Exploring the relationship between digitalisation, resilient agri-food supply chain management practices and firm performance

Abstract

Purpose: This study aims to explore the mediating role of digital technologies-based Supply Chain Integrating (SCI) strategies on the agri-Supply Chain Performance (SCP) and Firm Performance (FP). This research has introduced recently emerged digital technologies such as IoT. Further, based on theoretical support and an extensive literature review, this research has proposed some hypotheses which have been quantitatively validated for their significance.

Design/methodology/approach: A conceptual model was formulated based on an extensive literature review. Data for this research was gathered from a survey completed by 119 respondents from different departments of agri-firms. Further, Partial Least Square (PLS) based Structured Equation Modelling (SEM) was used to test the proposed hypothetical model.

Findings: The results confirm that IoT-based digital technologies and supply chain processes (organisation integration, information sharing and customer integrations) have a significant positive correlation. Furthermore, supply chain practices are positively associated with SCP. Finally, it has been found that FP is positively impacted by SCP.

Research implications: This research is used to analyse the mediating impacts of digital supply chain processes as a linking strategy for SCP and FP. For practical purposes, this research provides investment decisions for implementing digital technologies in SC strategies. The findings have proposed implications for managers and practitioners in agri-firms based on existing theories - contingency theory and relational view theory. Also, this study suggests the deployment of smarter electronically based tags and readers which improve the data analytics capabilities based on auto-captured data. Thus, the availability of quality information improves the data-driven decisional capabilities of managers at company level.

Originality/value: This is a unique and original study exploring the relationship between digitalisation, resilient agri-food supply chain management practices and firm performance. This research may be extended to other industries in view of the results from SCP and impact of digitalisation.

Keywords: Agri-Food Supply Chain; Internet of Things (IoT); Supply Chain Integration; Resilience; Digitalisation.

1. Introduction

Agri-food industries involve organisations that seek to produce and turn raw materials into finished goods (agri-products), building networks of interaction starting from primary activities to consumers' feedback (Akhtar et al., 2016). An agri-food firm addresses the vital requirements that are mandatory for the sustainability of wellbeing on this planet (Ali et al., 2019). After the cultivation of agri-grains, several practices are implemented, such as processing, packaging, retailing and distribution by logistics' suppliers, until goods reach consumers within a specified period (Allaoui et al., 2018). About 1.3 billion tonnes, or thirty three percent of the global agri-food supply that is intended for individual consumption, is currently being lost and then dumped (Krishnan et al., 2020).

Agri-food sustainability is one of the major problems, as the global population may hit 9.7 billion by 2050, and there will be a rise in agri-food demand of between 59 and 98% (Schmitz et al., 2017). The factors contributing to agri-food wastage in the supply chain (SC) are shortage of warehouses, wastage disposal, processing degradation, insufficient packing, transportation delays and increased inventory caused by inaccurate forecasting (Bravi et al., 2019). Agri-food goods must be shipped on schedule through a digitalized Agri-Food Supply Chain (AFSC). The adoption of digital technologies, such as Internet of Things (IoT), will provide tracking of Supply Chain Management (SCM) practices more effectively (DaneshvarKakhki and Gargeya, 2019). The waste of agri-food goods that expire in warehouses is moderated by accurate tracking and shortened distribution time (Jagtap and Rahimifard, 2019). Further, the implementation of IoT is useful in allowing the SC to adapt more rapidly and increase efficiency (Wen et al., 2018). Emerging networking and data analysis technology may perform a novel function in the agri-food product life cycle in the digital world (Zhao et al., 2019). To make it relevant to all stakeholders, knowledge flow and governance across new technologies are essential considerations (El Bilali and Allahyari, 2018). To manage SCs in India, which is extremely dynamic and decentralized at differing stages, a range of knowledge and expertise are necessary (Behnke and Janssen, 2019; Naik and Suresh, 2018).

Through the introduction of new technology, the full value of the ASC structure may be recognized; companies can coordinate and make better decisions more easily (Kataike et al., 2019; Ulvenblad et al., 2019). The exchange of information throughout an SC will offer long-term gains, encouraging the participation of organisations (Dubey et al., 2019). IoT may assist as an integrating facility for real-time data sharing by decreasing SC ambiguity (Barnett et al., 2019). Lee et al. (2007) and Kumar et al. (2017), also discuss IoT-based Consumer Integration (CI), Supplier Integration (SI) and Organisational Integration (OI) on the performance of SC. Supply Chain Integration (SCI) with consumers requires tight collaboration and cooperation within the SC with potential consumers participating in tasks along with exchanging critical details (e.g. market forecasting, inventory status and processing strategies) over the defined mutual interaction platform (Kalyar et al., 2019; Jia et al., 2020). SCI with the supplier involves close collaboration and synchronization among a firm's suppliers involved in SCM (Birasnav and Bienstock, 2019). Internal SCI leads to aligning of processes within the firm's boundaries and SC operations (Turkulainen et al., 2017).

In several sectors, the advantages of IoT-based digital technology integration and aligning of SC stakeholders have been acknowledged; SCI is known to be amongst the key performance enhancement drivers (Flynn et al., 2010). However, there has been a range of viewpoints suggesting that SCI is not an appropriate performance improvement technique and that the comprehension of SCI is inadequate (Flynn et al., 2010). This incomplete knowledge about the impact of SCI practices continues to be an issue at academic and managerial levels (Childerhouse and Towill, 2000). As a result, more empirical studies on analysing the relationship between SCI and SCP have been called for (Rodrigues et al., 2004; Kumar et al., 2017). Based on the above discussion, reviewing the literature review and Table 1, the following research gaps have been identified for the benefit of future researchers:

- Most of the research has only focused on a particular stage of SCs; there is an absence of an integrated approach to examining all of the stages of SCs together e.g., processing, retailing, distributing etc. (Naik and Suresh, 2018).
- There is a gap in constructing a theoretical framework for IoT, SCM processes and FP based on hypothetical testing. Also, there is a lack of research in an empirical investigation to determine the perceived impact of IoT implementation in ASC which is positively correlated with SCP and FP (Stone and Rahimifard, 2018).
- Most of the previous empirical results are inconsistent in the IoT effect on SCI, SCP and FP. Some research has shown a positive correlation between SCI and FP while some studies have shown a negative correlation between SCI and SCP (Flynn et al., 2016). Thus, there is

a need to effectively analyse the actual impact of IoT on SCI, SCP, and FP to show conclusive results.

Thus, it is a prerequisite to empirically evaluate the impacts of SCI on financial performances from the viewpoints of both consumers and suppliers to assign additional parameters (Birasnav and Bienstock, 2019) and there is a need to create a framework for IOT adoption in SC and analyse its impact. In this regard, this study considers IoT-based digital technologies for integration in SC practices for company performance. The goal of this research is therefore to establish a theoretical structure for IoT, SCM activities and firms' performance by hypothesis validation (Fabbe-Costes and Jahre, 2008). This study requires an empirical study to analyse the actual impact of IoT on SCI, SCP, and FP by conducting a survey. Rönkkö et al. (2016) suggested using the partial least square methodology to analyse the empirical data for performance evaluation. In this research, the partial least square (PLS) has been adopted for evaluating the survey-based data as PLS is capable of handling small-size data for structural equation modelling (SEM). Further, the PLS approach has been chosen for its ability to support the initial phases of theoretical design. Also, there is no need for normally distributed data, independent data or uniform parameters (Yesil et al., 2013). Based on this discussion, the following research questions are proposed in this study:

RQ1. How can IoT technologies be integrated with agri-food SC practices at different stages?

RQ2. What are the impacts of IoT technologies on SC performance?

To analyse these research questions, the following research objectives have been set:

- To propose the theoretical backgrounds to support the relationship between IoT technologies and agri-food SC practices at different stages.
- To propose a hypothetical framework to analyse and uncover the previous inconclusive results.
- To analyse the proposed conceptual model to measure the IoT impact on SC performance and firm performance.

Smart PLS 4.0 software (Ringle et al., 2005) is used for primary data processing and it is a statistical tool for computing complicated multi-variable interactions between observable and latent variables (Navimipour and Zareie, 2015). This technique is often used in numerous social science fields of research due to its computability of small-size samples (Hair et al., 2017).

The paper is organized as follows. Section 2 details the literature review, section 3 explains the research design while section 4 gives the research methodology. Section 5 shows numerical illustrations, section 6 discusses the findings and finally, section 7 draws up the concluding remarks.

