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Moderating Effect Of Information & Communication Technology On The Relationship Between Post-Harvest Management And Supply Chain Performance Of Apples: Uttarakhand

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Abstract

Purpose: This paper determines to study the moderating effect of information & communication technology on the relationship between post-harvest management and supply chain performance of apples in Uttarakhand.

Research Design/ Methodology: An exhaustive review of previous studies has been performed to study the moderating effect of information & communication technology on the relationship between post-harvest management and supply chain performance of apples in Uttarakhand. A simple random sampling method was employed to choose the respondents (apple growers). The sample size consisted of 457 respondents. Out of 457, 409 responses were usable. Semi-structured questionnaires were distributed to the respondents (apple growers) of the study. Descriptive analysis, exploratory factor analysis, confirmatory factor analysis, correlation, and simple linear regression was used for the process of data analysis.

Outcome of the study: It has been revealed by the outcome of the study that there is a significant and positive relationship between post -harvest management and supply chain performance of apples. Results also indicated that information & communication technology moderates the relationship between post- harvest management (PHM) and supply chain performance (SCP) of apples in Uttarakhand.

Research Limitations: Only Uttarakhand has been considered in the study. This study covered only apple as a fruit.

Implications of the study: The study offers in depth knowledge to stakeholders of an apple supply chain in terms of what role can ICT and PHM play to enhance the overall supply chain performance of apples.

Originality/Value: The current study will justify the significance of adoption and implementation of ICT in supply chain of apples in Uttarakhand.

Keywords: post-harvest management; information & communication technology; supply chain performance; apple growers; Uttarakhand.

1 Introduction

1.1 Post-harvest management

Post-harvest management has been earning renewed research concern in the past years. Owing to such concern, it confirms to be mandatory to comprehend the impact of PHM on SCP (Sisipo et al, 2021). PHM is basically a process which incorporates cleaning, cooling, handling & storage of raw produce like apples, processing, packing, transportation from one point to another as the main activities of the process. It can have a sweeping effect on SCP by upholding the quality characteristics and shelf life of raw produce intact (Arah, 2016). Therefore, it becomes vital to be aware of some appropriate post-harvest management practices that can be employed for better productivity. The significant post-harvest management steps involved after the harvestation of the raw produce are as follows: washing, sorting & grading, packaging, warehousing & transportation.

1.1.1 Washing

Washing/Cleaning of fruits before they get packed is vital, especially the ones treated with chemicals. When the raw produce gets washed up, the appearance of fruits gets improved which further inhibits drooping/wilting (Ramjan & Ansari, 2018). Hygiene must be the foremost thing to consider for all apple growers as apples are not only prone to post-harvest diseases but can also transmit food-borne illness to the ones who consume them.

1.1.2 Sorting & Grading

To realize good profit margins, sorting and grading becomes vital for apple growers in Uttarakhand especially. Sorting & grading improves packaging, handling and other post-harvest functions. Apple growers of Uttarakhand are looking forward to efficient and real time-based producing-grading machine to alleviate paucity of labour (Londhe et al, 2013). Shittu and Barau (2021) points out that 87% of the apple growers (respondents) agreed that sorting and grading essentially adds value to fresh produce like apples.

1.1.3 Packaging

Packaging is principally done to enclose raw produce apples to defend them from mechanical damages, tampering, pilferage, and contamination from physical, chemical and biological sources **(Prasad & Kochhar, 2014).** In India, common packaging material used is cardboard

boxes and crates made up of plastic and wood. If good quality packaging is not done, then eventually it leads to spoilage of raw produce (Idah et al, 2007). Kasso & Bekele (2016) used descriptive analysis and revealed the outcome that unsuitable packaging system causes mechanical damage which supplementarily leads to worsening of the quality of raw produce like apples.

1.1.4 Storage

After the process of harvestation, raw produce like apples is transported to plainer areas for storage. Proper refrigeration and controlled atmosphere are used to improve the shelf life of apples. It has been noticed that apple growers of Uttarakhand pay exorbitant prices for these types of storage facilities which add to the overall cost (Sharma et al, 2015). A study revealed that 19.3% of apple growers stated that adequate storage facilities are one of the factors that can help enhance the overall SCP (Kasso & Bekele, 2016). All types of supply chains face issue related to storage or warehousing which further add on to poor performance of the SC. Therefore, to be competitive and responsive the supply chains are required to perform well (Nadeem et al, 2018).

