

AGRI-PRICING SUPPLY CHAIN: SELECT ISSUES

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JULY, 2023

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Submitted

In fulfilment of the requirements of the degree of Doctor of Philosophy

To the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

JULY, 2023

CERTIFICATE

This is to certify that the thesis entitled “**Agri-pricing supply chain: Select Issues**” being submitted by **Arkajyoti De** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** is a bona fide record of original research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of the thesis, which has reached the requisite standard.

The result contained in this thesis has not been submitted, in part or full, to any other University or Institute for award of any degree or diploma.

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ACKNOWLEDGEMENTS

I would like to express my deep respect and gratitude to my thesis supervisor, Dr. S.P. Singh, for his excellent scientific guidance and patience throughout the journey. His constructive feedback has always encouraged me to do novel research. His encouraging words during success and motivating words during failures have greatly influenced me. His friendly interactions and support have always been a source of strength in going forward. This thesis could not have reached its present form without his directions, positive influences, and guidance.

I greatly acknowledge my reviewers, internal and external experts, and SRC chairperson for critically analyzing my research works and pushing me forward to enhance my capabilities.

I acknowledge my colleagues Shraddha, Sachin, and Mamta for their technical and conceptual support and advice. I thank my friends Aritra, Alinjar, Subhasis, Rita, and Souvik for their support and encouragement.

I am also thankful to the Indian Institute of Technology (IITD) for funding my research through the Institute Fellowship.

I express my deepest gratitude to my parents and other family members for their love and blessings.

Arkajyoti De

ABSTRACT

The random growing population has led to acute food shortages throughout the world. The world, especially the European and American supermarkets, has been importing several crops and grains from the highly productive Asian tropical region for the last few decades. As the globalization of the Agri-supply chain started, regional markets began to expand. These market expansions have encouraged more nations to international trade fresh Agri-products like fruits and vegetables. The developments of precision agriculture have positively impacted Agri-productivity a lot. Asian mass Agri-producing countries like India, Bangladesh, Pakistan, China, and Vietnam are successfully fulfilling a significant percentage of global food demand over the last few decades. However, inefficient Agri-pricing, cold-chain transportation, and Agri-marketing policies still limit the supply chain's profitability and sustainability.

Moreover, the post-covid growth of e-agribusiness has led to high competition in the Regional Agri-supply chain (RASC). This increasing competition results in a profit and share loss for Agri-supply chain drivers. Thus, this thesis aims to address these issues through Agri-pricing supply chain framework building, considering the ongoing supply chain globalization and digitalization. The developed models help the Agri-supply chain drivers regain their profit margin and provide optimum service quality to the supply chain process. Most of the proposed models use the Stackelberg game theoretic approach to formulate and solve the problem using subgame perfect Nash equilibrium.

The thesis first attempts to revise the Agri-price support policy for smallholders to secure a sustainable profit for smallholder farmers and retailers in the post-covid situation. The model gets influenced by the false narrative of Government Leadership (GL) and formulates one alternative leadership strategy: Farmer's Leadership (FL). The formulated model integrates the traditional BSO model with farmers, retailers, and the government and analyzes the impact of

leadership strategies to compare them in light of each driver's profit gain, government price-support policy, and social welfare maximization. The results claim that although the FL strategy ensures an equilibrium state between the farmer and the retailer, it neither guarantees an equilibrium and optimal state between farmers and government, nor an optimal social welfare function. As this model is limited to the national level, the study missed the global supply chain issues. Thus, the thesis further integrates this model with the logistics outsourcing framework and upgrades the basic demand function to price and quality-dependent demand. This model considers the post-covid growing demand for high nutrient content dry fruit. The proposed model aims to regain the RASC driver's profit loss through sustainable pricing policy-making and to secure a high cold-chain logistics service quality of different variants of date fruit. The model formulates two channel leadership strategies; Logistics Provider's Leadership (LPL) and Supplier's Leadership (SL). The results claim that the LPL strategy can assure a better impact on price gain and cold-chain logistics service quality level than the SL strategy, only if the product's nutrient content is sufficiently high.

However, these models do not consider the high competition in RASC due to post-covid globalization and digitalization. Thus, the thesis integrates the last model with competitiveness in logistics outsourcing and updates the deterministic market demand with market share gain and the drivers' profit with expected marginal profit gain. This model formulates optimistic and pessimistic competitive strategies and compares them in light of the 3PL firm's profitability and market share. The results claim that the focal 3PL firm can secure its profit and market share through a wise selection of competitive strategy and firm parameters only if the firm has perfect information regarding its peer's strategic movement. The model is further integrated with the technology outsourcing framework, considering an equity finance model with the technology R&D institute for cold-chain cost reduction. The model analyzes the effect of the equity finance scheme on the 3PL firm's profit and claims that the scheme is favorable

to the 3PL firm only if the 3PL firm's capital investment to the technology institute's cost reduction efficiency ratio $\left(\frac{I}{\alpha}\right)$ is sufficiently high. The study further analyzes the effect of the supplier's post-harvesting loss rate on the 3PL firm's profit to decide whether the particular RASC is investable.