2. Literature review

Agribusiness in developed nations is currently in a process of transition from conventional to modern agriculture, meaning that the existing agri-food SC is faced with certain issues. Knowledge misalignment and unstable partnerships are two major concerns, contributing to poor competition and unsustainable agri-SCP (Mangla et al., 2018). In this regard, Spieske and Birkel (2021) presented a review on improving resilience in supply chains through adoption of digital technologies. The authors developed a framework that shows the relationship between digital technologies and its impact on enhancing resilience in the supply chain. The result of the study shows that velocity and visibility are the two resilience capabilities of supply chains that are improving most, due to digital technologies. Ali et al. (2021) proposed resilience strategies for food supply chains to tackle the COVID-19 pandemic. Hobbs (2021) suggested that adoption of digital technologies is necessary for long term resilience improvements in a food supply chain. Firms have also recognized that the use of IoT is a powerful way to address these challenges in SCs (Tu, 2018). Research has shown that the deployment of IoT among various stakeholders can minimize the lead-time of information sharing and strengthen relationships, thereby showing a positive correlation with AFSC (Li et al., 2009). IoT allows stakeholders to work remotely to manage activities relating to optimization of processing operations at an organisational level (Ojha et al., 2015). Also, IoT based SCI improves the flexibility within the agri supply chain (ASC); this increases the efficiency of organisations. Previous literature (Ben-Daya et al., 2019) has acknowledged the inter-relationship between SCI and agility, concluding that an agile SC may deal better with external market conditions and that collaboration-based integration may place a greater influence on the FP. Fayezi et al. (2017) concluded that the alignment of both inter and intra-SCI is responsible for the establishment of firms' successful SCs. Further, SCI may be considered a strategic tool which may enable a firm to quickly recognize and adapt to inter and intra-firm uncertainty based on effective SC collaboration. One of the studies by Waqas et al. (2022) suggested that risk management has a positive mediating role in agri-supply chain performance. Further, Muduli et al. (2022) also analysed the role of blockchain technologies in enhancing supply chain performance. The study also suggested that the adoption of digital technologies ensures the reduction of various threats that arise from pandemics and war. A study by Maaz and Ahmad (2022) also suggested that supply chain performance as a significant positive correlation with firm performance and even customer satisfaction played a significant mediating role between SC performance and firm performance.

2.1 Review of past works on IoT implementation in AFSC

Table 1 shows a review of past works on IoT implementation in AFSC. The studies are mainly classified as case studies, empirical-based studies, and literature works.

Table 1: Previous works on IoT adoption in AFSC

Authors	Techniques	Approach adopted	Research findings
Ali et al. (2017)	Covariance Based (CB) - SEM	Survey	Four important sources of Cold Chain Logistics Risks (CCLR) - temperature fluctuations, standards of packing, environmental hazards and agri-food qualities. Also, six resources or capabilities (multi skilled workers, effective collaboration, quality managing, certified practices etc.) are utilised for building resilient SCs. Further, SC resilience acts as a moderator among CCLR and agri-firm performance.
Attia (2018)	CB-SEM	Survey	As per the results of the analysis, Inbound Supply Efficiency (ISP) is positively influenced by Supply Logistics Integration (SLI). In addition, SLI and ISP may directly influence Competitive Performance (CP).
Moazzam et al. (2018)	Supply chain operations reference (SCOR) model	Case study	The proposed outlines of this study address the performance measuring metrics which consider the issues in the multi-tier subsystems of agri-food SC. The presented SCOR model is scaled at deeper levels for utilizing these metrics as a benchmark by different agri-food firms.
Han and Huo (2019)	CB-SEM	Survey	The findings demonstrated that various attributes of Green SCI (GSCI) showed varied consequences. Green OI laid the groundwork for both inter and intra firms' green practices, which further drive economic and social outcomes.
Puška et al. (2019)	CB-SEM	Survey	This research observed that innovation-based processes, flexibility and resilience are the main parameters in SCP. Also, the results showed a positive correlation between CI and firms' SCP.

Tarifa-Fernández et al. (2019)	Hierarchical multiple regressions	Survey	The findings confirmed that High Performance Human Resources' Practices (HPHRP) are key factors for improving the Absorbing Capacity (AC) or resilience of ASC. Also, findings observed that AC acts as a moderator between SCI or CI and SCP.
Zhao et al. (2019)	Bibliographic/ Network analysis	Literature review	Advanced IoT related technologies such as block chain may lead to implementation of traceability, data privacy. Further, this research has recognized several barriers such as scalability, bullwhip impact, high data storage cost, data management and lack of expertise.
Azwan et al. (2020)	(PLS-SEM)	Survey	The findings showed the clear association between environmental related fluctuations and SCI which included CI, SI and OI. Firms' ambidexterity or capabilities have a positive correlation with SCI. Also, SCI facilitates SC agility and firms' flexibility.
Wamba et al. (2020)	SEM-CB	Survey	The findings validated the hypothesis and showed that block chain implementations would boost efficiency of the SC. Results show, in addition, that information distribution and stakeholders' influence serve critical roles in the implementation of block chain by providing transparency in the SC.
Ali and Aboelmaged (2021)	Bibliometric Systematic Literature review	Literature review	The findings show that the main factors are a decrease in supply-demand asymmetry, fast-changing customer demands and cost optimization, whilst the crucial hurdles are a lack of cooperation, corporate reluctance, and lack of understanding.

2.2 Theoretical backgrounds

There are various theoretical lenses identified in this research as discussed below. Table 2 shows outcomes based on a theoretical approach.

- **Relational Based Theory (RBT):** As per the RBT approach (Alam et al., 2014), critical resources must not be restricted to the focal firms; these must be expanded to firms' boundaries to maximise stakeholder income. Stakeholders' income, the profit obtained by various partners of the firm, might not be possible if a business works in isolation. Collaborating firms may produce relational based income based on several capabilities; namely, investing in relation building approaches, effective collaboration, integrating IoT facilities, exchanging of information, efficient governing bodies, suppliers' involvement, trust etc. (Huang et al., 2014).
- **Contingency Theory (CT):** As per the CT approach, the performance of any organization is mainly based on the fit between the firm's strategies which must be followed in future and the firm's structure design. CT also considers the alignment among the firms' network design, basic processes and external market behaviour (Kim and Chai, 2016). Thus, attributes of SCI must be associated with contingent variables (Flynn et al., 2016). These include uncertainties

in business, SC structure, network design, government policies and innovative technologies for improving company performance (Wong et al., 2017).

Table 2: Theoretical backgrounds with relevant area and outcomes

Theory	Area of study	Outcomes variables
Relational Based Theory (RBT)	Supplier involvement	SC performance
	Collaborative advantage	Firm performance
	Production and information integration	Operational performance
	Knowledge exchange	SC performance
	Trust	SC performance
	Collaborative culture	Operational and Collaborative advantage
Contingency Theory (CT)	Alignment between SCI dimensions	Financial performance
	Competitive strategy, SCI	Logistic performance
	Business uncertainty and SCI	Firm performance
	IoT based SC dynamism and SCI	Operational performance
	National culture and SCI	SCI
	Technologies and demands ambiguity, SCI	Servicing based reduced cost

2.3 Coding of constructs and items

All six constructs and their 33 items are shown in Table A1 of the appendix. The six constructs that have been identified are IoT, OI, CI, IS, SCP and FP; based on this, 33 items have been identified.

2.4 Hypothesis formulation

Seven hypotheses have been formulated based on the six constructs as shown below in Figure 1. IoT is an evolving digital informational service infrastructure built on the cloud platform; it enables the sharing of commodities in global SC channels by creating value to all stakeholders (suppliers, consumers, firms' workers) (Green et al., 2017). The ubiquitous existence of RFID tags, sensors/actuators, and digital phones is stated to have the potential of real time tracking of all stages of AFSC, namely, procurement, transporting, warehouse, selling and returning of agri-products (Haddud et al., 2017).

This promotes an effective and reliable forum for the sharing of knowledge on commodities and services in the global SC (Mishra et al., 2016). Thus, beyond conventional ICT, IoT seems to have the ability to resolve the knowledge gap in current SC by collecting and operating the detailed data circulating between SC firms, equipment devices and other stakeholders (Tu, 2018). Additionally, RBT urges companies to exchange their essential capabilities with SC stakeholders in order to increase profits, which would be difficult to achieve if companies operate independently (Khanuja and Jain, 2021).

