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Role of Information and Communication Technology in Mitigating Risks in Indian Agricultural Supply Chains

Abstract

Purpose – Theorising from a resource-based view perspective, the intersection of supply chain management and the use of IT has been investigated in this study. This work aims to investigate supply chain performance as an essential outcome of the use of IT and explores the effect of supply chain collaboration on supply chain performance. In addition, volume uncertainty has been explored and tested to establish whether various associated uncertainties can be mitigated when the use of IT is involved.

Design/methodology/approach –A sample of 121 senior executives from agri-tech firms was collected by travelling and meeting the executives in person in various states of India. Structural equation modelling (SEM) was used to test the hypothesized relationship of volume uncertainty to supply chain performance via the use of IT and supply chain collaboration.

Findings – The results show that volume uncertainty significantly impacts supply chain collaboration via the use of IT and supply chain performance via supply chain collaboration. The use of IT positively and significantly impacts supply chain performance via supply chain collaboration.

Practical implications – Witnessing the potential benefits of the emerging use of IT in the uncertainty reduction as reported in this study, agri-tech firms operating in emerging rural and agricultural economies can enhance supply chain collaboration to improve supply chain performance.

Novelty/Social implications–The study unfolds how risks in agricultural supply chains sourced due to the volume uncertainty can be mitigated through the use of IT and supply chain collaboration to influence supply chain performance in rural agricultural and developing economies. Volume uncertainty at agri-tech firms and farmers is a ground reality that has led to an inability to plan and prepare, resulting in wastages and disruptions in agricultural supply chains and farmers' struggles.

Keywords- Information and communication technology, supply chain collaboration, use of IT, supply chain performance, volume uncertainty

1 Introduction and motivation

Owning to the increased importance of supply chains, the research on the supply chain of the food segment has gained momentum among experts (Mesic, Molnár and Cerjak, 2018). A report from the Food and Agricultural Organisation (FAO) of the United Nations in 2016 reported that around 23% of the total damage caused due to medium and large-scale natural disasters between 2006-2016 accounted for agriculture in developing countries. The report highlighted that agriculture could be the victim of disasters and solve disaster risk by using agricultural technologies. These agricultural technologies help reduce farm-level risks much more effectively than the usual practices and have also been responsible for 2.5 times higher net economic benefits (FAO Chile, 2017). Also, equal collaboration with the farmers is crucial to having a sustainable supply chain to respond to various issues concerning the demand, technological, and socio-economic factors (Yang et al., 2021).

The focus of this research is in the context of developing economies, especially India, where agriculture is crucial for its economy due to it represents major employment generating sector (70%). Despite its importance, the agricultural sector in India suffers from significant problems and issues. Some reasons for such problems and issues are uncertainty and information asymmetry in the entire supply chain due to middlemen and stakeholders. The agricultural supply chain in India includes tier 1 suppliers such as marginalized farmers, middlemen, agri-tech firms, distributors, retailers, and end-consumers. The use of IT reduces uncertainty and information asymmetry by enhancing collaboration among stakeholders as it keeps them aware of real-time information. This collaboration helps in the coordination of tasks and events in the agricultural supply chain and eventually leads to improving supply chain performance.

More specifically in this paper, we consider a scenario where the supply and demand risks are mitigated through digitization, leading to better supply chain collaboration and improved performance in the overall supply chain (Shukla et al., 2022). Agriculture as employment has become a risky business these days. By agricultural risks, we mean that "everyday farming decisions of farmers affecting the farming operations cannot be accurately predicted due to several factors; this is the risk" (Kahan, 2008). In recent years, the risk has taken more detrimental forms like destroying whole crops, hurricanes, pests, fire, diseases etc. (Hazell, 2010). New conceptual models are in the development process to expel extreme risks due to the weather in developing countries (McMichael *et al.*, 2003).

The focus on agricultural risk is motivated by the growing concerns of national governments, international agencies, financial institutions and other stakeholders in the supply chain (Jaffee, Siegel and Andrews, 2010). Given the complexities prevalent in the agricultural sector, risk and uncertainty have been a long-standing issue for developed and developing regions (Leat and Revoredo-Giha, 2013). These include weather-related risks, risks due to natural calamity, uncertainty in the availability of agricultural infrastructure, and demand and supply-side risks (Jaffee, Siegel and Andrews, 2010).

This study concentrates on the demand and supply-side risks as it severely impacts the agricultural supply chain (Tang, Sodhi and Formentini, 2016). The importance of risk selection aggravates when any of the concerned stakeholders in the supply chain belongs to the marginalized community (Valkila, Haaparanta and Niemi, 2010). Marginalized community means, “an individual's or a group's inadvertent stance and the situation on the periphery of social, political, economic, ecological, and biophysical systems that discourages them from accessing resources, assets, and facilities, restricting freedom of choice, inhibiting the growth of functionalities, and ultimately leading to severe poverty” (Von Braun & Gatzweiler, 2014).

In countries like India, most of the agricultural farmers belong to the BoP (Bottom of Pyramid) and, as a result, do not enjoy financial comfort against risks and uncertainties. The role of ICTs has been extensively used to increase traceability and automate the entire process for better efficiency (Daneshvar Kakhki and Gargeya, 2019). However, very few studies in developing nations have attempted to analyse whether ICT is an effective risk mitigation measure in the agricultural sector (Khatri et al., 2017).

2 Literature review, theory and hypotheses development

The literature review is divided into two parts. The first subsection discusses the current risk mitigation strategies adopted in the supply chain context. The second subsection explores how ICT has minimized risks in a different context. Then, a triangulation of the literature is done in two parts and coupled with the motivation of the agricultural sector from the literature across and specifying developing countries; the research gap is stated in the last subsection.