The final model of the thesis integrates the RASC framework with the platform supply chain framework and upgrades the demand function to the platform's utility function. In light of platform competition, this model analyzes the effect of inter-platform spillover on RASC's profitability, considering inter-platform competition and cooperation strategies. The results claim that the platform competition favors RASC's profitability if the inter-platform spillover rate is sufficiently high.

Finally, the thesis summarizes all the models discussed, highlights major contributions, provides implications for academicians, practitioners, and policy-makers, and recommends future research directions.

Keywords: Agri-pricing supply chain, Agri-price support policy, BSO policy, logistics outsourcing, 3PL, logistics outsourcing competition, technology outsourcing, equity finance modeling, Agri-platform supply chain, platform competition, platform cooperation, strategy-making, decision-making, policy-making.

सारांश

यादृच्छिक रूप से बढ़ती आबादी ने दुनिया भर में तीव्र भोजन की कमी का कारण बना है। दुनिया, विशेष रूप से यूरोपीय और अमेरिकी सुपरमार्केट, पिछले कुछ दशकों से अत्यधिक उत्पादक एशियाई उष्णकटिबंधीय क्षेत्र से कई फसलों और अनाज का आयात कर रहे हैं। कृषि आपूर्ति श्रृंखला के वैश्वीकरण के साथ, क्षेत्रीय बाजारों का विस्तार हो रहा है। इन बाजार विस्तारों ने अधिक देशों को फलों और सब्जियों जैसे ताजा कृषि उत्पादों का व्यापार करने के लिए प्रोत्साहित किया है। सटीक कृषि के विकास ने कृषि उत्पादकता को बहुत सकारात्मक रूप से प्रभावित किया है। भारत, बांग्लादेश, पाकिस्तान, चीन और वियतनाम जैसे एशियाई बड़े पैमाने पर कृषि उत्पादक देश पिछले कुछ दशकों में वैश्विक खाद्य मांग का एक महत्वपूर्ण प्रतिशत सफलतापूर्वक पूरा कर रहे हैं। हालांकि, अक्षम कृषि-मूल्य निर्धारण, कोल्ड-चेन परिवहन और कृषि-विपणन नीतियां अभी भी आपूर्ति श्रृंखला की लाभप्रदता और स्थिरता को सीमित करती हैं।

इसके अलावा, ई-कृषि व्यवसाय की कोविड के बाद की वृद्धि ने क्षेत्रीय कृषि-आपूर्ति श्रृंखला (आरएएससी) में उच्च प्रतिस्पर्धा को जन्म दिया है। इस बढ़ती प्रतिस्पर्धा के परिणामस्वरूप कृषि-आपूर्ति श्रृंखला ड्राइवरों के लिए लाभ और शेयर हानि होती है। इस प्रकार, इस थीसिस का उद्देश्य चल रही आपूर्ति श्रृंखला वैश्वीकरण और डिजिटलीकरण को ध्यान में रखते हुए कृषि-मूल्य निर्धारण आपूर्ति श्रृंखला ढांचे के निर्माण के माध्यम से इन मुद्दों को संबोधित करना है। विकसित मॉडल कृषि-आपूर्ति श्रृंखला ड्राइवरों को अपने लाभ मार्जिन को फिर से हासिल करने और आपूर्ति श्रृंखला प्रक्रिया को इष्टतम सेवा गुणवत्ता प्रदान करने में मदद करते हैं। अधिकांश प्रस्तावित मॉडल सबगेम परिपूर्ण नैश संतुलन का उपयोग करके समस्या को तैयार करने और हल करने के लिए स्टैकेलबर्ग गेम सैद्धांतिक दृष्टिकोण का उपयोग करते हैं।