This extensive literature review has shown that IoT has the capabilities to assist with real-time information collection which facilities inter/intra-firm communicating and integrating activities (Zhang et al., 2017). In addition, IoT monitors the retail distribution process, shop advice, customer buying activity and brand monitoring where IoT can support consumers by tracing SC processes (from upstream to downstream) (Kumari et al., 2015). Thus, it may be hypothesized that:

H1: *IoT capabilities have a positive impact on inter/intra-firm integration.*

H3: *IoT capabilities have a positive impact on customer integration.*

IoT consists of various connectivity outlets, such as mobile networks, internet connectivity and knowledge platforms to create new interconnectivity across global projects, improving the speed of value-added activities for food business networks as well as their partners (Farhat, 2012). Real-time accessibility and processing of huge amounts of data are facilitated by cloud platform. The goal of the IoT framework is to bring individuals of shared interest for a commodity to a common forum to encourage the sharing of data among them, regardless of ranges dependent on geographical area (Whitmore et al., 2015). This provides users to control and monitor the transfer of knowledge and information within ASC (Srivastava, 2010). Huge volumes of data obtained from a wide variety of business processes, devices, equipment and sensors which are stored on remotely distributed servers called IoT cloud platform (Tsang et al., 2018). Real-time accessibility and processing of huge amount of data is facilitated by IoT platform. Furthermore, CT asserts that there is no ideal manner to utilise a data platform in every circumstance; instead, contingent variables (i.e., variables that the organisation cannot control) must be taken into account when working with consumers and other partners to develop and utilise data platforms (Shao et al., 2016; Morais and Barbieri, 2022). Thus, IoT based platforms may be seen as rapidly evolving and driving more data-driven initiatives with complicated SC practices (Zhou et al., 2015). Thus, it may be hypothesized that:

H2: *IoT capabilities have a positive impact on information sharing within ASC.*

Over the last few years, the inter-relationships between SCI and SCP have been extensively examined in many studies. Cook et al. (2011) found that SCI is helpful to both financially based efficiency and operationally based effectiveness. Kim and Chai (2016) examined the association between SCP and SCI based on the role of SCI in predicting market fluctuations. Further, Yu et al. (2018) utilised a study of agri-food firm to examine and conclude that II was favourably linked to both reactive and proactive resilience and increased the operational efficiency of the business.

Some studies have indicated that SCI might affect the efficiency of an organisation under some circumstances, since integration needs huge investment in data resources and external disputes may be generated (Yu, 2015). In addition, a higher degree of SCI may lead to unnecessary data and duplicitous actions (Evans, 2007). For evidence, Zhou et al. (2014) looked at the interaction between II, SI, CI and firm success and found that too little or too much SCI might hinder SCP. Thus, there should be optimum degree of SCI (inter/intra firm and CI) for achieving desired degree of SCP. SCI with consumers includes strong alignment (Kalyar et al., 2019; Jia et al., 2020) and collaboration within the SC of an organization with key customers engaged in activities such as the exchange of key details (e.g. market forecasts, inventories level and manufacturing strategies) over the defined mutual contact platform. Lastly, as per RBT, collaborative relationships (connectivity with stakeholders) provide an additional option of interpersonal rents, or super normal revenue made by collaborative initiatives of exchanged relationships, that is challenging to achieve while working separately (Wieland and Wallenburg, 2013). Thus, it may be hypothesized that:

H4: *Inter/intra-firm integrations have a positive impact on supply chain performance.*

H6: *Customer integration has a positive impact on supply chain performance.*

Effective communication provides a significant role in enhancing a firms' efficiency. Exchanging information provides the advantages of increased facilities and IoT infrastructure utilisation, cost savings and efficient control of SC activities (Kim and Chai, 2017). Firms with developing SCs may upgrade their consumers' and suppliers' demands by effective shared information which facilitates the IoT based visibility of SC processes (Zhong et al., 2017). Also, several studies have emphasized the type of outcomes achieved by efficient data exchange (Kembro et al., 2017). SC firms may upgrade their consumers' and suppliers' demands by effective shared information which facilitates the IoT based visibility of SC processes (Barratt and Barratt, 2011; Zhong et al., 2017). Also, several studies emphasized on type of outcomes achieved by efficient data exchanging (Marinagi et al., 2015; Kembro et al., 2017). Also, inter-firm data sharing facilitates the effective adoption of government policies which can give a firm advantage over its competitors (Guesalaga et al., 2018). Precise and on time data sharing among SC stakeholders allows quick decision taking for implementing various strategies that provide flexible and adaptive SCs (Ralston et al., 2015).

Furthermore, CT contends that a firm's objectives and requirements are effectively achieved when its leadership design is appropriate for the SC practices (explained by IoT technologies) and firms' adaptive capabilities (i.e., competing effects of governmental policies) within the fluctuating business system (managed by data sharing) (Abedin, 2022). Therefore, it may be proposed that:

H5: *Information sharing has a positive impact on supply chain performance.*

FP means a strategy that enables a firm to achieve the desired market and economically related outcomes. Also, firm performance may be measured based on its market shares, sales and competitive advantageous. There are several studies which have observed positive correlations between SCP and FP (Vanpoucke et al., 2017). For instance, SCI increased the effectiveness of data exchange within the SC (Qrunfleh and Tarafdar, 2014). This improved FP by decreasing inventory levels and their holding and carrying expenditure, and also by improving the on-time deliveries of agri-food products. Similarly, a high correlation has been observed between SC flexibility and FP (Kumar et al., 2020). Thus, the ability of the SC to produce and deliver products in response to consumer requirements results in improved FP (Huo et al., 2014). Therefore, it may be hypothesized that:

H7: *Supply chain performance has a positive impact on firm performance*

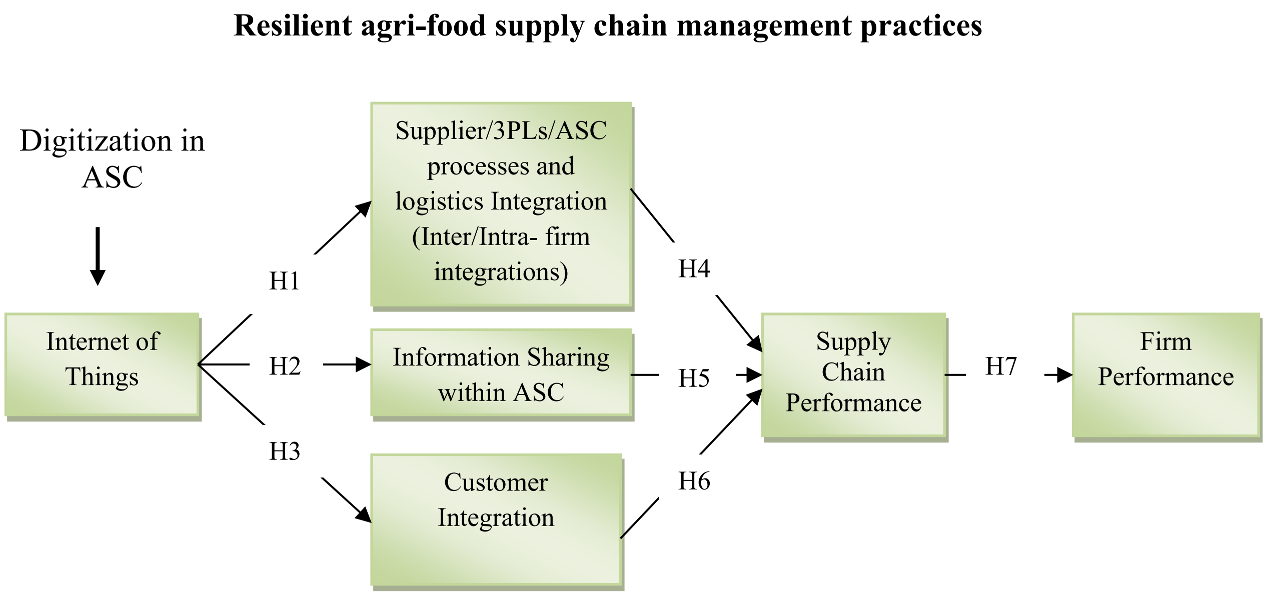

Figure1: Hypothesis framework of the proposed study

3. Research design

Research design consists of three sections. The first section represents the measuring instrument, the second section represents data collection, and the third section details the demographic profile of respondents as given below.

3.1 Measurement instrument

The questionnaire was created using a three-step procedure (Christmann, 2000). We first created a preliminary questionnaire after conducting comprehensive literature research to determine the measurements for the important variables. Then, in order to reduce task difficulty, expertise was invited to interpret our official English translation into their native syntax. To confirm the authenticity of the interpretation, this native language edition was converted again into English by additional professionals. Two English translations were compared to find any differences or contradictions. Finally, fifteen businesses participated in pilot tests. Based on a pilot test, we further improved and altered the questionnaire in response to their input to make sure it is clear and appropriate to procedures in Indian agri-food enterprises.

The data was gathered by using a well-prepared survey with a 7-point Likert scale. Lewis and Erdinç (2017) observed that a 7-point rating provides better inter-relationships among the variables. In comparison to open-ended mindset queries, 7-point Likert scale are easier to interpret, comprehend and also items are adaptable, and simple to assemble. Also, in order to measure a broader construct, one can acquire a summed value.

The final survey was conducted during June 2020–April 2021. The present research consisting of six latent constructs- IoT, OI, CI, IS, SCP and FP - were measured by 33 construct items. The next section of the survey includes demographic details about the survey participants as well as a profile of the firms.