2.1 Supply chain risk mitigation

Supply chain literature already has supply chain risk mitigation information in abundance (R. Sreedevi and Saranga, 2017). Organizations need to bring in capabilities that can mitigate supply chain risks. Three major risks are common in supply chains, namely: supply risks, demand risks, and operations risks (Diabat, Govindan and Panicker, 2012). Supply risks occur during the movement of materials from the supplier to the firm. Operational risks, on the other hand, are associated with the firm’s capability of producing and processing the goods. Finally, demand risks are associated with the movement of goods from firms to consumers (Diabat, Govindan and Panicker, 2012). Chen, Preston and Xia (2013a) showed how each type of risk could be reduced by internal and external collaboration.

The study by Aqlan and Lam, (2015) pointed out that lean proved to be an effective risk mitigation tool as it increases the issue of over-dependency among the supply chain partners leading to inefficiencies in the supply chain. The moderating effect of supply chain flexibility in reducing the potential risks in uncertain environments was shown by (Sreedevi and Saranga, 2017). Lack of coordination among the supply chain partners also leads to supply chain risks (Sreedevi and Saranga, 2017).

To summarize, the risk mitigation literature highlighted the importance of integration between stakeholders, improving flexibility, agility, and cultural context in reducing supply chain risks in uncertain environments. However, very few studies (Kim, 2010), highlighted the role of digitization as a risk-mitigating tool in the supply chain literature, especially in emerging economies.

This study is undertaken within the context of India, which is a developing country where deploying IT is a ‘big game-changer’ and where the majority of the farmers comprise a marginalized community. In such a scenario, when there is a problem with the right information in hand related to price, there is also a problem of information asymmetry, resulting in a high level of uncertainty in demand and supply. Thus, our first intention was to investigate whether the use of IT plays a significant role in bridging these gaps. Secondly, the focus of the study is not on any specific product related to IT due to in countries like India, the expansion of IT will take time in terms of the specifics of its usage. As of now, it is just at a stage where it helps in connecting the marginalized farmers with the mainstream supply chain and agri-tech buyers. These farmers are provided IT help as per their needs and problems like pest infestation or flood or drought.

2.2 ICT, risk and supply chain

Vertical collaboration and technology adoption with suppliers helps in increasing competitiveness (Benitez et al., 2021). There is a constant need to adopt new technologies to improve the entire supply chain (Yadav *et al.*, 2020). ICT had been studied in-depth for the past few decades in information systems literature (Majchrzak, Markus and Wareham, 2016) and operations management literature (Kumar, Singh, & Modgil, 2020) too.

Not only operational and financial risks but supply chains are burdened and susceptible to strategic risks too. A study by Xue (2014) showed how digitization could mitigate strategic risks in supply chains. One of the first few studies which discussed the role of IT in risk management in the Indian agricultural sector was done by (Mittal 2012). The author highlighted the critical situation of the sector, low productivity, shrinking agricultural land base, poor market linkages, and the relevance of ICT in agricultural development. Also, in the agri-food sector, information sharing is crucial among the various players to respond quickly to new market possibilities (Anastasiadis and Poole, 2015).

To summarize, ICT had been an effective tool in mitigating risks in different contexts. Although Mittal (2012) mentioned the problems of the Indian agricultural sector and subsequently the role of IT in risk management, it did not specify whether or not IT can be implemented in such contexts. On the one hand, we found that farmers belonged to the marginalized community, and on the other hand, there were large numbers of fringe players (agricultural buyers) who cannot afford such systems. We, therefore, argue that understanding how IT can be implemented in the Indian agricultural sector and the real impact of IT in mitigating risks in the agricultural supply chain and thus improving the overall performance remains to be documented in the management literature (Dhaigude et al., 2021).

2.3 Research Gap

The risk mitigation literature in the supply chain suggested higher integration between stakeholders to reduce risks from highly uncertain environments. Since the agricultural sector is burdened with high supply uncertainty, we select volume uncertainty (VU) as one of the constructs in addition to the use of information technology (UOI) as a tool. However, higher integration could only happen when high supply chain collaboration (SCC) occurs in the agricultural sector, especially in developing markets like India. This is because collaboration can incentivize farmers to integrate the information with buyers. As a result, we argue that the UOI should lead to SCC when there is uncertainty.

To conclude, we intend to observe whether the UOI leads to SCC during uncertainty. Once SCC is achieved, we believe that risks arising due to uncertainties will decrease, and hence overall supply chain performance (SCP) should increase. Therefore, we select SCP as our main dependent variable for our model.

We present below the research questions in the context of agri-tech firms in the agricultural sector in emerging economies:

Research Question 1: *How does the volume uncertainty influence the use of IT, supply chain collaboration, and supply chain performance?*

Research Question 2: *How does the use of IT influence supply chain collaboration and supply chain performance?*

Research Question 3: *How does supply chain collaboration influences supply chain performance?*

3 Theoretical background

The natural–resource-based view (RBV) of the firm, as suggested by Hart (1995), to explain the research framework was used. The RBV of the firm explains how the organization exploits the competitive resources and converts them into organizational routines and activities to gain a competitive advantage (Sardana, Terziovski, and Gupta, 2016). The RBV approach can be effective in understanding, how firms can achieve competitive advantage at the BoP level by utilizing a single resource and capability within the entire supply chain (Figure 1).

< Insert Figure 1 about here>

Following our research motivation that agricultural companies and farmers tend to economically lose in the supply chain due to information asymmetry that flows bi-directional, impacting and creating uncertainties in both demand and supply. We show the importance of the RBV framework to our research hypothesis. The RBV framework suggests that the resource needs to be valuable and non-substitutable. We consider that UOI for advisory services or forecasting purposes is valuable while working at the BoP level for two reasons: first, value is tacit as the advantage cannot be easily transferred to other players.

