performances in larger global networks will sustainably create value for all stakeholders.

From a dynamic capabilities perspective, innovation is conceptualised as part of the dynamic capability building process that helps firms sustain optimal performance (Teece, 2007). In respect, the three most common types of innovation: product, process and technological innovations may result in a win-win situation so that economic, social and environmental performances of supply chain members are improved simultaneously (Haji Vahabzadeh et al., 2015). For example, innovative firms that differentiate their products from their competitors through embodying the green concept in their processes and products, can boost their competitive advantage; thereby improve their corporate image, increase sales and open new market opportunities for their green products (Dangelico and Pujari, 2010). Technological innovations such as the implementation of information technology systems and advanced technologies enables effective communication with reliable information sharing (Prajogo and Olhager, 2012) and facilitates better operational processes, quicker response to dynamic customer requirements and waste elimination (Tajima, 2007; Wu and Chuang, 2010). Thus, innovation based on a new product or process development, including new technological opportunities creates sustainable benefits to the supply chain entities and needs to be explored further in the context of FSC.

2.4 Research gap

Although the relationships between SCC, SCI and SCS have been discussed in the literature, a holistic supply chain approach taking into account all the entities, the different types of innovations and the various sustainability dimensions, are lacking in this literature, especially for the FSC. In particular, a few related researches were found to investigate the linkage between SCC and innovation such as works done by Cassivi et al., (2008), Haus-Reve et al., (2019), Jimenez-Jimenez et al., (2019) & Soosay et al., (2008). However, the previous studies focused mainly on the investigation of innovation on a single type of innovation like product innovation or process innovation. While few studies have sought to explore the influences of innovation on sustainable performances (see El-Kassar and Singh, (2019); Gualandris and Kalchschmidt, (2014); Zailani et al., (2015)) limited evidence of studies investigating the impact on all three dimensions of sustainability was found in previous researches. Also, the above mentioned researches mostly used survey methods to explore a positive association between these variables but failed to provide real evidence on how SCS is facilitated through SCI emanating from the collaboration of FSC entities. Hence, there is a lack of evidence that shows how collaboration in FSC results in innovation and sustainability outcomes.

3. Framework and economic model development

In this section, we propose a conceptual framework and an economic model that shows theoretically how the collaborative formation of FPO yields innovative practices and how the outcome of these collaborative innovations lead to sustainable FSC benefits.

3.1 Conceptual Framework

Figure *1* illustrates the step-by-step conceptualisation of the proposed framework in three phases. Phase A, in Figure *1*, illustrates the SCC of FPO, farmers and customers. The formation of FPO is itself an innovative business model which is promoted by the Indian Government with a vision to build a sustainable agriculture sector through the collective action of farmer members that enables them to utilise the resources sustainably and realise higher margins (Dept. of Agriculture and Cooperation, 2013). The FPO organisations further collaborate with farmers and customers for better management of FSC and yield many innovative practices (Agarwal and Selen, 2011, 2009). These innovative practices are classified into three types - product, process and technological (Gao et al., 2017), as shown in Phase B of Figure *1*.

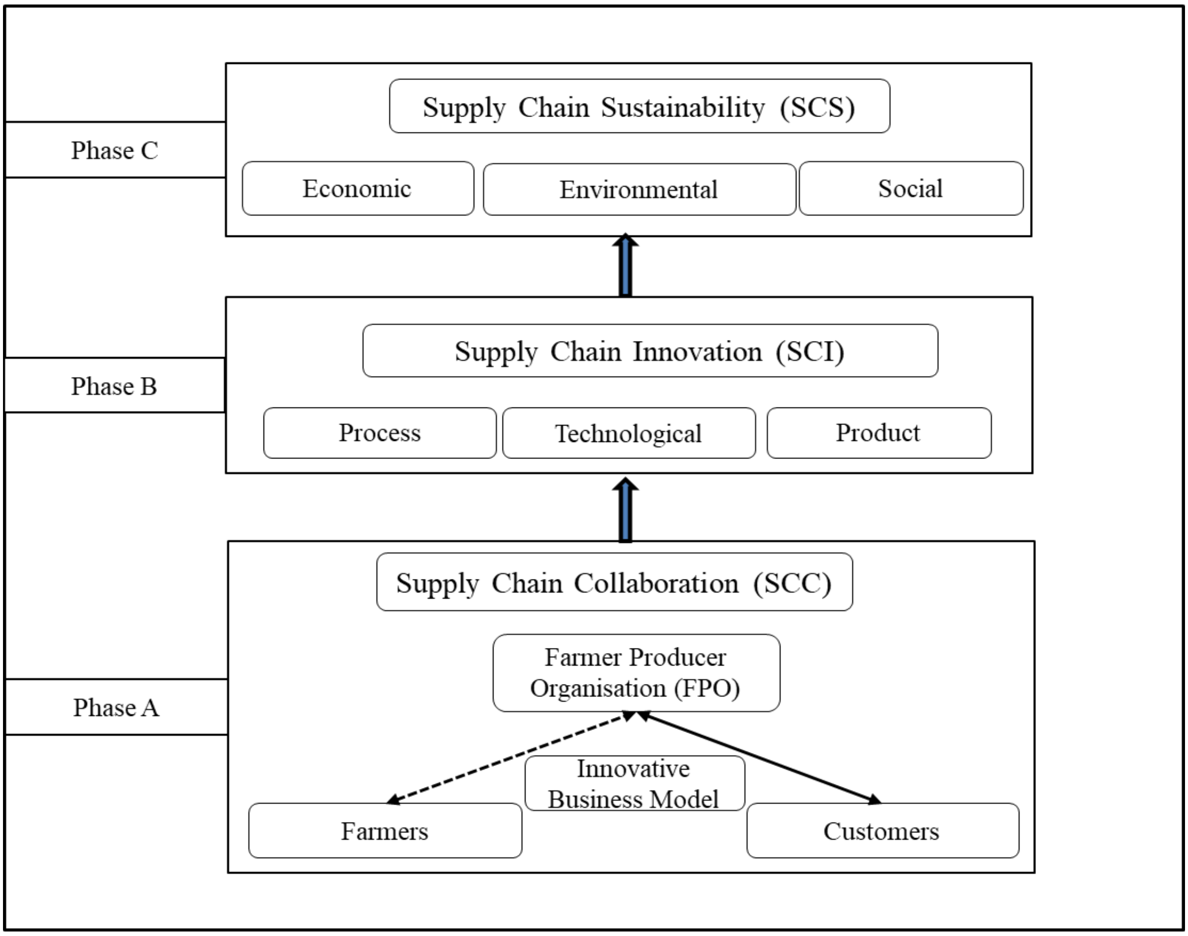


Figure 1 Conceptual Framework

Introduction of new product variants such as boiled, flattened and broken rice instead of selling the paddy in raw form and use of waste to create value and produce valuable components are some of the innovative practices categorised under product innovation. Crop selection strategy based on soil condition and expected market demand for product, providing training to farmers on new agricultural practices such as mixed and intercropping and direct marketing of products to customers without intermediaries are some of the outcomes of the FPO collaboration which were not possible when farmers were operating independently. These innovative practices are classified under process innovation. Similarly, technological interventions such as information sharing with farmers and customers through social media platforms have transformed the way the FSC operates. The outcome of all these individual and collective innovative practices has a significant impact on the FSC and the impacts of these innovative practices are captured in terms of economic, environmental and social impacts (Seuring and Müller, 2008) – the three dimensions of sustainability as illustrated in Phase C of Figure *1*. Section 3.2 provides an economic model to elucidate the relationship provided in the conceptual framework.