3.2 Data collection

As suggested by Ketokivi and Choi (2014), the research utilized a quantified technique with samples gathered from food service and retailing industry managers using a purposively sample testing (gathering data from experts) approach from June 2020–April 2021 (Palinkas et al., 2015). The agri-food firm was purposefully chosen as a scenario and labelled as "ABC". It is a major agri-food retailing, processing and distribution firm. The firm was established in the 2000's, managing over 25 Indian urban centres with over 150 retailing platforms. The firm focuses on different prepacked agri items, transporting primary agri grains and fast moving agri goods like perishable vegetables to fulfil the demands of over two million customers. In each firm, we found a critical source who was well familiar with both intrinsic and extrinsic SCM practices. First, a phone conversation was made with these respondents to confirm their readiness to engage in the assessment and to encourage them to provide honest answers. Also, Google form of the questionnaire was created and mailed to around 250 concerned experts based on social media platforms such as WhatsApp and LinkedIn. Reminders were sent out again to all after 15 days. Following a two-week interval, we started a second wave of phone calls in an effort to increase the response rate. Finally, 213 valid questionnaires were used for further analyses, yielding a response rate of 26.63%. A total of 119 responses was obtained; the response rate of 47.6% is similar to other online studies (Chen and Paulraj, 2004).

3.3 Respondents and firms' characteristics

Respondent profiles and characteristics are given in Table 3. Also, the demographic profile of the firm, the firm size, and firm turnover are presented in Table 4.

Table 3: Respondents' profile

Demographic factor	Characteristics	Frequency	Percentage
Gender	Male	95	79.83
	Female	24	20.17
Education	Intermediate	35	29.41
	Graduates	60	50.42
	Post-Graduates	18	15.13
	Doctorate	6	5.04
Age in Years	25-35	26	21.85
	35-45	55	46.22
	45-55	25	21.01
	Above 55	13	10.92
Experience in Years	1-5	57	47.90
	6-10	34	28.57
	11-15	16	13.45
	Above 15	12	10.08
Designation	Top Management	74	62.18
	Research and Development experts	23	19.33
	Supply Chain Managers	7	5.88
	Agricultural institutions' experts	6	5.04
	Any other	9	7.56
Department	Procurement, retailing and purchasing	23	19.33
	Processing's operations and logistics	46	38.66
	Audit risk, compliance and Human Resource Management	19	15.97
	Technical infrastructure	14	11.76
	Any other	17	14.29

Table 4: Details agri-firms surveyed in the study

Type of agri-firm	Percentage	Agri-firm size (in terms of number of worker)	Percentage	agri-firm turnover (in millions)	Percentage
Primary agriculture processing	22%	<100	53%	<10	41%
Wholesale and retailing	15%	100-500	29%	10-30	27%
Third party logistics	45%	501-1000	13%	31-50	21%
Pre-packaged food industries	8%	>1000	5%	>50	11%
Any other	10%				

4. Methodology

SEM is a better approach than other statistical models (e.g. multi-regression method) for construct validation and evaluation (Soleimani et al., 2017). The current study objective is to analyze the conceptual framework; thus, PLS-SEM has been employed in this paper due to its benefits in this exploratory form of research and enrichment of existing literature (Gefen et al., 2011). The PLS approach mainly involves two kinds of models. The outers measuring model specifies the inter-relationships among latent constructs and items, while the inners structural model indicates the inter-relationships among the latent constructs. PLS is widely adopted for hypothetical-based model checking (Peng and Lai, 2012). Thus, the present research has employed the PLS technique since path modelling and testing of the proposed framework is the key objective of this research.

In PLS software a bootstrapped technique may be performed for larger sub-samples (5,000 sub-samples) (Chin, 1998; Peng and Lai, 2012) for estimating the models' path coefficients, statistics' significance and other dependent parameter values. The bootstrap approach is used for approximating the sampled distributions of an estimator by re-sampling or by replacing the original sample (Kumar et al., 2020). This study firstly checked the reliability of the collected dataset followed by a check of the convergent and divergent validity, drawing a structural model and measuring path coefficient for hypothesis checking. The stepwise procedure of Figure 2 is explained below.

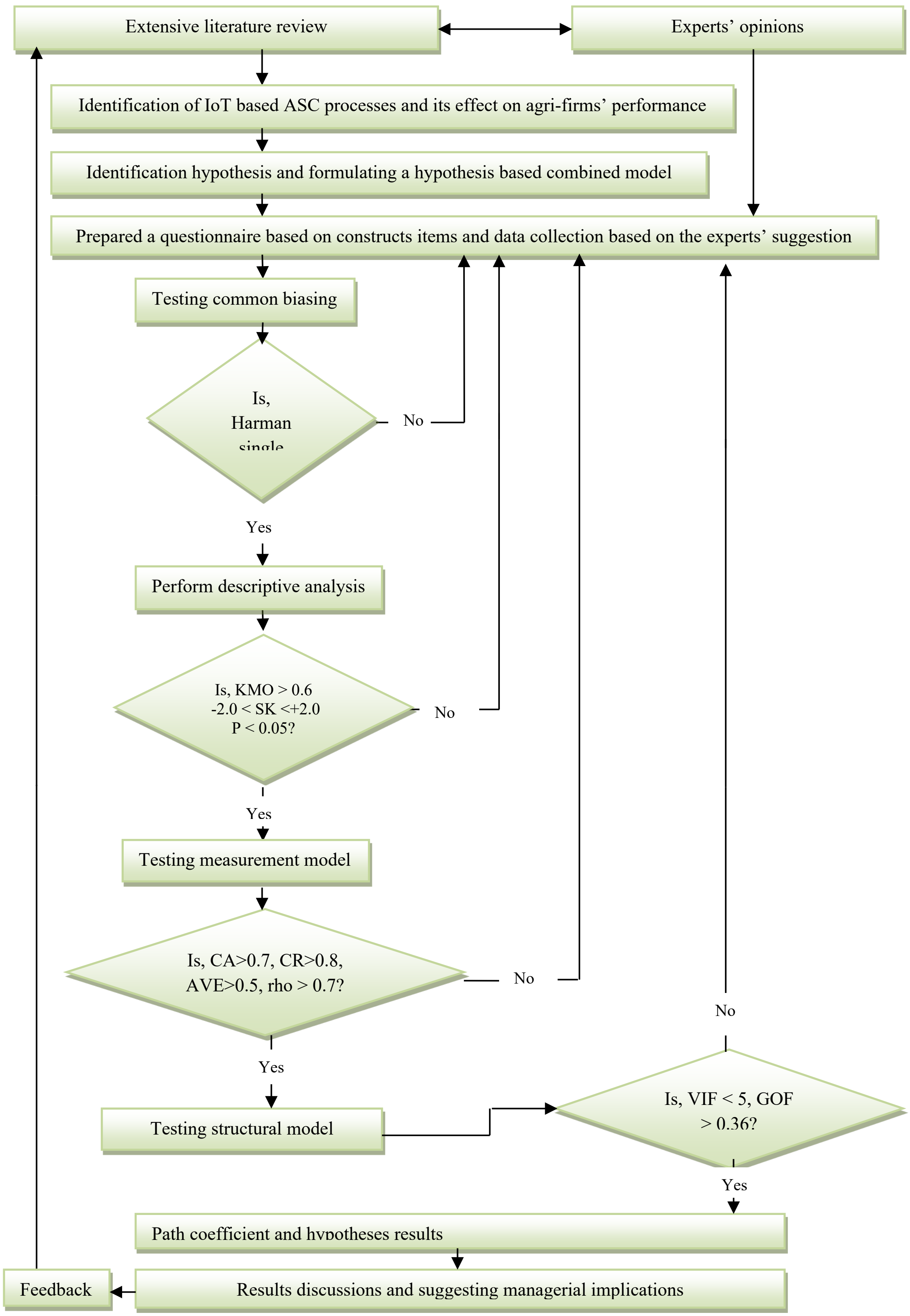

Figure 2: A combined research framework

4.1Descriptive statistics

In descriptive analysis, all skewness and kurtosis values must be between -2.00 and +2.00 for a dataset's normality validation (Zelbst et al., 2019). Also, Kaiser-Mayer-Olkin (KMO) and Bartlett's Test of Sphericity (BTS) are employed to check adequacy of the samples and reliability.

4.2 Content validation and non-response bias

The extent to which items in an instrument represent the topic generalization is known as contents or face validity of the developed questioners (Cronbach, 1951). By examining the many indications from a rigorous literature study that have already been supported by experts, its validity may be confirmed (as indicated in Appendix A). The survey's questions were drawn from a variety of research literature streams and were theoretically supported. The instrument has content validity and responders can comprehend it if items have a factor loading of more than 0.6. (Shafique et al., 2018). All the items exhibit content validity, as evidenced by the factors' loading values in Table 6.