In other words, small players do not have complete information for operating at the BoP. Second, the value is socially complex as operating in such environments requires local knowledge and information to operate in such environments. Third, we also consider UOI to be partially non-substitutable as challenges at the BoP are many, and companies may not find it economically viable to implement the same.

The sole purpose of implementing digitization is to exchange information between farmers and agricultural companies to estimate the supply disruptions, and farmers can estimate the demand for the next season. Also, in the agri-food sector, information sharing is crucial among the various players to respond quickly to new market possibilities (Anastasiadis and Poole, 2015). Upon adopting the new technology, a farmer's decision is unbiasedly dependent on its value for his profit (de Janvry and Sadoulet, 2020). Therefore, agricultural companies can now offer better prices to the farmers as risks and uncertainties are minimized.

This leads to improved SCC between farmers and agricultural companies, thus paving the way for high SCP. Furthermore, when IT is facilitated to the farmers, they get a scope of learning more benefits of new technology (de Janvry and Sadoulet, 2020). Talking about the performance, we mainly concentrate on revenue and cost advantage due to the minimization of risks. In addition, the agricultural companies can attain a superior position in positioning their warehouses, optimizing the ordering quantities and estimating the market prices and hence revenues in subsequent seasons.

3.1 Hypothesis development

Uncertainty means the status quo when the information cannot be accessed directly, and the situation remains ascertained (Peng *et al.*, 2020). Uncertainties in the various supply chain stages add to the complexities and reduce efficiency (Peng *et al.*, 2020). Not much work is done concerning the in-depth discussion on uncertainty, as it cannot be forecasted (Wang, 2018). Supply chain flexibility has been discussed to solve uncertainty (R. Sreedevi and Saranga, 2017). Demand uncertainty is the major source of uncertainty in supply chains (R. Sreedevi and Saranga, 2017). However, there are numerous studies on demand uncertainty (Ekinci, Serban, & Duman, 2019; Ouhimmou et al., 2019), but very few, where demand uncertainty is used in the supply chain context are tested empirically (Huo, Zhang and Zhao, 2015). One of the interesting studies by (Hançerlioğulları, Şen and Aktunç, 2016) showed how demand uncertainty could negatively impact inventory turnover in the supply chain. Further, Ding, Lu and Fan (2017) find that the relationship between customer integration and operational performance weakens in the presence of high demand uncertainty.

Frequent changes in the production process increase the supply chain's complexity and uncertainty (Sreedevi and Saranga, 2017). The unforeseen changes in supply or orders lead to variations in the production processes (Sreedevi and Saranga, 2017). The uncertainty in demand, supply and manufacturing levels affects delivery quality and reliability (Sreedevi and

Saranga, 2017). VU is the inability to accurately foresee the volume requirements (Ford, 2017). High VU leads to poor utilization of capacity, a rise in production costs, and inventory variations (Ford, 2017). Firms with VU need to exchange a large amount of information with their partners to fulfil the requirements or find new partners if existing ones cannot perform (Mishra, Konana and Barua, 2007).

Thus we observe that uncertainty in demand can negatively impact the performance of the firm consideration. Therefore, to foresee the uncertainty, there needs to be the UOI that can help predict the VU with much closer accuracy. We also argue that in the presence of VU, supply chain partners will tend to contribute to factors that can help promote SCC to mitigate the negative effects of VU. Finally, we also discussed the effect of VU on SCP in the agricultural context. We, therefore, state our hypotheses:

Hypothesis 1: *Volume uncertainty positively leads to supply chain performance via IT in the agricultural sector*.

The literature on the relationship between IT and SCC is scant and diverse. Different studies have defined; IT constructs differently, and their impact has been statistically tested in different contexts. For instance, (Afshan, Chatterjee and Chhetri, 2018) defined segregated IT in two dimensions: information quality and information sharing. The authors highlight that some firms have failed to extract the full benefits of IT despite huge investments in IT. Extending on similar lines, the paper also highlights that although information sharing is critical to SCC, it becomes more important to guarantee that the quality of information shared is accurate and reliable (Chen et al., 2011). Work done by Cai et al. (2016) discussed how IT capability has positively strengthened the relationship between SCC and organizational receptiveness.

Panahifar et al. (2018) argued that if the channels of information sharing are trustworthy and free of leakages, different stakeholders will be willing to collaborate for higher benefits. One of the studies by Salam (2017) shows how technology leads to improved SCC. The importance of technology turbulence as a moderator to the relationship between resource complementarities and SCC was highlighted (Srivastava, Srinivasan and Iyer, 2016). The study by Wu & Chiu (2018) showed that better information quality does not directly lead to SCC; rather, the relationship is mediated through user satisfaction.

Summarizing the literature, we find that information sharing, information quality, technology capability, and technology turbulence directly or indirectly affect SCC, especially in uncertain situations. Taking a shift towards the Indian agricultural sector, where the penetration of IT is very low and there is negligible evidence to prove collaboration between marginalized farmers (as suppliers) and buyers, we argue that if buyers use IT as a tool, both farmers and buyers will stand to gain both in the short and long run thereby improving SCC among partners. We present our second hypothesis below:

Hypothesis 2: *Volume uncertainty positively leads to supply chain collaboration via the Use of IT in the agricultural sector.*

As already discussed in their earlier hypothesis, the primary purpose of SCC in the agricultural sector is to ensure that risks and uncertainties within the supply chain diminish. When it comes to SCP, literature has extensively used SCC and SCP in different contexts. SCC comes with many challenges when different entities are taken together (Solaimani and van der Veen, 2021).