3.2 Economic model for the collaborative business model of FPO

We formalise the conceptual framework described in Section 3.1 by developing an economic model to show how theoretically the outcomes from a collaborative innovation can result in scale efficiencies that improve both farmer conditions (e.g., improved levels of profitability) and farming conditions (e.g., improved levels of environmental conservations and sustainable practices). This economic framework is then used to help frame the empirical analysis to investigate the innovative practices and sustainable outcomes in FPOs.

We begin by illustrating the effects of scale efficiencies through innovations and sustainable practices that minimise waste of an FPO in agricultural markets in Figure 2. Panel A of Figure 2 illustrates the average cost of a pre-FPO farmer for a given farm size and capital equipment (ATC_1). This level of production is characterised by individual efforts, that is, how the farmer operates and sources inputs to grow their agricultural produce independent of other farmers. In a market made up of many farmers selling relatively homogenous products, the farmer faces a price that is subject to market forces. That is, the farmer faces a highly elastic demand for their product.

The introduction of the FPO brings together farmers with like-minded goals. Their objectives are to produce knowledge hubs that lead to collaborations that increase farmer efficiencies through innovative practices potentially supported by improved technologies, thereby enabling the farmer to learn, acquire and internalise ideas to strategize better practices for growing crops and sourcing inputs through a process of collective bargaining (represented by the FPO). These farmers' demand curve is represented by DM in Panel B of Figure 2.

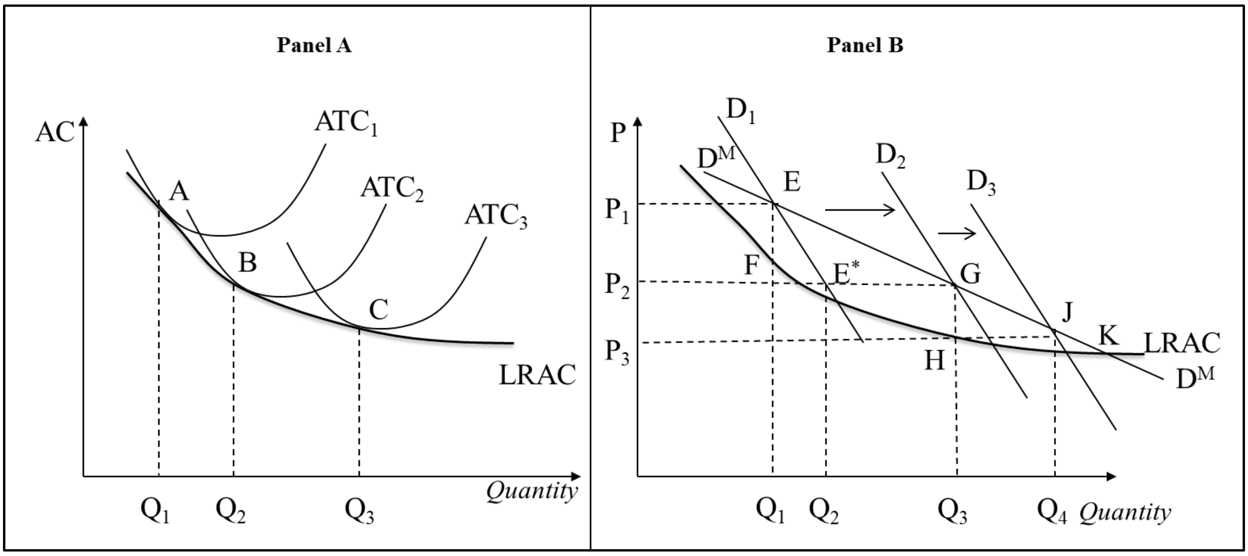


Figure 2 Effects of Innovation and Scale Efficiency of FPOs

As the FPO procures the farmer's produce, this gives the FPO greater market control over supply than any farmer could individually. These efficiency gains help reduce the average cost of production for each farmer, which in Panel A of Figure 2 may be represented by ATC_2 – characterised by lower average cost and high production when compared with ATC_1. As more farmers become members of the FPO, the average cost of production continues to fall and farmer's average costs move to ATC_3. The locus of points representing the lowest possible costs for each level of output is represented in Panel A of Figure 2 as the long-run average cost (LRAC) curve. This same LRAC is illustrated in Panel B of Figure 2. At point E in Panel B of Figure 2, the profit margin per unit of output for each farmer in the FPO is represented by the distance EF. It should be noted that point F represents the average cost of farmers in the FPO which is lower than that for the same level of production (Q_1 in Panel B) if the farmer was to operate independently (i.e. pre-FPO). Profit margins for the farmer in that case would be substantially lower.

As the FPO acquires additional farmer members and therefore increases in scale and efficiency, the profit margins of farmers, at current prices and levels of production would increase. This provides the FPO with an opportunity to improve societal well-being by reducing agricultural produce prices while still maintaining a healthy profit margin for farmers above those received during the pre-FPO period. If the FPO with its current membership decreased prices from P_1 to P_2 (in Panel B of Figure 2), it would experience an increase in the quantity demand for produce supplied by FPO members to Q_2. Combined with any increases in membership, this would increase quantity demanded to Q_3. Likewise, further price reductions to P_3 would expand demand along demand curve D_2 and this combined with additional farmer membership, will increase demand to D_3 and quantity to Q_4. The locus of points E, G and J (in Panel B of Figure 2) on the various demand curves, produces the market demand (DM - DM) for agricultural produce by the FPO and other non-member farmers in a given district.

Assuming that point J (on demand curve D_3) represents a situation where all district farmers are members of the FPO, we can describe such a scenario as a 'quasi-natural monopoly'. In this case, the FPO has a considerable cost advantage over any non-FPO farmer in cost and scale as well as having access to a greater national distribution network to sell FPO agricultural produce. Despite this, the FPO is still subject to competitive pressure from neighbouring districts with similar FPOs.

These scale economies and production efficiencies are jointly affected by farmer's contribution to more sustainable practices. Chouinard, et. al., (2008) presents a model to explain profit trade-off decisions made by farmers when considering 'stewardly activities' across their farm practices. The model suggests that a higher level of profits may result at the expense of environmental considerations and the preference of farmers toward more environmental stewardship will influence their engagement with sustainability practices. This model has relevance for the FPOs as their objectives are nested in a combined goal of improving productive efficiency (as described above) and improving environmental outcomes. The same innovation processes that result in both technical and in a more allocative efficiency is combined with environmental objectives in Figure 3.