The non-response bias test is used to determine any significant variation among responders and non-respondents (Chen and Paulraj, 2004). Such bias exists when non-respondents are different from the remaining respondents (Sala and Lynn, 2009). In alternative ways, non-response biasing is defined as the variations between the responses of the responders and non-responders (Studer et al., 2013). To verify this, we evaluated the independence of the first phase of 80 responses and delayed responses with the second phase of 39 late responses (Dubey et al., 2015; Armstrong and Overton, 1977). The t-statistics show that there was no significant variance in replies between the two times ($p = 0.15 > 0.05$). Additionally, as shown in Table A3, there were no statistically significant variations among the two clusters obtained from the Sig. t-test and Levene's test ($p > 0.05$) (Lopes de Sousa Jabbour et al., 2022). As a result, it can be assumed that non-response bias is not a problem in statistics.

4.3 Measurement model

The measuring model represents the inter-relationships among each construct item and corresponding construct variables. This model is evaluated by performing convergent and discriminant validation. Thus, in summary based on Kumar et al. (2020), the following limits must be satisfied to show convergent validity, discriminant validity and internal consistency as given below: 1) Item loading > 0.60 (statistical significance), 2) Composite Reliability

(CR)> 0.80 (internal consistency), 3) Average Variance Extracted (AVE)> 0.50 (convergent validity), 4) Cronbach's α > 0.7(internal consistency), 5) Square root of AVE>correlations among constructs (discriminant validity).

4.4 Structural model

The following two parameters were employed to evaluate the structure model fitness i.e., the R^2values and the goodness of fit (GOF) indexes. The structure model is checked for validation of the hypotheses by using R^2 value (combined impact of exogenous constructs on endogenous constructs) (Hair et al., 2017). According to the impact of size suggested for R^2, low = 0.19, medium = 0.33 and high = 0.67(Chin, 1998). Further, to avoid multi co-linearity, Variance Inflation Factor (VIF) values must be lower than five for each construct item (Hair et al., 2011). Finally, GOF is employed to evaluate the model fit based on average communality and average R-square (Peng and Lai, 2012). Generally, GOF provides a baseline value for PLS model validation and must be greater than 0.36 (Zeraati et al., 2019). The GOF index is determined as

$$GOF= \sqrt{average\text{communality}} \times \sqrt{average\text{R square}}$$

4.5 Path coefficient and hypothesis results

The statistical significance of the proposed hypotheses is checked based on the path coefficients (Mandal, 2018). PLS has used a bootstrapped 5,000 re-samples to test the proposed hypotheses based on the level of path coefficient significance. The path coefficient is considered significant if the t-value is greater than 1.96 (Kumar et al., 2020). The t value quantified the studies' hypothesis significance level defined by $p < 0.05$.

5. Analysis

5.1 Common method variance (CMV)

In social science, research methods are combined with the common method bias test using a single source and single point-of-time data collection method (Podsakoff et al., 2003). The difficulty of CMB occurrence is the condition of self-reporting datasets that have been collected based on identical questionnaires in the identical period. CMB indicates the variances which are attributed to a measuring technique; it may generate measuring errors and provide biased estimated values (Podsakoff et al., 2003; Guide et al., 2015). To minimise and investigate any potential effects of CMV, multiple strategies were explored. First, we mixed the order in which the issues happened to account for contextual influences. Secondly, we performed a Confirmatory Factor Analysis (CFA) to Harman's one-factor test (Sanchez and Brock 1996). The model fit indices were $\chi2$ = 4584.94 with degrees of freedom (d.f.) = 640, Root Mean Square Error of Approximation (RMSEA) = 0.18, Standardized Root Mean Square Residual (SRMR) = 0.16, Non-Normed Fit Index (NNFI) = 0.65, and Comparative Fit Index (CFI) = 0.67. These fit indices were not acceptable and much worse than the actual measurement model i.e., $\chi2$ = 1451.33 with *d.f.* = 604, RMSEA = 0.078, NNFI = 0.93, CFI = 0.96, and SRMR = 0.054, indicated that a single-factor model is not acceptable (Huo et al., 2020). Thirdly, this research also conducted another CFA model by the addition of a common method factor to the unconstrained CFA model. The firms' size and turn over were found to be the least correlated with the main factors, thus, we integrated these items into the marker single variable. We find that controlling for the common method factor as each factor loading is still significant ($p < 0.001$) as shown in Appendix Table A2. Hence, common method variance is not an issue. Therefore, we can conclude that common method bias was not a problem in this study.

5.2 Descriptive statistics

The results show that BTS is significant at a *p*-value of $0.000 < 0.05$; the KMO value of 0.847, more than 0.60, thus showing collected sample adequacy (Hair et al., 2014). Further, Table 5 shows that all skewness and kurtosis statistics are between −2.00 and +2.00, supporting satisfactory normality.

Table 5: Descriptive statistics

Constructs (latent variable)	Items	Mean	Standard Deviation	Excess Kurtosis	Skewness
IoT applications (IoT)	IoT1	5.025	1.312	-0.902	-0.137
	IoT2	5.017	1.145	-0.448	0.035
	IoT3	4.605	1.404	-0.513	-0.209
	IoT4	4.605	1.323	0.009	-0.318
	IoT5	4.084	1.307	0.066	0.163
	IoT6	3.983	1.209	0.573	0.582
	IoT7	4.445	1.418	-0.624	0.390
Organization Integration (OI)	OI1	4.328	1.258	0.094	0.435
	OI2	4.496	1.419	-0.782	0.428
	OI3	4.546	1.308	-0.782	0.206
	OI4	4.840	1.230	-0.989	-0.047

	OI5	4.479	1.334	-0.462	0.099
Costumer's Integrations (CI)	CI1	4.832	1.279	-0.764	0.369
	CI2	4.756	1.209	-0.805	0.134
	CI3	4.571	1.287	-0.731	0.319
	CI4	4.916	1.313	-0.897	0.157
	CI5	4.697	1.338	-0.619	0.145
Information Sharing (IS)	IS1	4.639	1.532	-0.197	-0.337
	IS2	4.412	1.574	-0.488	0.014
	IS3	5.042	1.469	-1.391	-0.09
	IS4	5.017	1.257	-0.986	0.019
Supply Chain Performance (SCP)	SCP1	4.412	1.497	-0.747	0.363
	SCP2	4.975	1.553	-1.085	-0.189
	SCP3	4.815	1.277	-0.703	-0.015
	SCP4	4.975	1.481	-1.001	-0.239
	SCP5	4.908	1.264	-0.927	-0.001
	SCP6	4.857	1.330	-1.226	-0.038
Firm Performance (FP)	FP1	4.597	1.463	-0.986	0.125
	FP2	4.714	1.153	-0.275	-0.02
	FP3	4.782	1.336	-0.986	0.109
	FP4	4.773	1.325	-0.393	0.053
	FP5	4.445	1.262	-0.854	-0.028
	FP6	4.689	1.395	-0.994	0.121

5.3Measurement model

Table 6 shows the convergent validity as item loading is above or closer to 0.6; CR > 0.8, rho A > 0.7, AVE > 0.5 and Cronbach alpha > 0.7. Further, Table 7 shows that discriminant validity as the square root of AVE for each latent variable is more than its correlations with other latent variables.

Table 6: Convergent validity and reliability

Constructs	**Items**	**Factor loading**	**Cronbach's alpha**	**rho_A**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
IoT applications (IoT)	IoT1	0.793	0.921	0.926	0.936	0.679
	IoT2	0.842				
	IoT3	0.818				
	IoT4	0.837				
	IoT5	0.903				
	IoT6	0.838				
	IoT7	0.725				
Organization Integration (OI)	OI1	0.624	0.783	0.839	0.844	0.524
	OI2	0.601				
	OI3	0.847				
	OI4	0.754				
	OI5	0.764				
Costumer's Integrations (CI)	CI1	0.760	0.844	0.852	0.886	0.608
	CI2	0.762				
	CI3	0.788				

	CI4	0.786				
	CI5	0.803				
Information Sharing (IS)	IS1	0.794	0.779	0.799	0.856	0.599
	IS2	0.694				
	IS3	0.817				
	IS4	0.784				
Supply Chain Performance (SCP)	SCP1	0.711	0.891	0.895	0.917	0.648
	SCP2	0.840				
	SCP3	0.814				
	SCP4	0.818				
	SCP5	0.822				
	SCP6	0.818				
Firm Performance (FP)	FP1	0.787	0.852	0.866	0.890	0.576
	FP2	0.818				
	FP3	0.841				
	FP4	0.772				
	FP5	0.676				
	FP6	0.636				

Table 7: Discriminant validity

Constructs	IoT	OI	IS	CI	SCP	FP
Internet of Things (IoT)	0.824	-	-	-	-	-
Organization Integration (OI)	0.466	0.724	-	-	-	-
Information Sharing (IS)	0.489	0.540	0.774	-	-	-
Customer Integration (CI)	0.384	0.178	0.431	0.78	-	-
Supply Chain Performance (SCP)	0.722	0.486	0.505	0.308	0.805	-
Firm Performance (FP)	0.560	0.486	0.378	0.620	0.610	0.759

5.4 Structural model

As suggested by recommendation seven in Evermann, and Rönkkö (2021), we calculated the Goodness of fit index (GOF). Calculations showed the structural model GOF fit as R^2 values i.e. 0.397 is more than 0.36 Thus, GOF index, which is above 0.36, validates structure model fitness. Also, Table 8 shows no multi-collinearity issues as VIF values of latent variables are below 5. Figure 3 shows the structural path model.