1.1.5 Transportation

The prime role played by transportation is unquestionable. Crum (2015) detailed that the enormity of transportation service would continue to have an essential role in SCM. Correspondingly, the eminence of services related to transportation continues to affect the customer satisfaction level, order fulfillment time which constitutes SCP by and large. It has been observed that in Dire Dawa Administration, the root cause of post-harvest losses (PHLs) in terms of quality is transportation (Kasso & Bekele, 2016).

1.2 Information & Communication Technology

Application of mathematical modeling-based technologies like membrane gas separation modeling for packaging, kinetic modeling for storage, stochastic modeling for transportation was mathematical modeling in supervising quality attributes of the raw produce was highlighted to monitor the quality loss of raw produce of fruits (Onwude et al, 2020). Perishable commodities like fresh fruits get decayed with environmental aspects like high temperature and moisture which need to be maintained and regulated on a real-time basis (Zambrano et al, 2019). Distribution of fresh fruits is required to be done timely which is only possible through information communication & technology (Han et al, 2017). The adoption and application of ICT Tools is worthwhile in the creation of SC capable of quick response time and enhanced SCP (Wen et al, 2018; Han et al, 2017). Studies suggest that there is a dire need to apply ICT tools and adopt the efficient ones to enhance/improve the SCP and income of apple growers in India (Agarwal, 2018). A survey on the extant literature on ICT exposes that the challenge is not increase the production of fresh fruits but to ensure that they are reasonably accessible in good quality to all sections of the society.

1.3 Supply Chain Performance

A model named Supply Chain Operations Reference was developed by Supply Chain Council. This model studied several factors that can be put in use by supply chain decision makers to have an approach which is balanced towards enhanced performance. Supply chain performance as a concept date back to 1990s which integrates various factors that have an impact on the various operations of a supply chain**.** Faranak et al, (2013), suggested important gauges of supply chain performance like quality attributes, safety, flexibility, post -harvest management. Trienekens et al (2008) indicated that efficiency, quick response, quality and distribution flexibility collectively all together play a vital role in improving the supply chain performance.

Given the significance of problem, the current research addresses this gap by examining the moderating role of ICT on the relationship between PHM and SCP of apples in Uttarakhand. Therefore, the purpose of this research paper is to develop a theoretical framework for PHM, ICT and SCP through hypothesis testing.

2 Research Questions

The current study addresses the following research questions:

Q1. How does PHM impact the SCP of apples in Uttarakhand?

Q2. Does ICT moderate the relationship between PHM and SCP of apples in Uttarakhand?

3 Research Objectives

- ✓ To assess the impact of post-harvest management on supply chain performance of apples
- ✓ To examine the moderating effect of ICT on post-harvest management and supply chain performance of apples

4 Research Hypotheses

- ✓ PHM has a significant and positive impact on SCP of apples in Uttarakhand
- ✓ ICT moderates the relationship between PHM and SCP of apples in Uttarakhand

5 Research Methodology

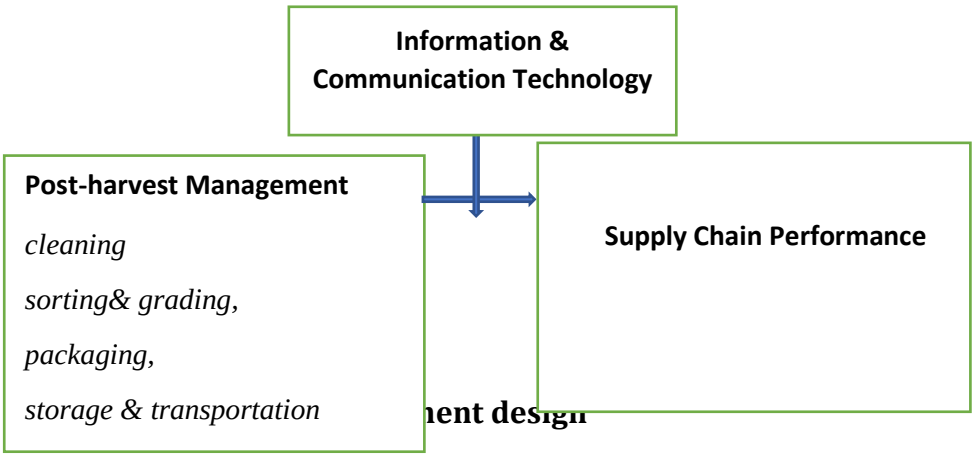
5.1 Research Framework

Figure 1 represents the proposed research model. This research aims to study the moderating effect of ICT on the relationship between PHM and SCM. PHM is an independent variable while the dependent variable is SCM. ICT acts as a moderator between PHM and SCP. Therefore, this paper has two hypotheses:

H1: Post- harvest management is significantly related to supply chain performance

H2: Information & communication technology moderates the relationship between post-harvest management and supply chain performance of apples

Figure 1. Proposed research model



ment design

In the current study, the respondents were apple growers from Uttarakhand State of India. The primary data was collected with the help of a structured questionnaire. A meticulous review of the extant literature was directed to scheme the structured questionnaire to cover all the items. The survey questionnaire consists of four sections viz.