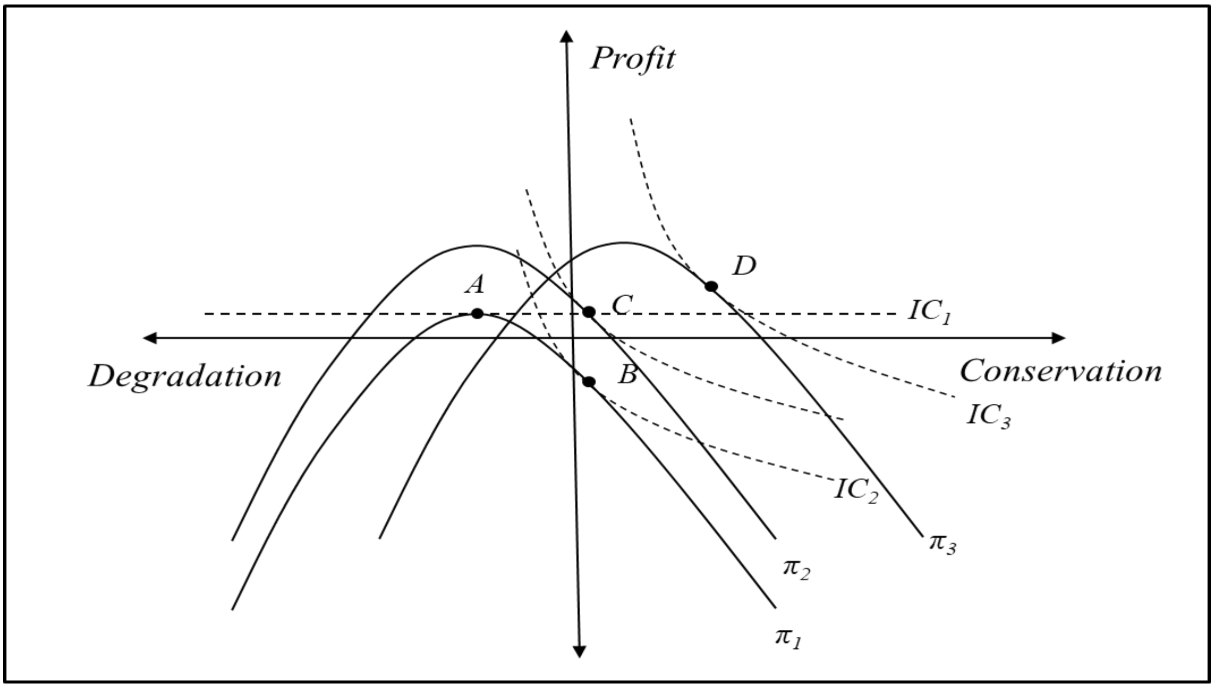


Figure 3 Trade-off between Environment outcomes and profitability

In Figure 3, we illustrate the typical profit function for each farmer pre-FPO (π_1). The vertical axis represents the level of profit (or loss) and the horizontal axis represents the level of environmental degradation or conservation. For the individual farmer, the profit function (π_1) is maximised at point A, suggesting that any decision to improve environmental outcomes beyond point A will come about at the expense of profitability. The farmer's small operation and low-profit margins may prohibit such a consideration. This would suggest that the farmer's indifference curve between profit and environmental outcomes is IC_1 and is tangential at point A. A farmer that is intent on improving their contribution to the environment but at the expense of their own overall profitability may be represented by the indifference curve IC_2, tangential to point B on (π_1). Such a position is unsustainable for the typical farmer, especially in a less developed economy with basic production technology. The introduction of the FPO and its effects on productivity from scale efficiencies results in greater levels of profitability for the same levels of the previous production. In panel A of Figure 2, we illustrate this effect by the reduction in average costs (average costs curves moving in the southeast direction). As this occurs, the profit function (π_1) in Figure 3 shifts upward and results in a move from point B to C. This upward shift in the profit function (to π_2) is the result of farmers striving to attain greater SCC in order to reduce cost, increase revenue, improve operational flexibility and access complementary resources (Park et al., 2004).

With continued gains from collaboration and innovation within FPO's, the farmer's profit function shifts further to the right (to π_3), with the farmer being represented on a higher indifference curve (IC_3) with greater levels of profitability and environmental conservation. This result suggests that collective action provides mutual benefits in terms of value creation as well as enhancing their relationship and ensuring the social dimension of sustainability (Chen et al., 2017). In addition, improving the environmental sustainability of the FSC has significant benefits for the workers and its surrounding population (Jones et al., 2005; Luhmann and Theuvsen, 2016), which in the process also addresses the social dimension of sustainability.

4. Methodology

The main objective of this study is to identify how the collaborative network structure would result in innovative practices leading to sustainable benefits. As not much is known about how sustainability is achieved through SCI, a case study approach is used in this study. Case studies are useful to answer the "why" and "how" research questions, especially when a research phenomenon can be affected by the context in which it occurs (Yin, 2009). In addition to this, "the distinctive need for case studies arises out of the desire to understand complex phenomena"(Yin, 2009, p. 2) such as how the innovative practices are emerging from SCC and how it contributes to sustainable outcomes. A case study research is highlighted as the most suitable when the focus of research is related to an emerging area such as sustainable SCI (Gao et al., 2017). Another strength of case study research is that it provides an in-depth understanding and a real-life observation of the research problem.

We have also adopted the SCOR model as a base to analyse the different levels of FSC. The SCOR model provides a common framework for the evaluation of supply chains across the plan, source, make, deliver and return levels (Lockamy and McCormack, 2004; Salazar et al., 2012). Taticchi et al., (2013) argue that while the SCOR model is widely implemented across the industry, its use in the academic literature received very little attention.

4.1 Sample selection

This study examines FPOs located in the southern state (Tamil Nadu) of India that produce rice and millets as their predominant agricultural output where the growing of millets were reintroduced through government initiatives (Kurumanath, 2016). Multiple case studies were employed to enable us to explore the differences within and between cases to identify the commonalities that may exist across cases with different characteristics (Yin, 2009). We have used purposive sampling to select sites and participants to ensure that innovative practices are implemented to some extent within their FSCs. Each of the FPOs selected for this study is made up of a large number of farmers ranging from 170 to 1000. The selected FPOs are representative of other FPOs in terms of the structure and functionality and so the findings can relate to other FPOs. The details of the chosen case organisations along with the description of their FPO, products procured from member farmers, products supplied to customers and FSC activities are summarised in Appendix - Table A1.

4.2 Data collection

For the data collection purpose, we have conducted a semi-structured interview with the head of each FPO and its farmer members. A total of four FPOs agreed to be interviewed. From each FPO, five farmer members and the head of that FPO were interviewed, so the total sample size is 24. Follow up calls were made multiple times for clarification purposes during the analysis. In order to make the interview process more effective, the interviewees were sent a brief guide to help them clearly understand the interview process. The interviews were conducted between

June and July 2018 and each interview lasted 30 to 50 minutes. The questionnaires used in this study are summarised in Appendix - Table B1. The first section of the questionnaire focused on the structure of the organisation. The second section explored the kinds of collaboration taking place within FPOs and the innovative practices that are currently being pursued. The final section gathered details related to the benefits realised through the formation of FPO.

We adopted an inductive approach for developing the integrated framework applicable to the FPOs. The findings from each FPO are consolidated and analysed separately, and a cross-case analysis was undertaken to examine for similarities and differences (Eriksson and Kovalainen, 2008). Five researchers with familiarity in SCI and sustainability were involved in the data analysis process to assess the four cases, providing reflections on the innovative practices and the collaborative efforts involved. Following multiple stages of discussions, the conclusions reached by each researcher were consolidated. The findings from this exercise were conveyed to all the interviewees to confirm the findings.

5. Research findings and discussions

The analysis of this study found that each of the four FPO organisations underpinned by the new business model had adopted various innovative practices through collaboration with stakeholders; and that this resulted in a series of innovative practices that had an economic, environmental and social outcome. This section provides details on these findings.

5.1 Innovative practices emanating from collaboration and leading to sustainable outcomes

The analysis of the four case studies demonstrates how each entity within the FSC collaborates with other by sharing information and jointly making (selected) decisions (Barratt and Oliveira, 2001). Each innovative practice identified, directly contributes to one or all the three sustainability dimensions. The FPOs were found to be characterised by awareness and understanding of the importance of collaborative efforts and interdependencies between the individual farmers and their impact on each other’s business operations. In Table ***1***, we illustrate the different innovative practices arising out of the FPO collaboration and represent the innovative practices under each level of the SCOR model across the four FPOs. Code IPP1 represents innovative practices at the plan level and IPS1 represents the innovative practices at the source level; similarly, for make, deliver and return level are considered.