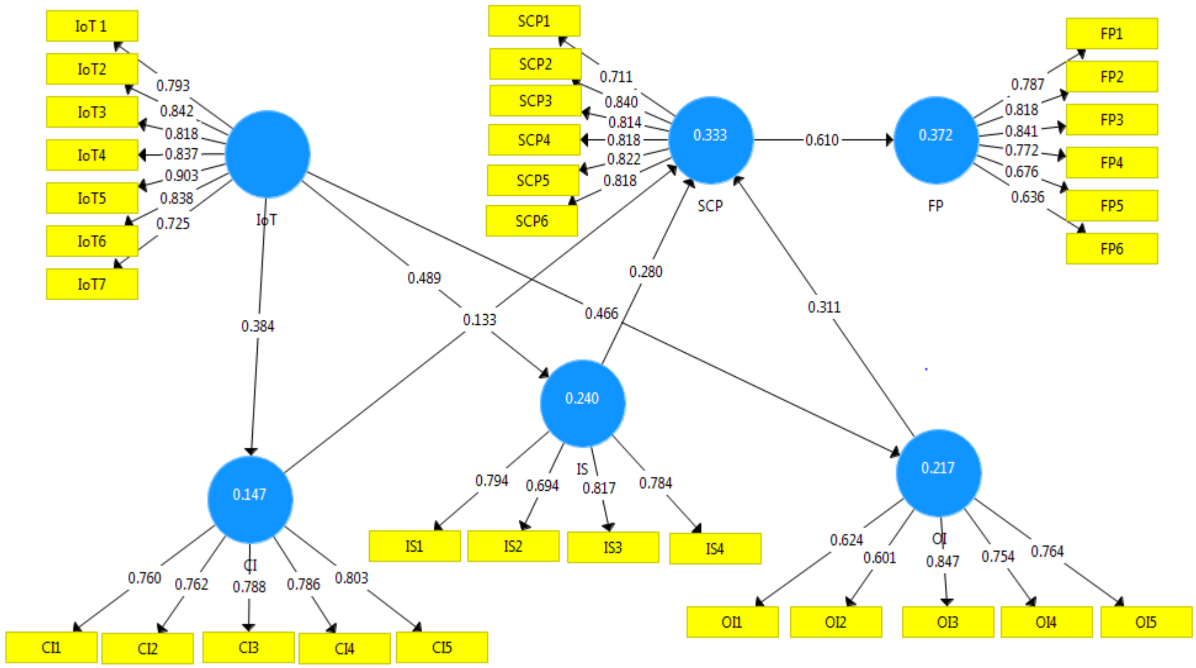

Figure 3: Structural Path model

GOF= $\sqrt{(0.679 + 0.524 + 0.608 + 0.599 + 0.648 + 0.576)/6} \times \sqrt{(0.147 + 0.240 + 0.217 + 0.333 + 0.372)/5}$

GOF= $\sqrt{0.605} \times \sqrt{0.261}$=0.397

Table 8: Multi-collinearity checking

Constructs	Items	VIF
IoT applications (IoT)	IoT1	2.519
	IoT2	2.856
	IoT3	2.565
	IoT4	2.568
	IoT5	3.992
	IoT6	2.724
	IoT7	1.634
Organization Integration (OI)	OI1	1.75
	OI2	1.914
	OI3	2.183
	OI4	1.782
	OI5	1.44
Costumer's Integrations (CI)	CI1	1.622
	CI2	1.628
	CI3	3.172
	CI4	2.747
	CI5	2.839
Information Sharing (IS)	IS1	1.466
	IS2	1.435
	IS3	2.14
	IS4	1.785

Supply Chain Performance (SCP)	SCP1	1.649
	SCP2	2.486
	SCP3	2.249
	SCP4	2.371
	SCP5	2.887
	SCP6	2.799
Firm Performance (FP)	FP1	1.766
	FP2	2.261
	FP3	2.9
	FP4	2.305
	FP5	1.928
	FP6	1.733

5.5 Path coefficient and hypotheses results

Figure 4 shows the results of path coefficient and *t* values after applying 5000 sub-samples on PLS software as suggested by recommendation two in Evermann, and Rönkkö (2021). It can be seen that the entire path is significant as "*t*" is greater than 1.96 except CI-SCP as the t value is less than 1.96 i.e. 1.910. Also, as given in Table 9, this study supports all hypotheses except H6 as "*p*" value is more than 0.05 i.e. 0.56. Thus, the results show that H1 ($\beta = 0.466$; $p < 0.05$), H2 ($\beta = 0.489$; < 0.05), H3 ($\beta = 0.384$; $p < 0.05$), H4 ($\beta = 0.311$; $p < 0.05$), H5 ($\beta = 0.28$; $p < 0.05$) and H7 ($\beta = 0.61$;< 0.05) represent significant relationships at two-tailed levels and are thus supported. H6 ($\beta = 0.133$; $p > 0.05$) represents an insignificant relationship and thus is not supported.

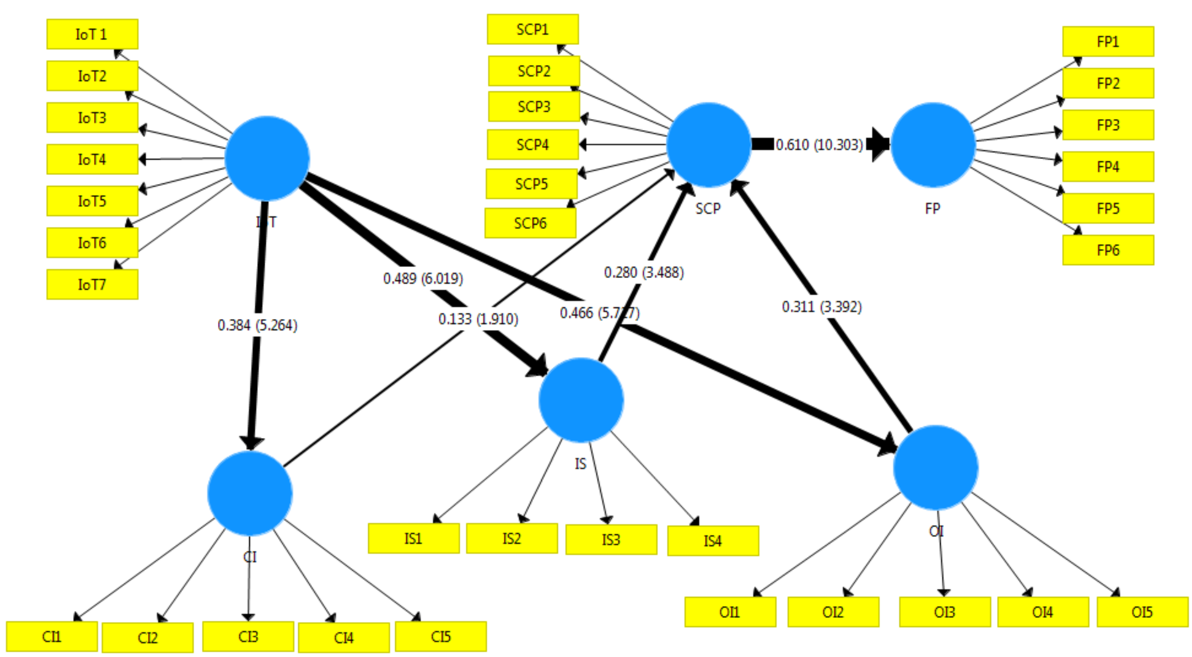

Figure 4: Structural model-based path coefficients

Table 9: Paths' coefficient and hypothesis result

Hypothesis	Path	Beta Coefficient	T -values	P- values	Hypothesis
H1	IoT →OI	0.466	5.727	0.000**	Supported
H2	IoT →IS	0.489	6.019	0.000**	Supported
H3	IoT →CI	0.384	5.264	0.000**	Supported
H4	OI →SCP	0.311	3.392	0.001**	Supported
H5	IS →SCP	0.28	3.488	0.000**	Supported
H6	CI →SCP	0.133	1.91	0.056**	Not supported
H7	SCP →FP	0.61	10.303	0.000**	Supported

5.6 Endogeneity and the predictive relevance power of the model

Endogeneity mainly consists of Common-Method Variance (CMV), measurement error and variable omission. As PLS software does not consider the assumption of normality (Shafique et al., 2018), PLS can calculate small variance for a smaller sample size (Fornell et al., 1982) resulting in negligible random measuring error. Omitted biasing may be present due to ignorance of important constructs' items of the main constructs (Antonakis et al., 2014). In this context, the most significant conduct is "theory, theory and more theory" (Akhtar et al., 2016). Therefore, the present research has used two theoretical approaches (RBT and CT) and outcome variables for developing constructs' items to avoid any important omissions. Finally, employing the Durban and Wu-Hausman tests, we examined endogeneity biasing. We adhered to the detailed process laid out by Ullah et al (2021). As shown in Table A4, we observed that the association among the parameters provided a $p > 0.05$. Consequently, we conclude that endogeneity biasing does not compromise the accuracy of our findings. Further, the predictive relevance power of the model may be shown by R^2. The R^2 may also provide in-sample predictive power (Rigdon, 2012). As a guideline, R^2 values of 0.75, 0.50 and 0.25 may be taken as substantial, moderate and weak (Hair et al., 2011). Based on the R^2 value obtained, (0.397) this research indicates a moderate predictive relevance power.