However, we will only look into studies that directly involve SCC leading to SCP. Adams et al. (2014) pointed out that relational technology intensity stands out as a mediator between collaboration and performance. The study by Cao and Zhang (2011) shows how SCC leads to collaborative advantage, leading to firm performance. Extending on similar lines, Pradabwong et al. (2017) discussed that SCC strives to change its performance by looking toward new opportunities. In addition, constructs such as collaborative advantage have been used in different forms in different settings (Liao, Hu and Ding, 2017). For instance, Haque and Islam (2018) use the term business competitiveness to test whether SCC has a positive impact. Shifting our focus towards organizational learning, Cai *et al.* (2016) found that SCC positively impacts organizational responsiveness.

There are studies directly linking SCC and different aspects of firm performance, including performance towards sustainability (Seo, Dinwoodie and Roe, 2015; Pakdeechoho and Sukhotu, 2018). However, it is interesting to note that none of the studies has linked SCC explicitly with SCP when there is a trace of uncertain behaviour and risks. Therefore, we hypothesize that SCC will directly lead to SCP in uncertain environments.

Hypothesis 3: *Volume uncertainty positively influences the supply chain performance via collaboration in the agricultural context.*

Studies have discussed that the ICT in the supply chain is very effective in developing supply chain capabilities (Nandi et al., 2020). However, different articles have used different IT constructs to justify the claim (Vijayasarathy, 2010). Technology improves various dimensions like collaboration, integration, transparency, efficiency and performance (Frederico et al.,2019). The UOI will directly lead to logistics integration which will serve as a mediator to SCP, which was discussed in work by Alam et al. (2014). This study encompasses multiple emerging countries integrating different industries. Extending the logic on integration, Chen, Preston, & Xia (2013b) stress the need for IT integration in improving the SCP of a firm.

Further, Kumar et al. (2017) show how IT can directly lead to supply chain agility. The importance of RFID technology to improve SCP was highlighted by Zelbst *et al.*(2012). Along similar lines, Kim, Hwang, & Rho (2016) show how supply chain culture strengthens the relationship between RFID utilization and SCP. Finally, the study by Chang, Tsai and Hsu (2013) discussed that e-procurement has a positive impact on SCP. Synthesizing the above discussion, we find that some studies have delved deeper into specific IT functionalities, while others have tried to capture an overall perspective of the consequence of UOI. However, it was difficult to see the studies showing that UOI has a direct impact on SCP.

Whereas the contextual motivation of UOI is immense, we argue that UOI will directly impact SCP in the agricultural supply chain. Furthermore, understanding the information provided in H3, we also find the importance of SCC towards SCP. We, therefore, present our hypothesis below.

Hypothesis 4: *The Use of information technology positively impacts supply chain performance via supply chain collaboration as a mediator in the agricultural context.*

Considering the knowledge collected from the above two hypotheses, H1, H2, H3, and H4, we can also posit our fourth hypothesis, which is intended to understand UOI and SCC's mediating role in the SCP. Hence we state our second last hypothesis as.

Hypothesis 5: *The effect of volume uncertainty on supply chain performance is mediated via the Use of IT and supply chain collaboration in the agricultural sector in emerging economies.*

4 Methodology

To test our proposed hypotheses, data were collected from Indian agri-tech firms. The scales used in the study were adapted from the published literature. We then used the partial least square structural equation modelling (PLS-SEM) to test hypotheses (Chin, 1998). PLS-SEM has certain advantages over the CB-SEM approach. First, this approach allows the researcher to take fewer assumptions regarding the distribution of the sample data (Sarstedt et al., 2014). Second, this method is robust to smaller sample size limitations (Hair et al., 2016) for exploratory research.

4.1 Measures

We collected the data from the founders, managers and employees of the agricultural firms, which facilitate the UOI to the farmers to improve SCC by mitigating uncertainties in agriculture and leading to an improved SCP. The survey was distributed via online emails, in-person discussions, and phone calls. All the items are measured on a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree". We also introduced the reverse coded questions in a few items to easily eliminate the casual respondents.

We contacted the various firms operating in the country's different states for our data collection (Table 1).

< Insert Table 1 about here>

The survey instrument design comprised a total of 20 items. In order to adhere to the rigour of the study, a pilot was conducted on 33 firms' employees, and the survey underwent many revisions before finalizing the same.

4.2 Sampling and data collection procedures

The data collection was done in 2019-20. The data was comprised across the Indian Subcontinent. In each state like Uttar Pradesh, Haryana, Gujarat, Karnataka, Rajasthan, Maharashtra, etc., the buying firms were selected based on their association with the respective farmers and were given the ICT services. The idea of choosing various places was multi-fold. The simple reason was to keep the diversity in our portfolio simultaneously, and we wanted to see if the idea of poor suppliers and buyback firms is really helpful in SPI improvement.

A total of 138 responses were collected, out of which 17 were discarded due to missing values and ten were rejected due to multiple or repeated ticks for the same items. So overall we had a total of 121 responses with approximately an effective 25% of response rate.

The emphasis on SCP was adapted from the study by Rodrigues, Stank and Lynch (2004) as our overall intention was to understand the behaviour of the entire supply chain, including stakeholders, when the use of IT is introduced. Similarly, UOI was adapted from the study of Boynton, Zmud and Jacobs (1994) since the use of IT was the main construct to help us establish our claim related to uncertainty reduction and improving the supply chain performance. SCC was adapted from Corsten and Felde (2005), as we wanted to understand whether the use of IT leads to supply chain collaboration because until then, obtaining an improvement in supply chain performance might be a challenging task. Finally, VU was adapted from Mishra, Konana and Barua (2007) because the supply chain in agriculture is already filled with numerous challenges and information asymmetry due to a high level of uncertainty, therefore this is one of the major constructs in our work.