Table 1 Innovative practices emanated from collaboration at each level of the SCOR model

Level	Innovative Practices	Code

Plan	Seamless flow and transparency of information among the FSC members	IPP1
	Crop selection strategy based on demand information shared by FPO and soil test report obtained by farmers	IPP2
	Maintaining a database of farmer details regarding crops grown, production capacity, etc.	IPP3
Source	FPO gathers and provides knowledge on best farming practices to farmers (SRI, Drip Irrigation, etc.)	IPS1
	Procuring from registered farmers	IPS2
	Training to farmers on best farming practices	IPS3
	Supply of farm inputs to farmers	IPS4
	Training farmers on seed production organically	IPS5
	Establishment of the farmer knowledge centre	IPS6
	Procuring premium quality products from selected farmers and selling as seeds	IPS7
Make	Value addition to obtain product variants based on customer requirements	IPM1
	Employment for the local population, especially for female employees	IPM2
Deliver	Social media in order processing by collaborating with customers to ensure on time delivery of products	IPD1
	Elimination of intermediary to provide direct delivery to customers	IPD2
	Demand aggregation through Social Media by collaborating with customers	IPD3
Return	Recycling of wastes obtained from the grading process	IPR1
	Reuse of low-grade items as raw material for cattle feeds	IPR2
	Bio-fertilizer production	IPR3
	Development of waste processing equipment	IPR4

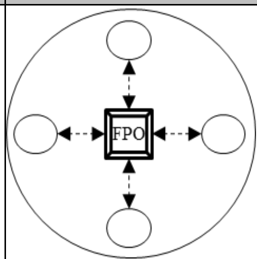
Plan Level

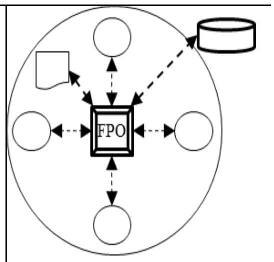
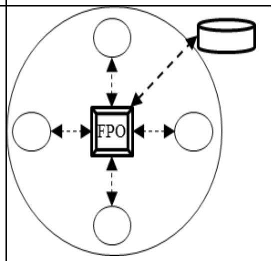
In the SCOR model, the planning level focuses on activities related to demand and supply planning and management of proper information flow among the entities of the FSC. The SCOR plan level also includes activities related to improving and measuring the FSC efficiency spanning across inventory, assets, transportation and regulatory compliance, amongst others.

In the upstream of FSC, FPOs are gathering information regarding market trends, price of the products in the market, stock availabilities, minimum support prices for the crops grown, customers' preferences and feedback on the various products that are supplied to the customers (Melander and Pazirandeh, 2019; Nakandala and Lau, 2019). All this information is shared with FPO members (IPP1) during the training programs, bi-weekly meetings and by SMS and social media applications such as WhatsApp and Facebook groups. This information helps FPO members with planning crops in terms of seasonal crop selection, seed variety selection, agricultural inputs planning, sowing and harvesting schedules. This ensures a maximum return for their crops and also strengthens the relationships with both upstream and downstream entities of the FSC by providing timely and quality supply of harvested food products (Kim, 2009). Further sharing of information related to the way the products are grown improves customers' confidence and willingness to pay more for the products (Wognum et al., 2011; Zhang et al., 2018). The ability of the FPO to contact customers directly regarding their purchase intentions is an innovative process, which did not exist in traditional FSC settings, where lack of demand information resulted in either over or under production, price variability and food wastage.

In Table 2, we summarise the different types of innovative practices pursued by each FPO. The figures in the last column illustrate the process view of how innovation is occurring. For example, the process view of IPP1 illustrates the interaction farmers have with each other through this business model innovation (FPO). Selected quotes from the interview process are provided in the fifth column for each of the innovative practices.

Table 2 Innovative practices, innovation type and sustainability dimension - Plan level

Innovative Practices	Adopted by	Type of Innovation	Sustainability Dimension	Quote Evidence	Process View of Innovation
IPP1	FPO1, FPO2, FPO3, FPO4	Process	Economic, Social	*We share the demand information with farmers to make sure that the products are ready by the time demand arises….* *We receive demand information for each product from each departmental store to which we are selling our products. This information is shared with our farmers*	

IPP2	FPO1, FPO2, FPO3, FPO4	Process	Economic, Environmental	*We combine the demand information with soil test reports to select the crops to harvest in a particular season.*	
IPP3	FPO1	Technological	Economic	*We maintain documents for all 300 farmer members of our organisation about the type of products growing, expected harvest date and expected yield. This helps us to be market ready by targeting yields. This also ensures the continuous availability of supply of farm products in raw form and helps plan our future sale.*	

In an unsophisticated and developing agricultural market, farmers typically decide what to grow based on their own familiarity with the product and its market, basic evaluations of profitability, the crop that the neighbouring farmers are growing (the 'bandwagon effect') or by selecting commonly available crops that are sold in higher volumes (Aggarwal and Srivastava, 2016; Gardas et al., 2017). This uncoordinated approach to crop plantations often results in an oversupply to the market. To improve the efficiency of crop selection, the FPOs examine demand information from customers and market forecasts along with soil test reports from farms to determine the appropriate crops to grow during specific seasons (IPP2). Soil test reports helps to ensure that the land is sufficiently fertile to produce the crop and that the volume required can be achieved with minimal environmental impact and cost (Bachinger and Zander, 2007).

Before the formation of FPOs, farmers rarely focused on estimating the yield of crops (Balaji and Arshinder, 2016). Now, with yield data, FPO's are better able to negotiate on volumes and prices. For example, one FPO (FPO4) introduced a technological intervention in their FSC through the introduction of an electronic database of farmer members (IPP3) using the Microsoft Excel tool. This database contains records of the number of acres of land used for growing each crop, crop variety, expected yield and expected harvest date. This database helps the FPOs estimate the total supply and updates the customers on the availability of products and manages the orders to reduce stock uncertainty, maintain market price stability, meet its commitments to the customers and maximise the margins realised by the farmers.

The process view of technological intervention across FSC can be seen in Figure 4. This process view can be a precursor to develop advanced Internet of Things (IoT) enabled technologies and guide an algorithmic view to developing decision support systems. The real time data with this process view would help in forming various algorithms to forecast demand, manage the logistics issues and enable decision making on prices and costs while maintaining transparency in the system (Saadatfar et al., 2020).