1. Demographic profile of the respondents
2. PHM
3. ICT
4. SCP

The demographic profile of the respondents includes gender, age and experience. The questionnaire included closed-ended questions, where the respondents were required to fill it with a five-point Likert scale. The dimension of the scale includes (1=strongly disagree, 2=Disagree, 3=Neutral, 4=agree and 5=strongly agree).

6.2 Data Collection

A self-administered structured questionnaire was put in use to obtain data for the purpose of analysis. The apple growers of Uttarakhand filled the questionnaire and provided relevant information. Below mentioned tabulated data is related to frequency analysis.

Table 1. Demographic Profile (Frequency Analysis)

Gender	Male	398	97.31
	Female	11	2.69
Age	18-25 years	80	19.5
	26-35 years	73	17.8
	36- 45 years	62	15.1
	46-55 years	62	15.1
	Above 55 years	132	32.2
Experience	1-5 years	15	3.6
	6-10 years	178	43.5
	11-15 years	97	23.7

	16-20 years Above 20 years	84 35	20.5 8.5
Education	Less than elementary High School Intermediate Graduation Post-Graduation and Above	131 157 45 49 27	7.57 38.3 11.0 11.9 6.6

Simple random sampling was used as a sampling technique to select the apple growers of the State. By attaining obligatory permission, a Google form was created and distributed to the apple growers with a note explaining the relevance of the study. The apple growers were made sure about the confidentiality of the responses. 457 apple growers agreed to participate, and the total response obtained was 409.

7 Data Analysis

Descriptive analysis was performed using the study variables to compute the values of mean, correlation, and standard deviation. Exploratory factor analysis, correlation analysis and confirmatory factor analysis was conducted to ensure the psychometric properties of the variables used in the study. The convergent validity and divergent validity of the model were found to be satisfying. The hypothesis testing and model fit of the structure is discussed in the last section of analysis. To ensure the model fit, goodness of fit index (GFI), CHI Square/df (CMIN/degree of freedom), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR) and comparative fit index (CFI) were put in use. The value of Chi square/df was found good as 1.96 which lies in between the limit of 1 to 3. Similarly, the values of SRMR and RMSEA were less than 0.1 which were considered correct (Bentler and Bonett, 1980). The value of CFI and GFI were found > 0.9 which is considerably good (Scott and Bruce, 1994).

7.1 Descriptive analysis

Table 2 denotes descriptive analysis of the study variables. The standard deviation of variables lies between 1.27 to 1.86. The mean value of variables found between 2.02 to 2.93. The Pearson correlation among the constructs was found below 0.7, so there is no collinearity among the variables.

Table 2. Descriptive Analysis

Descriptive analysis

	Mean	St. deviation
Post-harvest management	2.02	1.27
Information & communication technology	2.93	1.86
Supply chain performance	2.83	1.53

Note: **p<0.001

7.2 Correlation Analysis

Correlation analysis was undertaken by the researchers to compute the values of correlation amongst the study variables. Table 3 shows the values of correlation.

Table 3. Correlation analysis amongst study variables

	ICT	PHM	SCP
ICT	1		
PHM	0.039**	1	
SCP	0.77**	0.385**	1

7.3 Exploratory Factor Analysis

Using SPSS, exploratory factor analysis (EFA) was performed to obtain the items of ICT with threshold values above 0.7. EFA was conducted using a principal component method. 9 ICT items, 9 PHM items and 6 SCP items were extracted based on threshold scores of factor loadings. Using Varimax method, factors were obtained. Therefore, included items for analysis have more than recommended value of 0.7 at least. The tabulated data below displays the value of Cronbach's alpha, results of EFA, and values of AVE and CR.