The PLS-SEM model is properly examined and accordingly interpreted intelligently with the sequence: first, the assessment related to reliability and validity were determined, and then secondly, the structural model was assessed. Finally, the consistent PLS algorithm obtained the path co-efficient, loadings, weights and quality criteria. A few dummy variables were also used as control variables (Table 2).

< Insert Table 2 about here>

4.3 Statistical model

$$SCP = \beta_0 + \beta_1 * SCC + \beta_2 * UOI + \beta_3 * VU + \varepsilon$$

$SCC = \beta_4 + \beta_5 * UOI + \beta_6 * VU + \beta_7 * UOI * VU + \varepsilon_1$

$UOI = \beta_8 + \beta_9 * VU + \varepsilon_2$

Where,

SCC - Supply chain collaboration

SCP - Supply chain performance

IT - Use of IT

VU - Volume Uncertainty

4.4 Measurement model

The model (Table 2) under the investigation comprised four multi-item constructs. With exploratory factor analysis (EFA), we ensured that all the item loading for its underlying latent variable is greater than 0.6 (Table 3), without cross-loadings taking place. We also did confirmatory factor analysis (CFA) for testing the measurement scales of all the constructs. We also checked the reliability and uni-dimensionality, i.e., the correlation of the item to the total. Our model also stood by the discriminant and convergent validity requirements that are both the Composite Reliability (CR) and Average Variance Extracted (AVE) were found above the threshold value of 0.7 and 0.5 (Fornell and Larcker, 1981).

<Insert Table 3 about here>

4.5 Reliability and validity

After this, the discriminant validity is an important measure that reflects the extent to which the measures of one variable do not reflect the other variable. This is an indication that the variable of interest has a low correlation with the other variable. (Fornell and Larcker, 1981). The square root of the AVE, i.e., the diagonal values of every construct, is larger than all other correlations with other constructs, pointing towards the required discriminant validity, shown in Table 4 below.

Since few schools of thought differ in the opinion that the discriminant validity is not reliably detected by Fornell and Larcker (1981) in common research situations (Henseler, Ringle and Sarstedt, 2015). Therefore, they suggested an alternative approach to assessing the discriminant validity based on the multi-trait-multimethod matrix: the heterotrait-monotrait (HTMT) ratio (Threshold > 0.85) of correlations (Henseler, Ringle and Sarstedt, 2015). Thus, we tested discriminant validity through this method (Table 5).

< Insert Table 4 and 5 here>

4.6 Endogeneity and common method bias (CMB)

After the data collection was over, data was cleaned and managed to conduct the analysis. Endogeneity is pervasive and sometimes inevitable in business research (Deng, 2016). The issue has fetched attention only in the recent past (Sarstedt, et al., 2020). Hult et al., (2018) argued that there is no comprehensive framework that combines the approaches to address endogeneity in SEM research. They also described that Endegeinity may have roots in common method variance, and simultaneous causality. In our research, we have addressed the issues of CMB with appropriate rigour using standard methods.

Since our data collection was from a single respondent, we checked for CMB in multiple ways, namely: (1) instrument design and administering stage; (2) design of the survey, by incorporating the reverse coded items; and (3) through statistical control. We changed the order of the constructs as designed in our framework to address the common method bias (CMB). The face and content validity of the survey ensured that the survey items were compact and easy to understand. Harman single factor test found a total variance explained as 38.94% (Threshold < 50%). Furthermore, it has been argued that the studies involving mediation analyses are generally free of CMB because it is not possible for the respondent to bias the responses to influence the results (Chang, 2010).

A straightforward way to reduce the endogeneity is to specify a set of control variables (Reeb, 2012; Bernerth and Aguinis, 2016). We have used all relevant controls (Age of respondent, Education, Income, Experience, employee strength, and annual turnover) from the list of controls as suggested by Shu, Jin, and Zhou (2017).

To address the endogeneity concern, we conducted the tests of endogeneity by using instrumental variables (Hult et al., 2018) in the model. We report the Durbin test, and Wu-Hausman test statistics to confirm that the equations were free of endogeneity issues, and our results were unbiased. If the p-value in both the tests is more than 0.05, the tests confirm the absence of endogeneity. The Durbin and Wu-Hausman p values for SCP (0.8793, and 0.8905) and SCC (0.7965, and 0.8054) were observed respectively in our endogeneity tests. This confirmed the absence of endogeneity in our models.

Since we confirmed the absence of significant endogeneity in the research models, we continued with PLS-SEM models to test our mediation hypotheses using non-corrected estimates (Hult et al., 2018).

4.7 Structural model and empirical results

We assessed the structural model by considering the R^2, beta, and the respective t-values obtained by bootstrapping process using a resample of 5000, as suggested by Hair et al. (2016).

So, we check the relationships among the variables (Table 6). We find that, VU has negative and significant effects on UOI and SCP, (β = -0.442; p =0.000) and (β = -0.185; p=0.054). UOI positively and significantly affected SCC (β = 0.251; p=0.011). Similarly, SCC also positively and significantly influences SCP (β = 0.591; p=0.000). We also found the specific indirect effects from UOI to SCP to be significant (β = 0.149; p=0.027), which means that SCC mediates the relationship between the two. VU negatively and significantly leads to SCC via UOI (β = -0111; p =0.009) and negatively and significantly leads to SCP via UOI and

SCC both as mediators (β = -0.066; p =0.026). Therefore, we see that out of 5 hypotheses, H2, H4, and H5 are supported.

< Insert Table 6 about here>

The obtained values for R^2 for the phenomenon under investigation SCP is (0.457). Next, an important aspect is to assess the f^2 which is the effect size. The results discuss p-values that give the significance level but do not indicate the effect size. Thus, to reduce readers' confusion while interpreting the results and data, it is necessary to report both the parameters: the p-value for significance and the F square for effect size. In order to measure the effect size, we adhered to (Cohen, 1988) guidelines that follow 0.02 for small effects, 0.15 for those considered to be medium and 0.35 for the large effect. We have shown the effect size in Table 4 above.