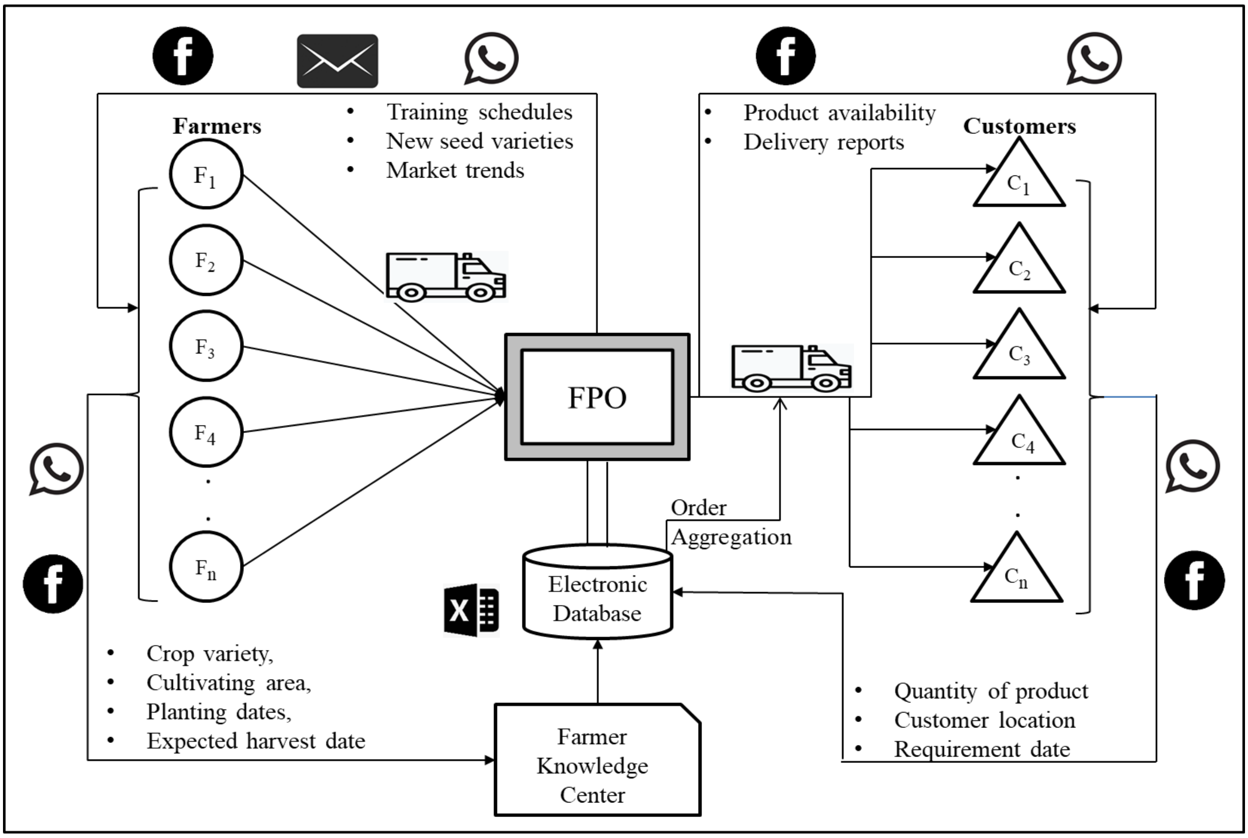


Figure 4 Technological interventions supporting FSC operations (Icons used in the figure are downloaded from www.flaticon.com)

Source Level

At the source level, the procurement of products from appropriate suppliers at the right time is ensured (Salazar et al., 2012). By procuring only from registered farmer members (IPS2), FPOs are able to eliminate the uncertainty typically associated with supply (Saritas and Kuzminov, 2017). This in turn reduces the uncertainty in demand for their produce.

A lack of awareness about the best farming practices is one of the reasons for lower productivity (Balaji and Arshinder, 2016). To address this issue, dissemination of information gathered from conferences and workshops on farming-related technologies and best practices helps to improve farming practices (IPS1) significantly. FPO1 and FPO3 provide a variety of training programs for their farmer members (IPS3) at regular intervals. The training programs cover crop development, integrated pest management and new water irrigation methods, to name a few. In addition to these training programs, FPO1 has been providing training to the farmers on organic farming and production of bio-fertilizers using organic processes (IPS5). Training programs such as these also provide a platform for farmers to interact with other farmers and share their experiences on these agricultural practices (Nakandala and Lau, 2019). FPO4 established a farmer knowledge centre (IPS6) enabled with computers with an internet connection, digital display board to show the latest agriculture related news, agricultural-related newspapers and magazines. This helps to increase the awareness amongst FPO members on the best farming practices around the world, day to day price of commodities, new seed varieties, weather related information, new irrigation methods and farm equipment related information (Melander and Pazirandeh, 2019). Through this process, the FPO maximises its revenue through informed decision making and efficient use of resources and strengthens its relationship with farmer members by sharing this information.

FPOs also contribute to alleviating the pressures on government by reducing farmers' reliance on subsidies. For example, FPO1 uses the power of collective action for the procurement of agricultural inputs at lower prices and supplying them to the farmer members of FPO (IPS4). The collective procurement of agricultural inputs has also reduced the overall cost of transportation for individual farmers. This innovative practice has benefitted the FPO members by ensuring timely availability of the agricultural inputs such as fertilizers and pesticides throughout the season at a much lower price - about 10-15% lower than the market price. Through this innovative practice, the FPO is addressing one of the major constraints faced by Indian farmers – limited access to finance to procure the required agricultural inputs to produce quality output (Bikkina et al., 2018). Table C1 illustrates the different innovative practices undertaken by the FPOs at the source level and their corresponding impact on sustainability practices.

Although the introduction of fertilizers and pesticides in agriculture has increased crop yields, it has also resulted in soil pollution that has adverse consequences on human health and the ecosystem (Igbedioh, 1991). However, as society has grown to realise the benefits of organic food production, this sector of the market has been on the rise (Quah and Tan, 2009). One FPO (FPO1) has made it their focus to procure and sell only quality and hygienic products that are grown organically. To achieve this, it has provided training to farmer members on organic farming techniques on the use of bio-fertilizers in agricultural production (IPS5) as a means of reducing the environmental impact and inefficient resource use (IPS7). These innovative practices have created better market reach and reputation among consumers and farmers alike, which in turn have resulted in increased revenue generation.

Make Level

In the make level, the activities related to production management to meet the customer requirements are discussed and listed in Table C2. At the planning level, each FPOs gathers customer feedback on product requirements to ensure continuous improvement of business processes (Cao and Zhang, 2011). To meet customer requirements, the FPOs produce multiple variants of products through the value addition process (Nakandala and Lau, 2019). For example, instead of selling the harvested paddy in raw form, FPOs are encouraging farmers to process and produce different variants of rice - flattened, boiled, boiled-broken and other variants, as a way to increase sales and revenue through the provision of differentiated products.

In addition to increased sales, value addition activities have created additional job opportunities across the production lines. These job opportunities are filled by the local population, particularly by women (IPM2) from neighbouring villages, which enhance their economic status and promotes empowerment of women (Labuschagne et al., 2005).

Deliver Level

The delivery level of the FSC involves all the activities related to order management, transportation and on-time product delivery (Salazar et al., 2012). With the advent of technology in the contemporary business world, technology plays a crucial role across the entire FSC operation, including forecasting, transportation and order tracking (Gong et al., 2015). As shown in the process view in Table C3, each of the four FPOs is making use of the available technologies, in particular, social media applications such as Facebook and WhatsApp. Using Facebook and WhatsApp group services, the FPO connects with its customers and updates them about order delivery status (IPD1) which in turn helps customers to track their orders in real-time. Also, by eliminating the intermediaries for logistics and transportation management, FPOs are able to provide the product at a better price as compared to the market price to the customers.

In addition to this order processing, FPO1 uses social media applications to update their customers about stock details and receive orders from customers. Aggregation of orders help FPO1 to ensure that sufficient demand is available (IPD3) for the product and helps to plan its supply and transportation related decisions. This also reduces the uncertainty in supply and brings down the cost of transportation for delivery (Trebbin and Hassler, 2012).