6. Discussion

Prior studies have shown that IoT based digital technologies influence both the success of a business and its SCM (Kim, 2017). The results of this research indicate that IoT integrated SCs and organizational resilience improves the firm performance (Mesic et al., 2018). In this research, it was established that the IoT has a substantial impact on three integrated aspects -

suppliers, inter-firms' practices, and consumers (Odongo et al., 2016). IoT vision comprises of physical devices such as sensing, actuation, hand gadgets, and smartphones (Rejeb et al., 2021). IoT is capable of both internal and external integration (e.g. connecting suppliers and consumers with internal business processes) so that data collection, collaboration, and inter-firms' connections may be established (Aamer et al., 2021). Cloud technology, RFID, WSNs, block chain, and other IoT-related innovations have an immediate impact on SI and CI. Furthermore, as shown in supply chain research, IoT provides an indirect impact on SCP and FP with a mediated impact on SI and CI (Kirwan et al., 2017). In this research, IoT is viewed as an exogenous factor, while CI and SI are represented as mediators across IoT, SCP and FP. This study establishes dynamic characteristics across other organizational capacities. It indicates the potential of integrating, developing, organizing, and reconfiguring to fulfil evolving market needs to produce numerous continuous sustainable capacities at the same time in unpredictable, unsteady, or turbulent scenarios (Peng et al., 2016).

The results also show that IoT based digital technologies are positively correlated to SCI. Further, IoT-OI (H1), IoT-IS (H2) and IoT-CI (H3) hypotheses have been supported based on ($t = 5.727$; $p = 0.000 < 0.05$), ($t = 6.019$; $p = 0.000 < 0.05$) and ($t = 5.264$; $p = 0.000 < 0.05$) respectively. The above inference may be strengthened by the fact that the IoT may enable more effective and autonomous ASC communications in terms of agri-products' availability, inventory levels, delivery position, and production necessities (Aamer et al., 2021). IoT may also be utilized to manage SC stakeholders' collaboration, market predictions, and manufacturing scheduling (Cai et al., 2016). IoT is a key enabler of SCI since it enables data to be connected smoothly and efficiently. It also enables important data to be recorded, coordinated and communicated both inside and outside of companies. Digital information interconnection and organization resource planning processes are also essential aspects of SCI (Hu et al., 2021). IoT could even aid in integrating processes by enabling real-time data exchange and lowering process variation (Barnett et al., 2019). Tracking, visibility, and SC coordination are essential in an SC such as agri-food; as they assist ensure food security and distribution to shoppers (Haleem et al., 2019). IoT may track the efficiency of intermediate methods using real-time information (Barnett et al., 2019). As a result, IoT based transparency in any SC means ensuring the company's long-term viability, consumer trust, and brand demands (Sarpong, 2014). Furthermore, SC collaboration aids in the secure and timely distribution of the right products to the right consumers (Naik and Suresh, 2018).

Another hypothesis states that OI and SCP (H4) are positively related based on OI-SCP (t = 3.392; p = 0.001 < 0.05). This finding may be verified because OI is characterized as the extent to which functionality or business purposefully communicates with internal or external SC participants (Lee and Ha, 2018). OI also manages the inter and intra-processes required to ensure productive and economical outflows of goods, operations, knowledge, revenue, and procedures to provide optimum satisfaction to consumers (Zhao et al., 2019). This study has predicted a favourable relationship between IS and SCP (H5) (t = 3.488; p = 0.000 < 0.05). Thus, the argument is validated. This finding may be verified since it may aid in the establishment of stronger relationships with its SC stakeholders, leading to improved productivity (Khan et al., 2016). Integrating data impacts inventories, and middle-management choices, and enables businesses more reactive to consumers. This allows agribusinesses to keep buyer–suppliers' relationships maintained, efficiently collaborate with trade partnerships, and reduce transactional costs (Du et al., 2012).

Based on (t =1.91; p = 0.056 > 0.05), the analysis also suggested that CI and SCP (H6) are not validated. This outcome may be reflected in the fact that the establishment of CI-SCP interconnections necessitates the firm's awareness of its consumers, the creation of stronger profits for their customers, cost reductions, and a knowledge of the quick changing customers' needs, business turbulence, and competitiveness (Prajogo and Olhager, 2012). It is also necessary for consumers to implicitly engage in product advancement (Saitone and Sexton, 2017). Finally, based on (t =10.303; p = 0.001), the present study validates the SCP-FP (H7) hypothesis. This claim may be supported by the fact that the SC works effectively when it has achieved integrated strategies at both upstream and downstream levels, is adaptable to changing trends, or is sensitive to consumer needs (Dubey et al., 2015). As a result, the focus company will profit from better productivity based on commodity pricing, quality, and delivering within fixed time frames (Kassem et al., 2019). Also, SCP improves firms' performance by lowering inventory volumes and expenses and boosting on-time distribution by ensuring the effectiveness through which knowledge is exchanged across the SC (Zeng and Lu, 2020).

6.1 Theoretical implications

This research is an initial approach to investigating the empirical effects of IoT and SCI on the FP by utilizing two theoretical backgrounds (RBT and CT). Integration of IoT technologies in a food supply chain will enhance collaboration among different stakeholders and signify RBT based on several capabilities such as investing in a relation-building approach, effective collaboration, integrating IoT facilities, exchanging information, working efficiently with governing bodies, supplier involvement, trust etc. Adopting digital technologies signifies Contingency Theory (CT) that considers the different contingent factors likewise, alignment among firms' network designs, basic processes and external market fluctuating behaviour.

Also, this study has empirically tested a hypothetical model to show the path significance and measure the model fit. As agri-firm goods have to undergo rigorous security and quality requirements, integrating efforts of this analysis seems to have some unique consequences above conventional studies. Thus, this analysis may be a good theoretical foundation for future agri-SCI studies. By adopting contingencies and organizational theories, this study has correlated business uncertainties (related to suppliers, demands and technologies), IoT, CI, SI and OI of agri-firms. Also, this research acts as groundwork for the adoption of IoT-based integration at both upstream and downstream levels of SC which have been disrupted due to COVID -19. Thus, this paper identifies the antecedents (enablers) of FP - SCP, IoT, IS, OI and CI. Hypotheses have been drawn between different enablers to validate the proposed structure model.

The present study provides a theoretical based demonstration for aligning knowledge-shared activities with various business processes. Thus, this research fills the theoretical gaps between the contingent factors (Covid-19 pandemic) of dynamic business strategies and IoT based information sharing at the company level. This study provides the parameters related to competitiveness, SC coordination, data exchange to minimize ambiguities, quick shipment, and accessibility of various practices at an affordable price. SC partners may gain substantial advantages from knowledge transfer, such as lower operating costs and semi-product flow periods, as well as increased adaptability and innovative capabilities. Thus, this study supports both the contingency theory and relational based theory.

6.2 Managerial implications

The results of this research may guide managers to think of IoT enabled applications as an extended means of establishing long term digitally based SCI capabilities. Also, this study suggests deploying smarter electronically based tags and readers which improve the data analytics capabilities for managers based on auto captured data. The availability of quality information improves data driven decisional capabilities of managers at operational level.

The findings of this work can guide managers in prioritizing their business strategies (day to day practices) by stressing the importance of OI, CI and OI on FP. The results also suggest that managers must first develop OI within the agri-firm processes; afterwards managers may focus on external integration or CI. These research findings may direct managers in improving FP by more efficient allocation of their assets and facilities. This paper also helps managers in effective forecasting of uncertainties for mitigation of supply demand risks in any disruptive scenario (COVID19). This study provides the ground work to managers for implementing the strategies for SC flexibility by considering the parameters of SCI. This research is a helpful guide to managers to improve the adaptability of their organizations during any SC disruption (COVID-19) or business uncertainty. The adoption of digital technologies may not only help in dealing with pandemic but also with other disruptions related to climate change and war.