Next, the important parameter measured is the Q^2 which is the predictive relevance. (Chin, Peterson, & Brown, 2008), discussed it as a technique following the sample reuse. It is measured by the blindfolding method in SmartPLS3, which shows the ability to reconstruct the data empirically by model and the PLS parameters. If the value for Q^2 is greater than 0, it is an indication of the model possesses predictive relevance, and less than zero implies that the model is devoid of predictive relevance.

5 Discussion, conclusion and limitations

This study has key results that contribute to the literature on the agricultural supply chain, especially at the intersection of Industry 4.0 and emerging markets (Mitra, Kapoor, and Gupta, 2022). First, the UOI is a positive contributor to SCC and mediated VU and SCC's relationship. Second, when VU was examined towards SCP via SCC in the first case and UOI in the second case, the results were not supported in both cases, which means SCC and UOI both do not mediate this relationship. Third, when the same relationship was double mediated with UOI and SCC, the results were supported, indicating the mediating role of the UOI and SCC when considered together. Fourth, the SCC was tested as a positive mediator between UOI and SCP, which supported our hypothesis.

It is also indicative that during uncertain situations in agriculture if the UOI is adopted, it enhances the buyer's (firm) and supplier (farmers). Fifth, the relationship was observed between UOI and SCP with SCC as the mediation effect. As a result, we believe that UOI will not directly lead to SCP in the agricultural sector unless there is adequate coordination between two players coupled with the infrastructural capability of the buyer. Hence, the mediated result is significant and positive, whereas the direct relationship is non-significant. Finally, SCC leads to high SCP in the agricultural sector in emerging markets.

A vast digital divide exists between developed and developing nations due to the lack of infrastructure, tools and relevant skills (Sharma *et al.*, 2020). However, there are few studies along similar lines concerning the detailing of developed and developing economies.

Firstly, the studies are mainly based on literature reviews on ASC, hence empirical works are lacking. Moreover, the majority of the work has been done in the context of developed nations. Thus, developing or underdeveloped nations have been devoid of much research (Routroy and Behera, 2017).

Secondly, previous studies have targeted the aspects of perishability, quality of food, safety standard, application of ICT, and losses face after the harvest (Routroy and Behera, 2017). The problem that crops up for developing countries is how to reduce information asymmetry and uncertainty (Routroy and Behera, 2017), which asks for immediate intervention. Thus, this study builds on the premise of reducing the uncertainty by UOI and ultimately improving the overall SCP. Agriculture is one of the major employment generating sectors in developing nations, therefore, the identification of the right areas with right strategies is important to enhance the overall improvement in ASC (agricultural supply chain). Unlike many other studies in ASC, this study delivers the strategy of providing UOI and leading to SCC, reducing VU that leads to SCP in developing nations.

Thirdly, previous works have discussed the changes in the prices in ASC due to weather, uncertainty in terms of price and environment, but have not discussed reducing the uncertainty (due to lack of right information), which is a major issue in developing economies' ASC (Routroy and Behera, 2017). This study stands different and unique by highlighting the role of private players by eliminating middlemen and information asymmetry by bringing ICT and improving the SCP.

5.1 Conclusion and discussion

This study addresses risk mitigation in the agricultural supply chain in developing economies under the environment of information asymmetry and uncertainty from the demand and supply sides, respectively. Based on real-life motivations, agricultural companies adopt ICT-based technologies in different capacities to address agricultural solutions in different contexts. One such capacity is risk mitigation due to high uncertainty in supply, which further aggravates when marginalized farmers are sceptical of their product's future due to high demand fluctuations attributed mainly to information asymmetry in the entire supply chain.

This study intends to capture whether digitization in different capacities contributes to better SCC and thereby ensures high SCP. Developing nations like India have recently adopted ICTs in the agricultural sector, and therefore, the industry is growing at different rates for different companies.

5.2 Theoretical contribution

The paper has important theoretical implications. First, our paper contributes to understanding digitization and supply chain literature in developing markets such as India. Since very few studies had addressed the impact of digitization in emerging markets (Kamble, Gunasekaran and Sharma, 2018; Tortorella and Fettermann, 2018); this study provides an important extension on the discussion of leapfrogging from Industry 2.0 to Industry 4.0 in developing markets such as India (Iyer, 2018). Second, the paper's contribution is to understand the agricultural supply chain where suppliers belong to marginalized communities ("poor as suppliers"). This provides additional challenges in deciding whether or not ICT technologies should be installed based on firm size, the institutional environment that includes the level of demand uncertainty and infrastructural support in rural areas (Sodhi and Tang, 2014).

5.3 Practice Implications

Towards the managerial contribution, this study indicates, that given the multitude of smallholder farmers with a lack of information and resources, the private firms need to come forward and take a stance on reducing agrarian distress by deploying ICT. The UOI will help reduce the search costs, and lower and understand the price volatility and rising production prices (De Janvry and Sadoulet, 2020). Implementing this approach shall reduce poverty and improve coordination (de Janvry and Sadoulet, 2020) and lead to the improvement in SCP. These interventions are aimed at improving:

- Ease of accessing the information about inputs used in agricultural processes. These include technology to check the health of the soil, selection of the right type of fertilizers, and pesticides, understanding seed quality and variety, weather-related forecasts, etc.
- The production process includes the use of sensors to collect data related to the growth of a particular type of crop continuously and furnishing the immediate advice and inputs, bringing the automated harvesters into use for higher harvesting yields, etc.
- Helping in accessing the information about output markets that helps the farmers to identify their selling channels in an informed way, including data about prices and availability of various commodities in different markets in a neighbourhood.