Furthermore, to reduce storage losses due to insects, FPOs keep insect traps and pack food products only when the order is received. Once the order arrives, the products are packed and sent directly to the customer's location, eliminating the need for intermediaries (IPD2) who have undertaken this task in the traditional FSC. FPO4 has opened retail outlets to sell its products to the customers. This elimination of intermediaries in the wholesale and retail structure reduces costs and increases farmers' profit.

Return Level

According to Genovese et al. (2017), waste is increasingly being reconceptualised for continued value creation as resources to be 'reused, repaired, refurbished and recycled'. The reuse of waste and its by-products is an important activity in the production processes of the FPOs as shown in the process view (last column of Table C4). For example, FPO1 processes the low-quality paddies to produce husks instead of using them for land filling or burning (IPR1). Selling these husks back to the farmers provides additional revenue to the FPO while also reducing the environmental impact that arises from landfill or burning of paddies. Not every FPO has fully embraced comprehensive waste management practices. Yet, its introduction is changing farmers' attitudes and appreciation of new business models that extend the life-use of input resources (Bocken et al., 2016). As noted by Parfitt et al. (2010), innovative practices can help discover new life cycles for food waste that arises throughout the FSC.

FPO2 reuses the wastes coming out of coconut oil extraction as a cattle feed (IPR2). This creates an additional income to the FPO while avoiding the environmental impact. Similarly, FPO4 follows composting practice to handle the waste and generates bio-fertilizer (IPR3). This bio-fertilizer is again used back in the farm. An innovative waste processing equipment called 'Haritaki' was developed by FPO4 to process agricultural wastes into bio-fertilizers (IPR4).

This bio-fertilizer is sold to farmers to use as an input during plantation, which reduces their dependence on chemical fertilizers. Through this innovative waste-recycling and reuse process, FPOs are able to reduce the environmental impact through recycling and encourage reductions in the use of virgin materials into the production process.

5.2 Integrated framework on collaboration and Innovation in Sustainable Food Supply Chain

Based on the innovative practices identified in this study, we illustrate how sustainability can be achieved at the different levels of SCOR by consolidating these results in a conceptual framework, as illustrated in Figure 5. This framework is an extension and application of the framework proposed by Gao et al. (2017) which did not identify how innovative practices impact the sustainability dimension across the FSC. This framework has been developed based on the empirical findings from the FPOs.

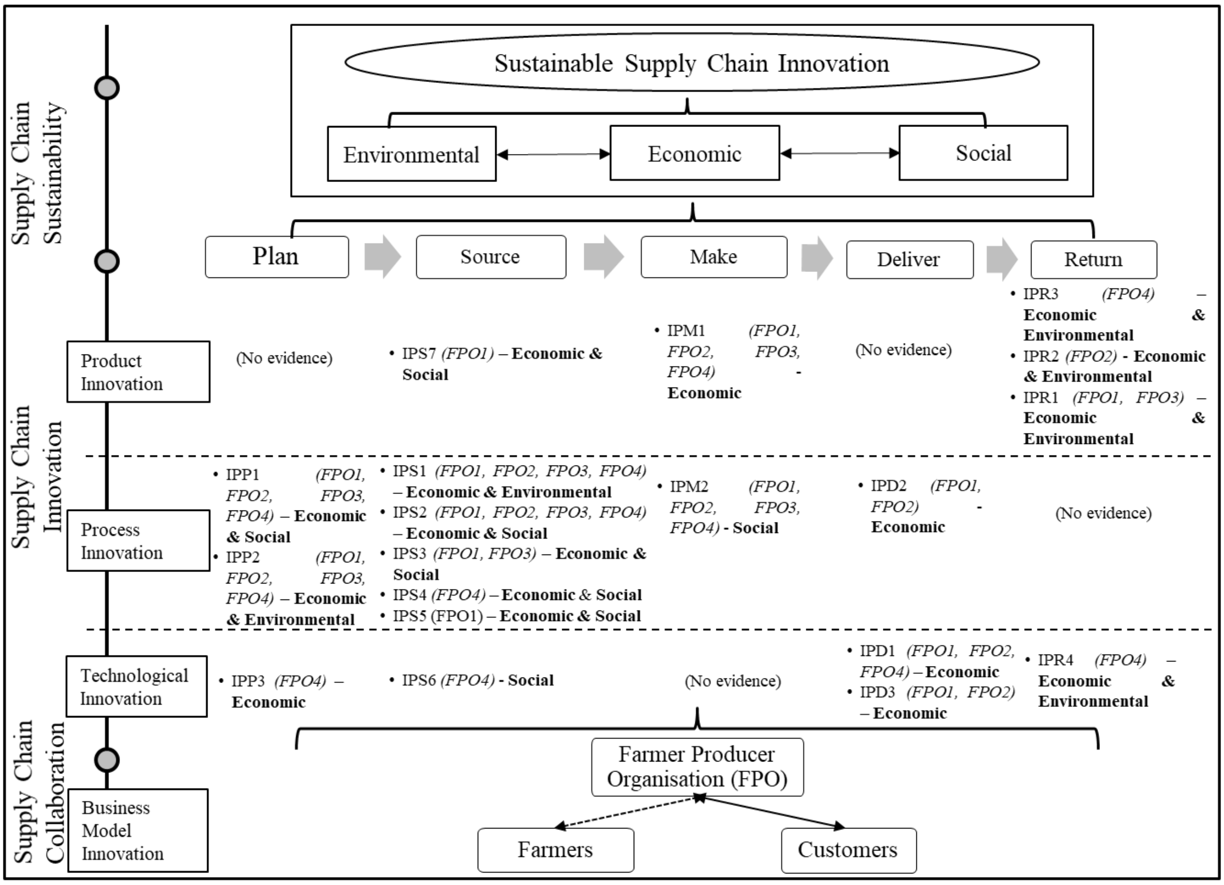


Figure 5 Framework of Classification of Innovative Practices at each level of the SCOR model

From Figure 5, it is possible to identify at which level of the FSC innovation is more pronounced and where there is a need for improvement through a process of innovation (an 'innovation gap'). It is also evident from Figure 5 that the number of innovative practices occurring at the source level is greater when compared to all the other levels. This highlights the benefits that farmer members gain from the introduction of this collaborative based business model as theorised by the economic model in Section 3.2.

6. Theoretical, managerial implications and policy recommendations

This study contributes to the SCI and sustainability literature by providing insights into how collaboration within FPOs drives innovative practices and improves sustainable outcomes across the FSC. The current study extends previous work to bring novel contributions to the literature in different ways. First, the study seeks a comprehensive approach to demonstrate an integrated innovation comprising of the three most common types of innovation, including product, process and technology innovations. Second, using the SCOR model as an analytical framework, different core functions and entities of the FSC are analysed. Third, this study explicitly evaluates the impacts of innovation on three different dimensions of SCS. Fourth, this study extends and makes a novel theoretical contribution to DCT, which was used as theoretical grounding to explain the impacts of SCC on SCI and the relationship between innovation and sustainability in the FSC. Fifth, this study addresses the call for a case study based research to validate the relationship between SCS and SCI by Gao et al., (2017). Sixth, the findings strengthen the linkage among SCI, FSC and sustainability literature, which was attempted by previous researchers.

The findings are also important to innovation and FSC practitioners. Managers can use the comprehensive framework constructed in this study as a reference for considering the initiatives and strategies such as collaborating with FSC partners for better innovation readiness and success. Acknowledging the anticipated benefits of SCI regarding the sustainable outcomes can also motivate practitioners to implement innovation practices across the FSC, simultaneously providing them measures to assess whether the innovation fulfils their sustainable goals.