The adaptive capabilities of an SC help a business to cope with disruptive events and also do not allow competitors to replicate the internal SC strategies. Once SC experts realize that complexity is implicit in the network, the main emphasis would not be on attempting to eradicate it. Instead, steps must be taken to engage in informational infrastructure or partnerships that improve the capabilities of data processing. This study guides industry managers towards adopting an integrative approach to GSCM. The research aligns sustainable design and goals with SC stakeholders and encourages a coordinated commitment of the entire SC. Explicitly, a multi-level (multi-tier) holistic method can be introduced. At the strategic stage, businesses must collectively develop green plans and goals in collaboration with stakeholders; at the tactical stage, organizations must exchange sustainable knowledge with one another; at the operational stage, firms must engage SC members in the entire product lifecycle. Thus, this research inspires the internal incentive of companies to follow GSCI and move forward with green practices. Finally, the path coefficients for the hypothetical model may motivate operational managers and top management in synchronization of various SC strategies with business outcomes for improving the firm's performance.

7. Conclusion

The present research identified a hypothesis-based framework that needed to be tested for its significance. Hypotheses have been identified based on a detailed review process and some theoretical contributions viz. CT (dynamic based and technology capability based), and RBT (SCI based and environmental based). To test the hypothesis model, collected data was checked for bias based on the CMV method; this was followed by analysis of descriptive statics, measurement model, structure model and path coefficient with hypotheses results. SPSS software indicates the adequacy of collected sample based on KMO (0.7) and BTS (p=0.000). The path analysis of the identified hypothesis was carried out by using smart PLS software. IoT based SC strategy collaboration does not provide a direct association with agri FP but increases FP through the mediation of firm-wide cross-functional integration. The empirical findings show that IoT based digital technologies and agri-food SCM processes (OI, IS and CI) are positively associated with each other. Further, SC practices are positively correlated with SCP. Also, FP is positively correlated to SCP. Thus, all of the six framed hypotheses are significant and supported. However, hypothesis CI-SCP (H6) is not supported based on the p-value; this is more than 0.05. The findings of this research must be considered while implementing IoT based strategies for developing competitiveness of agri-firms. Further, the research findings may guide managers in implementing their strategies and making investment decisions to improve the resilience of the firm.

7.1 Limitations and future scopes

Despite the identification of various implications, there are a few limitations of the present research. Firstly, there is the risk of common method bias, as the same expert may respond to the reflective and formative constructs in the proposed hypothetical model. The present research is restricted to the response of a single survey data from each of the agri-processed and distributing firms. Also, this study has involved only limited insights of theoretical contributions namely RBT and CT. Finally, this research has empirically tested only a limited number of pieces of data due to a lower completion rate of respondents.

In future, other theories may be introduced - institution theory or agency theory - to consider the institutional pressure (e.g. agri-product quality and safety regulatory bodies) as a mediating variable on the inter-relationships among IoT technology, SCI and FP. In future, a survey may be conducted using PLS-SEM based on an interview with the related field experts. Also, more latent variables and construct items related to the sustainable impact of IoT on FP may be tested based on CB-SEM. Further, the sample size of the study could be increased to perform a sub-group analysis based on SCI and FP of agri-firms. Finally, future research may involve several respondents from upstream managers to downstream consumers (e.g. farmers, e-commerce firms, supermarkets and retail managers) in gathering data for markers' variables to avoid common method variance (CMV) concern.

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Appendix

Table A1: Coding of constructs' items for data collection

Items coding	Items No.	Measurement Items	Rating of items on 7-point likert scale	References
Construct 1: Internet of Things (IoT) dependent capabilities in Agriculture Supply Chain				Antonucci et al. (2019), Cattaneo et al. (2020), Sharma et al. (2020)
In our organization IoT has been implemented in ASC:				
IoT 1	1.1	To provide identification of individual entities in the SC		
IoT 2	1.2	To offer identifications at the logistical stage (e.g. containers/pallets/trucks)		
IoT 3	1.3	For monitoring, track and trace SC entities and people based on data collected		
IoT 4	1.4	To provide real-time intelligence of SC operations and other farming practices.		
IoT 5	1.5	To provide data analysis and data storage tool for handling large volumes and variety of data generated at strategic, tactical and operation decision making.		
IoT 6	1.6	To support internal and external data exchange at firms' level of ASC.		
IoT 7	1.7	To strengthen communication and coordination between organizations workers/employee/Top management and other outside communities like government/farmers.		
Construct 2: Inter/Intra - Agriculture Organization Integration (OI)				Pu et al. (2018), Birasnav and Bienstock (2019), Kumar et al. (2017)
We were capable to improve our organizational practices by:				
OI1	2.1	Real time integrating of information for inter and intra-firms' functioning		
OI2	2.2	Real time communicating and linking of ASCs' members		
OI3	2.3	Real time monitoring of the inventories level.		
OI4	2.4	Real time searched information for logistical activities		
OI5	2.5	Accurate planning and adopting internal and external practices in ASC		
Construct 3: Costumer's Integrations (CI)				Lee et al. (2007), Kalyar et al. (2019), Jia et al. (2020)
We were capable to enhance marketing procedures among our consumers by:				
CI1	3.1	Real time sharing of our production stages with consumers		
CI2	3.2	Taking real time feedback of demand forecast from customers		
CI3	3.3	Improving the payment collection process from customers.		
CI4	3.4	Real time sharing of market information/trends from customers		
CI5	3.5	Improving the product delivery process by real time monitoring		
Construct 4: Information Sharing (IS)				Piramuthu et al. (2013),
We were capable of enhancing organizations' functions through data exchange. by:				
IS1	4.1	Integrating crucial finance, manufacturing, innovation, analytical, and business competitive data with all ASC partners		
IS2	4.2	Frequent and appropriate real time data exchanging		

IS3	4.3	By alerting the other participants or association regarding incidents or adjustments which may influence individuals.		Haleem et al. (2019), Cole et al. (2019)
IS4	4.4	Frequently face-to-face planning/communication with other members regarding policies		
Construct 5: Agriculture Supply Chain Performance (SCP)				Bao and Huang (2018), Shamout and Elayan (2018), Zhang et al. (2019)
We were allowed to improve our ASC practices to:				
SCP1	5.1	Improved farming practices		
SCP2	5.2	Fast customer response time		
SCP3	5.3	Improve perfect order fulfillment (deliveries with good quality of food products at right time).		
SCP4	5.4	Improve d SC delivery reliability.		
SCP5	5.5	Increase SC adaptability, i.e., respond to products' variations and sales trends.		
SCP6	5.6	Improve the sustainable competitiveness in the global market.		
Construct 6: Firm Performance (FP)				Lotfi et al. (2013), Um et al. (2018), Bouranta et al. (2019)
We have been able to reach the overall firm performance by:				
FP1	6.1	Return on Investment (ROI)		
FP2	6.2	Increase organizational profitability by controlling investments, services and operational expenses.		
FP3	6.3	Overall competitive position in the market		
FP4	6.4	Improve the product delivery cycle time.		
FP5	6.5	Improve the sustainability of the ASC at the economic, social and environmental level		
FP6	6.6	Improve customer/employee satisfaction.		

Table A2: Assessment of common method variance

Factors	Loading	Standard error (SE)	Z-Value	P-Value
IoT applications (IoT)	0.829	0.0890	9.31	< .001
Organization Integration (OI)	0.892	0.0945	9.43	< .001
Costumer's Integrations (CI)	0.755	0.0853	8.86	< .001
Information Sharing (IS)	0.554	0.0872	6.36	< .001
Supply Chain Performance (SCP)	0.632	0.0930	6.80	< .001
Firm Performance (FP)	0.609	0.1042	5.85	< .001

Table A3: Assessment of non-response bias

Constructs	Sig. Levene's Test	Sig. t-test
IoT applications (IoT)	0. 495	0.243
Organization Integration (OI)	0.542	0.137
Costumer's Integrations (CI)	0.056	0.456
Information Sharing (IS)	0.171	0.439
Supply Chain Performance (SCP)	0.091	0.745
Firm Performance (FP)	0.232	0.096

Table A4: Assessment of endogeneity bias using the Durban and Wu-Hausman tests

Path	Durban and Wu-Hausman (p-values)	Result
IoT →OI	$0.086^{n.s}$	No biasing
IoT →IS	$0.421^{n.s}$	No biasing
IoT →CI	$0.345^{n.s}$	No biasing
OI → SCP	$0.253^{n.s}$	No biasing
IS → SCP	$0.068^{n.s}$	No biasing
CI → SCP	$0.536^{n.s}$	No biasing
SCP → FP	$0.292^{n.s}$	No biasing
Note(s): n.s = not significant.		