Table 4. Post-factor analysis results

Constructs	Items	Statements	Cronbach alpha	Factor loading	Validity
ICT	ICT1	Platform for interaction among supply chain partners is being provided by ICT	0.975	0.714	AVE= 0.812 CR= 0.972
	ICT2	ICT Tools like personal computers, WhatsApp, telecommunication devices, GIS, GPS, Personal Digital Assistance,		0.848	

		web portals are being used by us to a greater extent			
	ICT3	Various challenges are being faced in using ICT as a tool		0.799	
	ICT4	GIS has enabled us to map the natural environmental conditions with regards to agricultural production, correct usage of fertilizers and other agrochemicals		0.722	
	ICT5	Government provides us proper training on how to use these modern ICT Tools is		0.856	
	ICT6	We have proper internet connectivity at our end all the time		0.848	
	ICT7	Tracking and traceability of the entire supply chain takes place smoothly which results into advanced cultivation practices		0.807	
	ICT8	ICT enables us to process the orders fast with reduces the lead time		0.851	
	ICT9	We utilize farm resources optimally all because of ICT		0.813	
PHM	PHM1	We need to build a greater number of cold chain facilities in the hilly regions	0.931	0.872	AVE= 0.601 CR=0.932
	PHM2	We have proper access to different modes of transportation for the movement of apples from one point to another		0.841	
	PHM3	Inspecting the storage structure at regular intervals help us identify the infected, bruised, and rotten apples form the clear ones		0.736	
	PHM4	We have round the clock availability of packaging material for apples		0.856	

	PHM5	We adhere to packaging standards (like WHO, ISO and APEDA) for the packaging of apples		0.875	
	PHM6	Our packaging of apples communicates the complete details of the fresh produce apples		0.839	
	PHM7	We sort, and grade apples based on variety colour size and spoilage		0.744	
	PHM8	Our packages of apples are easy to open and empty, fit in storage spaces and contains the appropriate amount		0.745	
	PHM9	Cost of refrigerated transportation in the hilly regions is very high as the price they get from wholesalers hardly covers the cost they incur in refrigerated transportation		0.866	
SCP	SCP1	We fill the orders of our buyers on time	0.898	0.819	AVE=0.623 CR=0.897
	SCP2	Instant response to revised customer orders is one of our strengths		0.817	
	SCP3	Organic manure, chemical fertilizers, and toxicants are being used by us to avoid pathogens		0.817	
	SCP4	Adherence to WHO and ISO standards is one of the guidelines		0.822	
	SCP5	Waste is reduced by converting the residuals into value-added products like jam, jelly, pickle, squash		0.785	
	SCP6	We avail high profit margins due to the production of the best quality apples		0.781	

7.4 Discriminant Validity and Convergent Validity

AVE Value of PHM (0.601), ICT (0.812) and SCP (0.623) was found to be above the threshold limit of 0.5. The composite reliability of all the variables used in the study ranged between 0.897-0.972. The value of CR and AVE ensures the convergent and discriminant validity of the variables. Hence, the model ensures convergent and discriminant validity amongst the constructs.

7.6 Assessment of measurement model using Confirmatory factor analysis

Figure 2 represents the measurement model of the current study. Using Amos v21, confirmatory factor analysis was done. The results of the model were found appropriate and ensured the necessary cut offs as CFI=0.987, Chi Square/df=1.492, PCLose =1.00, RMSEA =0.035, SRMR = as stated in the prior studies the values were found correct. The factor loadings of the items are above 0.7 representing good internal consistency (Hair et al, 2010b). The Cronbach's alpha of all the study variables PHM (0.931), ICT (0.975) and SCP (0.898) was above the acceptable value 0.7 which further confirms the internal consistency of the constructs.