Based on the outcome of this study, five broad policy recommendations across three broad categories are suggested:

1. *Motivating collaborative network formation*

    - The ‘collaborative network’ business model should be promoted to other regions of India by demonstrating and communicating the gains in terms of economic, environmental and social benefits.

- To support the establishment of collaborative platforms that facilitates collaborative interactions between FPO members and end-users (customers).

2. *Supporting collaboration via infrastructure development and technology assistance*

    - Provide financial support to FPOs to acquire advanced technology for cultivation, processing and packaging; and for expanding the scope of operations. The government should consider low-interest loans to increase the long-term viability of these collaborative arrangements.
    - Provide education to encourage technology adoptions through training programs, conferences and other equivalent means to expand the farmers' education.

3. *Fostering collaboration between Industry, Government and Research Institutions*

    - Foster greater collaborations between FPOs, government and research institutions, so FPOs can leverage external expertise to address specific problems and challenges.

7. Conclusion, Limitations and Future Research

Firms engage in innovative practices as a means of competitive strategy and consider innovation as an important method for their survival and gaining a competitive advantage (Gao et al., 2017). We address the research questions on how the formation of the new supply network, underpinned by collaboration lead to innovation; and how innovation leads to sustainability practices at all the operating levels of the FSC. The findings demonstrated that FPOs contributed to new innovative practices that were not present pre-FPO establishment, indicating that the dynamic capabilities (i.e. resource orchestration, co-value creation) enabled the FPO and their member farmers to reconfigure resources and apply these new practices on their farms in innovative ways, resulting in sustainable business outcomes (Gruchmann et al., 2019).

The findings suggest that the innovative practices at each level of the SCOR model have a clear and significant impact on one or more dimensions of sustainability across the FSC. This is consistent with the proposition put forward by (Gao et al., 2017). These findings also affirm that the farmers are able to balance economic, social and environmental values and practices (Aguinis and Glavas, 2012) and demonstrated how these practices manifested into value creation, delivery and capture mechanisms through the process view of interactions amongst different stakeholders (Foss and Saebi, 2018). These findings collectively illustrate the benefits but having a quantifiable measure of these specific benefits is the next step in this area of research beyond that identified from the interviews.

Although the sustainable benefits of this collaborative innovations are identified from the interview, the quantitative measure of economic, environment and social benefit of FPO formation is not done, which is one of the limitations of this study. Future researches could also consider quantifying the sustainable benefits of FPOs. Modelling this innovative FSC network to optimise the network is also an avenue for future research. One could also explore how technological intervention would further boost innovative practices across the FSC levels of FPOs.

Acknowledgements

We thank the CEOs of Farmer Producer Organisations for their support and valuable insights.

APPENDIX A

Table A1 Summary of the four FPO case organisations

FPO	Year	FPO membership	Procured products	Supplied products	Supply chain and associated practices
FPO1	2012	A self-funded organisation consists of 6 members in its board and 170 farmer members from nearby villages.	Premium quality raw and processed seeds of Paddy, Pulses, Vegetables and Fruits.	- Paddy seeds through “Seeds to Sale” program. - Boiled rice, brown rice, broken rice.	- Procurement of farm products from its member Farmers. - Support farmers by providing fertilizers, pesticides, etc. at low cost. - Processing at FPO. - Direct sales to its customers in the neighbourhood and across Tamil Nadu.

FPO2	2015	A self-funded organisation consisting of 10 members in its board and 200 farmer members from different districts.	Millets, multiple traditional paddy varieties, pulses, jaggery, oilseeds, coconuts and sesame, etc.	- Organic food products - Boiled rice, crushed rice, ragi flour, pearl millet flour, etc.	- Procurement of farm products from its member farmers at 10% higher price than which farmers would get upon directly selling in the local market. - Processing of raw products at FPO's own mills. - Packed and directly sold/sent to customers.
FPO3	2014	A self-funded organisation with 5 members in its board and 1000 registered farmer members from different districts.	Millets such as barnyard millet, little millet, finger millet and sorghum, etc.	- Both organic and non-organic food products. - Little millet flour, barnyard millet flour, ragi flour, etc.	- Procurement of farm produce directly from farmers. - Processing of raw produce at the FPO. - Packed and distributed to departmental stores. - Sold to customers through departmental stores.
FPO4	2015	A self-funded organisation formed through tribal health initiative program consisting of 5 members in its board and 300 farmers.	Millets, spices, pulses, vegetables and fruits.	- Ragi flour and barnyard millet powder. - Organically grown vegetables, greens and milk products.	- Procurement of farm product from farmers. - Provides training and employment to women in nearby villages - Processing at FPO. - Distribution to retail outlets. - Sold to customers through their own retail outlets.

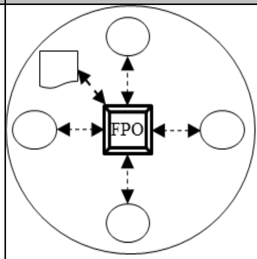
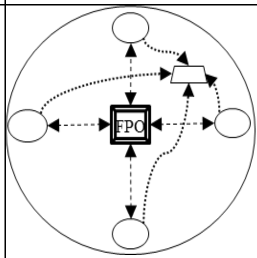
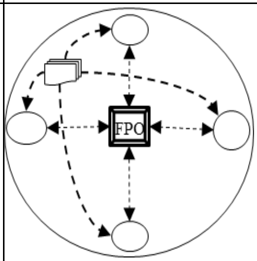
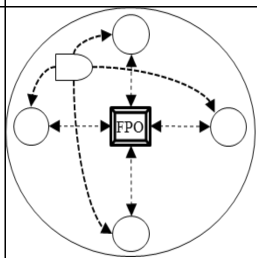
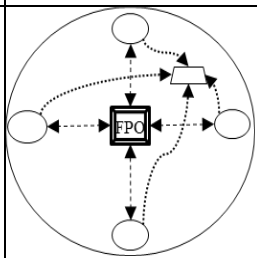
APPENDIX B

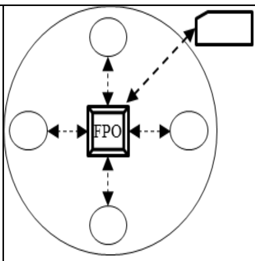
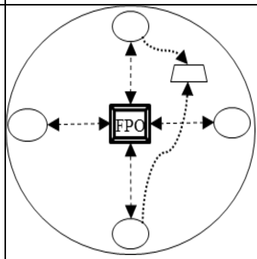
Table B1- Questionnaire used in the interview process

S. No.	Question
Section 1: Details of the case organisation	
1	What is the size of your organisation?
2	When was your organisation formed?
3	What are the products you are procuring from farmers?
Section 2: Identification of Innovative Practices	
4	How is the interaction between FPOs' members (i.e. resource sharing, assisting each other in operational processes, joint problem solving)?
5	How is demand aggregation occurring in your organisation?
6	How are products distributed to customers?
7	What are the different value-adding processes carried out on the purchased product and sold to customers?
8	What are the different practices (i.e. improving existing processes and implementing new technologies) that have been employed? And how often?
9	What wastes have been identified across the supply chain and how are these being tackled?
Section 3: Benefits of formation of FPO and innovation adoption	
10	What support are the farmers receiving through the formation of this FPO?
11	What are the different benefits you are seeing through this business model?
12	What benefits (i.e. financial, employment, working environment, equality etc) are the FPO or the food supply chain in general receiving from those innovative practices?