थीसिस में पहले छोटे किसानों के लिए कृषि-मूल्य समर्थन नीति को संशोधित करने का प्रयास किया गया है ताकि कोविड के बाद की स्थिति में छोटे किसानों और खुदरा विक्रेताओं के लिए एक स्थायी लाभ सुरक्षित किया जा सके। मॉडल सरकारी नेतृत्व (जीएल) की झूठी कथा से प्रभावित हो जाता है और एक वैकल्पिक नेतृत्व रणनीति तैयार करता है: किसान नेतृत्व (एफएल)। तैयार मॉडल किसानों, खुदरा विक्रेताओं और सरकार के साथ पारंपरिक बीएसओ मॉडल को एकीकृत करता है और प्रत्येक चालक के लाभ लाभ, सरकारी सहायता नीति और सामाजिक कल्याण अधिकतमकरण के प्रकाश में उनकी तुलना करने के लिए नेतृत्व रणनीतियों के प्रभाव का विश्लेषण करता है। परिणामों का दावा है कि यद्यपि एफएल रणनीति किसान और खुदरा विक्रेता के बीच एक संतुलन राज्य सुनिश्चित करती है, यह न तो किसानों और सरकार के बीच संतुलन और इष्टतम स्थिति की गारंटी देती है, न ही एक इष्टतम सामाजिक कल्याण कार्य। चूंकि यह मॉडल राष्ट्रीय स्तर तक सीमित है, इसलिए अध्ययन वैश्विक आपूर्ति श्रृंखला के मुद्दों से चूक गया। इस प्रकार, थीसिस आगे रसद आउटसोर्सिंग ढांचे के साथ इस मॉडल को एकीकृत करता है और मूल्य और गुणवत्ता-निर्भर मांग के लिए बुनियादी मांग फ्रंक्शन को अपग्रेड करता है। यह मॉडल उच्च पोषक तत्व सामग्री वाले ड्राई फ्रूट की पोस्ट-कोविड बढ़ती मांग पर विचार करता है। प्रस्तावित मॉडल का उद्देश्य टिकाऊ मूल्य निर्धारण नीति-निर्माण के माध्यम से आरएएससी ड्राइवर के लाभ हानि को पुनः प्राप्त करना और खजूर फल के विभिन्न रूपों की उच्च कोल्ड-चेन लॉजिस्टिक्स सेवा गुणवत्ता को सुरक्षित करना है। मॉडल दो चैनल नेतृत्व रणनीतियों को तैयार करता है; रसद प्रदाता का नेतृत्व (एलपीएल) और आपूर्तिकर्ता का नेतृत्व (एसएल), और दावा है कि एलपीएल रणनीति मूल्य लाभ और कोल्ड चेन सेवा गुणवत्ता स्तर पर बेहतर प्रभाव का आश्वासन दे सकती है यदि उत्पाद की पोषक तत्व सामग्री पर्याप्त रूप से अधिक हो। हालांकि, ये मॉडल कोविड के बाद वैश्वीकरण और डिजिटलीकरण के कारण आरएएससी में उच्च प्रतिस्पर्धा पर विचार नहीं करते हैं। इस प्रकार, थीसिस रसद आउटसोर्सिंग में प्रतिस्पर्धा के साथ अंतिम मॉडल को एकीकृत

करती है और बाजार हिस्सेदारी लाभ के साथ नियतात्मक बाजार की मांग और अपेक्षित सीमांत लाभ लाभ के साथ ड्राइवरो के लाभ को अपडेट करती है। यह मॉडल आशावादी और निराशावादी प्रतिस्पर्धी रणनीतियों को तैयार करता है और 3 पीएल फर्म की लाभप्रदता और बाजार हिस्सेदारी के प्रकाश में उनकी तुलना करता है। परिणामों का दावा है कि फोकल 3 पीएल फर्म प्रतिस्पर्धी रणनीति और फर्म मापदंडों के बुद्धिमान चयन के माध्यम से अपने लाभ और बाजार हिस्सेदारी को केवल तभी सुरक्षित कर सकती है जब फर्म के पास अपने सहकर्मी के रणनीतिक आंदोलन के बारे में सही जानकारी हो। कोल्ड-चेन लागत में कमी के लिए प्रौद्योगिकी आरएनडी संस्थान के साथ एक इक्विटी वित्त मॉडल पर विचार करते हुए मॉडल को प्रौद्योगिकी आउटसोर्सिंग ढांचे के साथ एकीकृत किया गया है। मॉडल 3 पीएल फर्म के लाभ पर इक्विटी वित्त योजना के प्रभाव का विश्लेषण करता है और दावा करता है कि यह योजना 3 पीएल फर्म के अनुकूल है यदि प्रौद्योगिकी संस्थान के लागत में कमी दक्षता अनुपात में 3 पीएल फर्म का पूंजी निवेश पर्याप्त रूप से अधिक है। अध्ययन आगे 3 पीएल फर्म के लाभ पर आपूर्तिकर्ता की कटाई के बाद की हानि दर के प्रभाव का विश्लेषण करता है ताकि यह तय किया जा सके कि विशेष आरएएससी निवेश योग्य है या नहीं। $\left(\frac{l}{a}\right)$