Figure 2. Confirmatory factor analysis

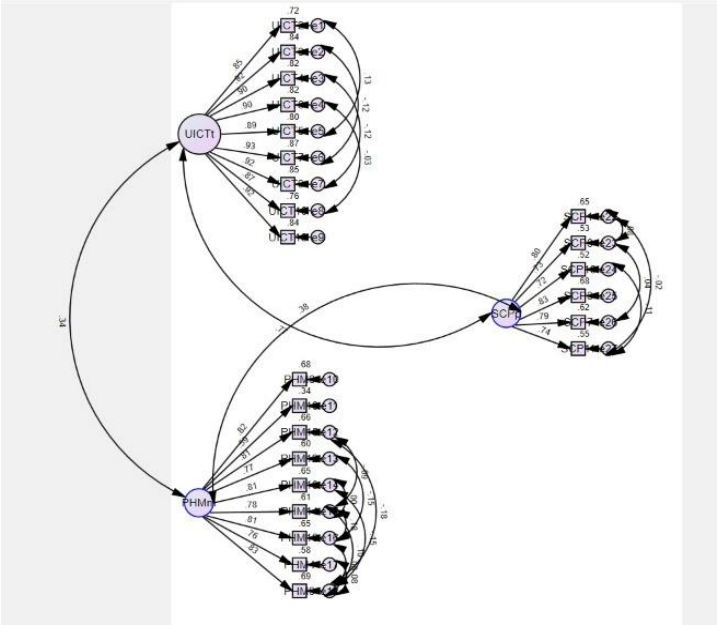


Fig. 2 Confirmatory Factor Analysis

7.7 Hypothesis Testing

The first hypothesis stated that PHM has a significant and positive impact on SCP of apples in Uttarakhand (Beta= 0.170 0, t= 4.376, p<0.000), therefore, H1 is accepted according to the results mentioned in the below table.

Table 5. Hypothesis Testing Summary

Hypothesis	Regression Weights	Beta Coefficient	t value	P-value	Result
H1	PHM→SCP	0.170	4.376	.000*	Satisfied
Note: *p<0.05, PHM: Post-harvest management, SCP: Supply Chain Performance					

The second hypothesis stated that ICT moderates the relationship between PHM and SCP of apples in Uttarakhand. Previous studies conducted by Mkwizu & Sichone (2019) used technology as a moderator on the relationship between user's attributes and an e-government information system in Tanzania**.** Ramyah (2010) used information quality as a moderator information exchange and supply chain performance whilst this study has used ICT as a moderator to contribute literature on the relationship between PHM and SCP of apples in Uttarakhand. The potential moderation of ICT on the relationship between PHM and SCP of apples in Uttarakhand is depicted in the table below, thereby, H2 is accepted according to the results in table.

Table 6. Moderation results using Haye's Method

Outcome Variable=Z SCP	Coefficient	SE	t-statistics	p	LLCI	ULCI
ZPHM	.100	0.372	2.691	.007	.027	.173
ZICT	.673	0.350	19.254	.000	.604	.741
ZPHM*ZICT	.073	0.350	2.084	.0.37	.004	.141

8 Discussion

The present study has three relevant variables naming PHM, ICT and SCP. The current study has tried to find the relationship between PHM and SCP with moderation effect of ICT. The results indicate that PHM has a significant impact on SCP of apples in Uttarakhand. Therefore, PHM is a predictor of SCP of apples in Uttarakhand. This study also reveals that ICT moderates the relationship between PHM and SCP. Theoretically, the significant results of the study support SCOR Model, Resource Based View Theory and Technology Acceptance Model.

9 Implications of the study

9.1 Theoretical Implications

Miemczyk et al, (2016) argues that the resource-based view theory can justify the significance of modern resources in ICT and expertise. From the point of view of SCM, enhanced performance can be attained by using the resources of ICT optimally. Barney (1991) clearly states that for the attainment of enhanced performance by RBV, the resources are required to

valuable, rare, have high imitation cost. The above nuance has been studied in several sectors and different situations. The result could be used as a basis for other future investigations.

9.2 Practical implications

Generally, it can be stated that it is essential to concentrate on the factors affecting the SCP of raw produce. The present research study reveals that post-harvest management and information & communication technology have an important role to play in the overall supply chain performance. Budding agriculturists must include the implementation of ICT Tools in the post-harvest practices to improve the overall performance of the supply chains. Further, training aids must be given to them to increase the awareness amongst them.

The study statistically inferred that ICT has an association with SCP. Hence, measures must be adopted by agriculturists to enhance the supply chain performance. The study also hypothesises the association between PHM, ICT and SCP by statistically exploring the moderating effect of ICT on the relationship between PHM and SCP.

10 Limitations and future scope of research

The present study is confined and has further scope of research and improvement. The outcomes of the study are confined to analysis of the association among various variables in agriculture supply chain in Uttarakhand only, more in depth exploration in this portion, as well as other portions, is needed to mark the results globally acceptable. Correspondingly, the data collected was cross-sectional in nature, therefore, have some limitations and confinements like common method bias (CMB) and causal relation. Furthermore, the size of the sample, sampling method and empirical tools may affect the results. Therefore, forthcoming studies must cross-check the results. With the above mentioned three variables, the study was carried out, impending studies may be conducted by adding more variables, mediators, and moderators. Additionally, facts on PHM, ICT and SCP were collected with the help of self-reported questionnaire which means assessment might have been swayed by individual perspective leading to Common Method Biase.

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