5.4 Limitations and future scope

This paper has certain limitations. First, we considered a situation in the agricultural sector where the UOI is rare in developing countries like India. This is because the rural sector does not have the bandwidth to transform the agricultural supply chain towards Industry 4.0 (Ivanov et al., 2019). This creates a lacuna in understanding the nature of the business at the field level and thereby shortens the total population concerning Agriculture 4.0 (Yost *et al.*, 2019) in developing nations like India. This provides an opportunity for future researchers to delve deeper into such individual companies and understand the operational constraints and needs which prompted them to use digitization as a tool. Second, our study focused on understanding how SCP is enhanced through digitization from the perspective of agricultural companies.

The agricultural companies may concede that due to ICTs, better SCC leads to SCP. However, whether the farming community, especially the BoP segment, appreciates and benefits from such collaboration is unknown. As a result, our study only addresses the concern of SCP from digitization from the perspective of an upstream player (Hirose and Matsumura, 2017), as our target respondents were the firm's employees. Future studies need to conduct a similar perspective from the downstream player and then validate whether digitization contributes to SCP.

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Figures

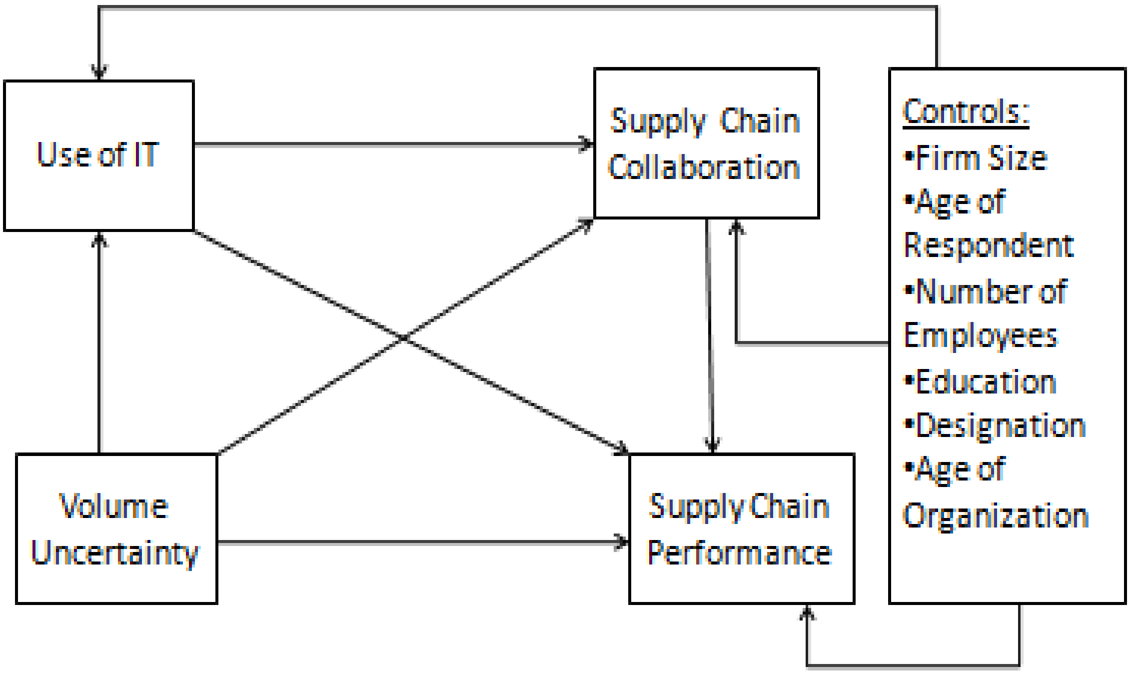

Figure 1: Research framework and conceptual model

Tables

Table 1: Variables description and definition

Variable	Description	Definition	Source
VU	Volume Uncertainty	VU is defined as the uncertainty of the agricultural commodity in the entire supply chain.	Mishra et al., 2007
UOI	Use of Information Technology	The use of IT is defined as how an organization deploys IT to support operational and strategic tasks.	Boynton et al., 1994
SCC	Supply Chain Collaboration	Tight coupling between SC partners in order to leverage the symbiotic benefits through process planning, target costing, technology development and process development	Cao and Zhang, 2011; Heide, &John (1990
SCP	Supply Chain Performance	The ability of the firm to perform on four parameters, namely, order fill capacity, delivery dependability, customer satisfaction and delivery speed	Wagner and Bode, 2008

Table 2: Respondent's profile

Demographic characteristics	Scale	Absolute numbers	Percentage (%)
Age	20-29	24	19.83
	30-39	30	24.79
	40-49	23	19.01
	50-59	30	24.79
	60-69	14	11.57
State	Uttar Pradesh	13	10.74
	Maharashtra	21	17.36
	Rajasthan	15	12.40
	Gujarat	12	9.92
	Madhya Pradesh	23	19.01
	Karnataka	13	10.74
	Punjab	16	13.22
	Chattisgarh	8	6.61
Age of the organization	< 05 years	13	10.74
	05 to < 10 Year	15	12.40
	10 to < 15 Year	22	18.18
	15 to < 20 Year	19	15.70
	20 to < 25 Year	23	19.01
	>= 25 Years	29	23.97
Annual revenue	<10 crore	25	20.66
	10 to < 20 Crore	28	23.14
	20 to < 30 Crore	21	17.36
	30 to < 40 Crore	17	14.05
	>= 40 Crore	30	24.79
Number of employees in the organization	<500	24	19.83
	500 to <1000	21	17.36
	1000 to <1500	26	21.49
	1500 to <2000	23	19.01
	>= 2000	27	22.31
Educational level	<= High school	4	3.31
	High school to< graduate	7	5.79
	Graduate	51	42.15
	Postgraduate or more	59	48.76
Designation	Founder and Owner	12	9.92
	President	4	3.31
	CEO	5	4.13
	Director	16	13.22
	Manager	25	20.66
	Analyst	10	8.26
	Engineer	36	29.75
	Scientist	5	4.13
	Clerk	8	6.61