APPENDIX C

Table C1 Innovative practices, innovation type and sustainability dimension - Source level

Innovative Practices	Adopted by	Type of Innovation	Sustainability Dimension	Quote Evidence	Process view of Interaction
IPS1	FPO1, FPO2, FPO3, FPO4	Process	Economic, Environmental	*Through drip irrigation method, we were able to save up to 60% of water. To control 'rhizome rot' of turmeric, we identified a new strategy of sowing various grains and millets together with turmeric and blending the grown plantings in field.*	
IPS2	FPO1, FPO2, FPO3, FPO4	Process	Economic, Social	*We provide 15% more price for the products we procure from our registered farmer members when compared with market price. We are doing payments within a weeks' time.*	
IPS3	FPO1, FPO3	Process	Economic, Social	*In the initial stage, once the farmer joins our FPO, we provide training to farmers to grow products through organic methods.*	
IPS4	FPO4	Process	Economic, Social	*We provide farm inputs at the lowest price by procuring in bulk quantity directly from the factory.*	
IPS5	FPO1	Process	Economic, Social	*...Our ultimate aim is to supply high quality products to the customer. Therefore, we provide training on producing organic inputs.*	

IPS6	FPO4	Technological	Social	*We have established a farmer knowledge centre with computers and agriculture related articles for the farmers use.*	
IPS7	FPO1	Product	Economic, Social	*We procure grains and millets from selected farmers and sell those grains for seeds after cleaning and grading the seeds.*	

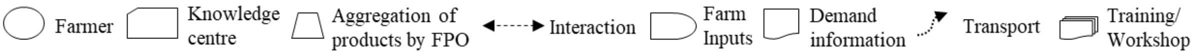
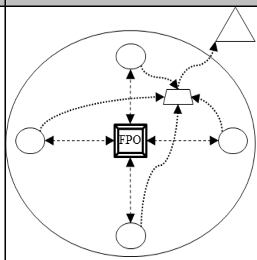
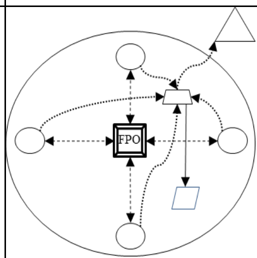


Table C2 Innovative practices, innovation types and sustainability dimension - Make level

Innovative Practices	Adopted by	Type of Innovation	Sustainability Dimension	Quote Evidence	Process view of Innovation
IPM1	FPO1, FPO2, FPO3, FPO4	Product	Economic	*...depending on customer requirements, we produce different variants from the same food product such as boiled rice, flattened rice and broken rice, etc. ...once we collect the raw product from farmers, it undergoes multiple processing to obtain product variants ...multiple product variants we are producing based on customer requirement.*	
IPM2	FPO1, FPO2, FPO3, FPO4	Process	Social	*We provide employment for local population in our mills.... After providing proper training on value addition process.*	

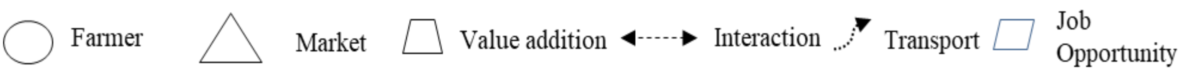
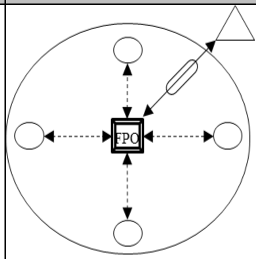
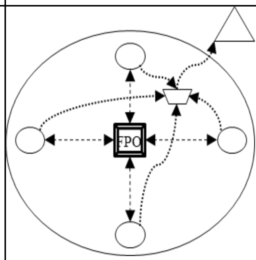
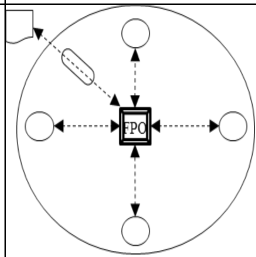


Table C3 Innovative practices, innovation types and sustainability dimension - Deliver level

Innovative Practices	Adopted by	Type of Innovation	Sustainability Dimension	Quote Evidence	Process view of Innovation
IPD1	FPO1, FPO2, FPO3, FPO4	Technological	Economic	*We reach our potential customers through social media applications for processing their orders.*	
IPD2	FPO1, FPO2	Process	Economic	*.. The products are directly sent to the customer's location without any intermediary like wholesaler and retailer in the traditional food supply chain, which ensures a single margin on the product and best price for the customer.*	
IPD3	FPO1	Technological	Economic	*…orders are aggregated through social media applications.* *We update our regular customer about the stock availability through social media such as Facebook and WhatsApp and receive the orders from them.*	

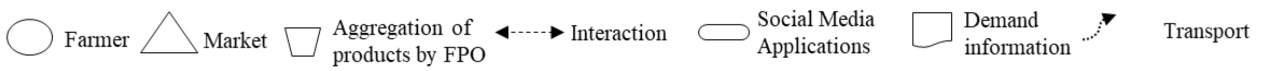
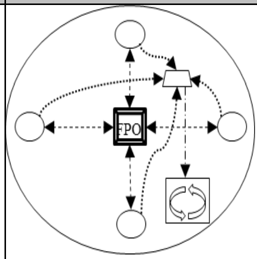
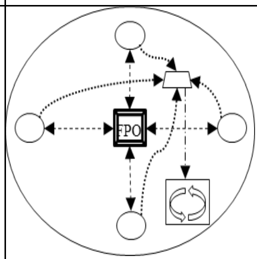
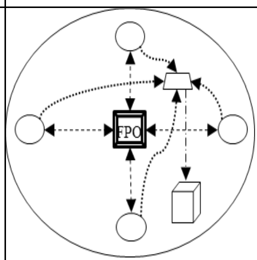
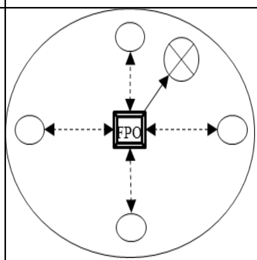
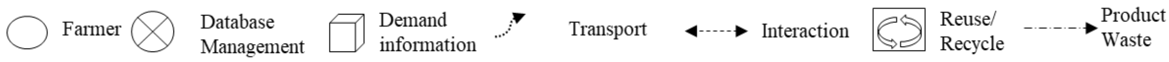


Table C4 Innovative practices, innovation type and sustainability dimension – Return level

Innovative Practices	Adopted by	Type of Innovation	Sustainability Dimension	Quote Evidence	Process view of Innovation
IPR1	FPO1, FPO3	Product	Economic, Environmental	*Around 10 to 20 percentage of paddy we procure from farmers are of low quality, which cannot be sold for both seed and food product. We process these low-quality paddies for making husks We process the low-grade millet and sell them as a feed for cattle*	
IPR2	FPO2	Product	Economic, Environmental	*The coconuts procured from farmers are processed in our coconut oil making machine to get oil. During the process of oil extraction some wastages comes out of the machine. We dry those wastes, break it and then sell it to farmer members as a feed for their cattle.*	
IPR3	FPO4	Product	Economic, Environmental	*…compost the wastes to produce bio-fertilizer*	
IPR4	FPO4	Technological	Economic, Environmental	*We have developed a multi-portioned tank, which extracts bio-fertilizer from cow dung, wastes of fruits and vegetables through 'Haritaki' layers.*	



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