थीसिस का अंतिम मॉडल प्लेटफॉर्म आपूर्ति श्रृंखला ढांचे के साथ आरएएससी ढांचे को एकीकृत करता है और मांग फ़ंक्शन को प्लेटफॉर्म के उपयोगिता फ़ंक्शन में अपग्रेड करता है। प्लेटफॉर्म प्रतिस्पर्धा के प्रकाश में, यह मॉडल अंतर-प्लेटफॉर्म प्रतिस्पर्धा और सहयोग रणनीतियों पर विचार करते हुए आरएएससी की लाभप्रदता पर अंतर-प्लेटफॉर्म स्पिलओवर के प्रभाव का विश्लेषण करता है। परिणामों का दावा है कि यदि अंतर-प्लेटफॉर्म स्पिलओवर दर पर्याप्त रूप से अधिक है तो प्लेटफॉर्म प्रतियोगिता आरएएससी की लाभप्रदता का पक्षधर है।

अंत में, थीसिस चर्चा किए गए सभी मॉडलों को संक्षेप में प्रस्तुत करती है, प्रमुख योगदानों पर प्रकाश डालती है, शिक्षाविदों, चिकित्सकों और नीति निर्माताओं के लिए निहितार्थ प्रदान करती है, और भविष्य के अनुसंधान निर्देशों की सिफारिश करती है।

कीवर्ड: कृषि मूल्य निर्धारण आपूर्ति श्रृंखला, कृषि-मूल्य समर्थन नीति, बीएसओ नीति, लॉजिस्टिक्स आउटसोर्सिंग, 3 पीएल, लॉजिस्टिक्स आउटसोर्सिंग प्रतियोगिता, प्रौद्योगिकी आउटसोर्सिंग, इक्विटी वित्त मॉडलिंग, कृषि-मंच आपूर्ति श्रृंखला, मंच प्रतिस्पर्धा, मंच सहयोग, रणनीति बनाने, निर्णय लेने, नीति-निर्माण।

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LIST OF INDICES, VARIABLES AND PARAMETERS

List of indices

i	Index for products	N = Maximum no of products, including the particular product and all its substitute product
j	Index for substitute products	
k	Index for focal 3PL firms	K = Maximum no of 3PL firms including the particular focal firm and all its peer firms.
l	Index for peer 3PL firms	
m	Index for retailer	M = Maximum no of retailers available in the supply chain

List of variables

A_{ik}^L	Relative attribute loss of the k^{th} 3PL firm for i^{th} product
A_{ik}^G	Relative attribute gain of the k^{th} 3PL firm for i^{th} product
Dem_i	Customer's demand of product i
e_{ik}	k^{th} 3PL firm's cold-chain logistics service level (Normalized) to product i
M_{ik}^{Op}	Market share gain of the k^{th} 3PL firm on i^{th} product in optimistic approach
M_{ik}^P	Market share gain of the k^{th} 3PL firm on i^{th} product in pessimistic approach
p_i	Price to the customer of product i
u_{ik}	k^{th} 3PL firm's service charge to product i

w_i	Farmer's wholesale price of product i
w^+	Government's minimum support price (MSP) to the farmer
w^-	Government's minimum support price (MSP) to the retailer
x_i	3PL firm's service charge for i^{th} product
y_{ik}	k^{th} 3PL firm's cold-chain logistics service level to product i
π_i^S	Profit of supplier for i^{th} product
π_i^R	Profit of retailer for i^{th} product
π^{3PL}	Total profit of third-party logistics provider
π_E^{3PL}	Total profit of third-party logistics provider under equity finance scheme
π^P	Total profit of platform

List of parameters

b_m	Price sensitivity coefficient of m^{th} retailer's customer base
B	Budget constraint of the Government
c_i^S	Production/Farming cost of supplier for i^{th} product
c_{ik}^T	Transportation cost of k^{th} 3PL firm for i^{th} product
c_i^P	Platform's maintenance cost for i^{th} product

D_{im}	Demand class of i^{th} product to m^{th} retailer
I	3PL firm's initial capital in technology outsourcing model
q	Buffer stock rate of the government
r	Post-harvesting loss rate of supplier
v	Technology R&D institution's cost reduction level
α	Technology R&D institution's cost reduction efficiency
β_m	Quality sensitivity coefficient of m^{th} retailer's customer base
λ_k	Service to cost ratio of k^{th} 3PL firm
ζ	Marketing spillover rate between i^{th} and j^{th} platform

LIST OF ABBREVIATIONS

3PL:	Third Party Logistics
4PL:	Fourth Party Logistics
BSO:	Buffer stock operations
CAP:	Common Agriculture policy
FAO:	Food and Agriculture Organization of United Nations
FL:	Farmer Leadership
GL:	Government Leadership
IoT:	Internet of Things
LPL:	Logistics provider's leadership
R&D:	Research and Development
RASC:	Regional Agri-supply chain
SME:	Small and Medium Enterprises
SL:	Supplier's Leadership