Table 3: Measurement model results

Constructs	Items	λ	μ	σ	α	AVE	CR
Volume Uncertainty	Production estimates are unreliable	0.836	2.608	1.093	0.914	0.744	0.936
	There are frequent changes in production volumes	0.854	2.700	1.121			
	There is a gap in demand and supply estimations	0.889	2.681	1.045			
	The inventory carrying costs are high	0.859	2.664	1.106			
	There are frequent shortages and stock-outs of demand	0.875	2.678	1.017			
Use of IT	*Our Information Systems developed to:*						
	Reduce the cost of business activities	0.658	6.442	0.516	0.815	0.738	0.892
	Assist in monitoring, to control, and designing business activities	0.944	6.233	0.681			
	Assist in formulating business strategies	0.943	6.233	0.692			
Supply Chain Collaboration	*We are working closely with the respective supplier in:*						
	Process development	0.708	6.083	0.637	0.782	0.608	0.860
	Target costing	0.866	5.775	0.956			
	Technology development	0.833	5.917	0.904			
	Project planning	0.698	6.075	0.665			
Supply Chain Performance	We provide the desired quantities consistently	0.912	5.983	0.641	0.873	0.725	0.913
	We meet the quoted or anticipated delivery dates and quantities consistently	0.856	5.842	0.808			
	We meet customer satisfaction with supply chain performance consistently	0.825	5.992	0.625			
	We maintain the time between order receipt and customer delivery	0.809	5.874	0.740			

Table 4: Fornell-Larcker Criterion

Details	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**
[1] Firm Size	1.00									
[2] Age of Respondent	0.13	1.00								
[3] Number of Employees	0.77	0.07	1.00							
[4] Education	0.47	-0.02	0.39	1.00						
[5] Designation	-0.01	-0.16	0.02	-0.17	1.00					
[6] Age of Organization	0.80	0.09	0.72	0.41	-0.04	1.00				
[7] Volume Uncertainty	-0.06	0.20	-0.11	-0.02	-0.13	-0.06	**0.86**			
[8] Use of IT	-0.05	-0.10	-0.08	0.12	-0.05	-0.13	-0.42	**0.86**		
[9] SC Collaboration	0.03	-0.08	0.02	0.05	0.05	0.05	-0.32	0.33	**0.78**	
[10] SC Performance	0.13	0.06	0.17	0.09	-0.05	0.15	-0.33	0.21	0.63	**0.85**

Note: Diagonals represent square roots of AVE

Table 5: Heterotrait-Monotrait Ratio (HTMT)

Details	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
[1] Firm Size										
[2] Age of Respondent	0.13									
[3] Number of Employees	0.77	0.07								
[4] Education	0.47	0.02	0.39							
[5] Designation	0.01	0.16	0.02	0.17						
[6] Age of Organization	0.80	0.09	0.72	0.41	0.04					
[7] Volume Uncertainty	0.06	0.21	0.12	0.03	0.14	0.07				
[8] Use of IT	0.08	0.11	0.10	0.14	0.06	0.14	0.47			
[9] SC Collaboration	0.09	0.17	0.05	0.08	0.06	0.06	0.37	0.41		
[10] SC Performance	0.14	0.11	0.18	0.09	0.08	0.16	0.37	0.25	0.74	

Table 6: Structural estimates (Hypotheses Testing)

Relationships	#	B	T	P	F-S
Controls					
Firm Size -> Use of IT		0.130	0.768	0.443	0.006
Firm Size -> SC Collaboration		-0.040	0.184	0.854	0.000
Firm Size -> SC Performance		-0.044	0.295	0.768	0.001
Age of Respondent -> Use of IT		-0.008	0.098	0.922	0.000
Age of Respondent -> SC Collaboration		-0.005	0.065	0.948	0.000
Age of Respondent -> SC Performance		0.122	1.615	0.107	0.025
Number of Employees -> Use of IT		-0.107	0.700	0.484	0.006
Number of Employees -> SC Collaboration		-0.042	0.288	0.773	0.001
Number of Employees -> SC Performance		0.131	1.286	0.199	0.012
Education -> Use of IT		0.186	1.817	0.070	0.034
Education -> SC Collaboration		0.010	0.120	0.905	0.000
Education -> SC Performance		0.002	0.028	0.977	0.000
Designation -> Use of IT		-0.081	1.016	0.310	0.008
Designation -> SC Collaboration		0.038	0.408	0.683	0.002
Designation -> SC Performance		-0.080	1.454	0.146	0.011
Age of Organization -> Use of IT		-0.261	1.765	0.078	0.030
Age of Organization -> SC Collaboration		0.126	0.784	0.433	0.006
Age of Organization -> SC Performance		0.034	0.263	0.793	0.001
Specific Indirect Effects					
VU -> Use of IT -> SC Performance	**H1**	0.017	0.394	0.694	
VU -> Use of IT -> SC Collaboration	**H2**	-0.111	2.608	0.009	
VU -> SC Collaboration -> SC Performance	**H3**	-0.120	1.192	0.234	
Use of IT -> SC Collaboration -> SC Performance	**H4**	0.149	2.216	0.027	
VU -> Use of IT -> SC Collaboration -> SC Performance	**H5**	-0.066	2.232	0.026	

Note: [#- Hypothesis number], [β – Beta coefficients], [T – t stats], [P – p significance value], [F-S: f square for effect size]