

The Role of Smart Contracts in Fresh Agricultural Product Supply Chain Finance: A Three-tier Supply Chain Game Theory Analysis

Guangmei Lyu

Department of Mechanical, Automation, and Materials Engineering
University of Windsor
Windsor, Canada
International Business School
Hainan University
Haikou, Hainan, China
lvguangmei2020@163.com

Qingkai Ji

Professor, International Business School
Hainan University
Haikou, Hainan, China
jorter@foxmail.com

Guoqing Zhang

Professor, Department of Mechanical, Automation, and Materials Engineering
University of Windsor
Windsor, Canada
gzhang@uwindsor.ca

Abstract

Fresh agricultural product suppliers face severe financial constraints due to long production cycles, seasonality, and product perishability, which result in tight cash flows and limited financing options. This paper develops a three-tier supply chain game-theoretic model involving suppliers, retailers, and third-party logistics (3PL) providers. The model examines suppliers' optimal financing strategies under dual financing needs—pre-delivery financing (bank loans, retailer prepayments, and 3PL financing) and post-delivery financing (factoring)—and investigates how blockchain-based smart contracts affect supply chain efficiency and their applicability boundaries. The results reveal three key findings. First, under traditional financing modes, 3PL financing reduces the commitment friction zone, while buyer direct financing (BDF) eliminates it entirely. High-risk suppliers are better suited to bank financing, low-risk suppliers benefit more from 3PL financing, and BDF proves most advantageous for suppliers with medium liquidity risk. Second, smart contracts generate both commitment and credit gains under bank and 3PL financing, but only credit gains under BDF. Third, smart contract adoption is not universally beneficial; under low-risk conditions, they may erode 3PL profits and reduce overall supply chain performance. This study makes three contributions. It develops a novel three-tier supply chain framework incorporating both pre- and post-delivery financing interactions; it identifies the differentiated effects of smart contracts across financing structures; and it emphasizes that smart contracts are not

a “one-size-fits-all” solution. These findings provide new theoretical insights and practical guidance for the design of financing strategies and blockchain-based smart contracts in fresh agricultural supply chains.

Keywords

Fresh Agricultural Supply Chain, Supply Chain Finance, Blockchain, Smart Contracts and Third-party logistics.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (72461009), and the Natural Sciences and Engineering Research Council of Canada Discovery grant (RGPI-2019-07115).

Biographies

Guangmei Lyu is a joint Ph.D. candidate at Hainan University and the University of Windsor. Her research interests focus on operations management and blockchain applications. She has published papers in journals such as *Frontiers of Engineering Management*, *Ocean and Coastal Management*, and *Computers & Industrial Engineering*.

Qingkai Ji is a Professor at Hainan University, where he serves as the Head of the Department of Management Science and Engineering at the International Business School and as a doctoral supervisor. He received his Ph.D. through a joint program between Dalian University of Technology and the University of California, Riverside, and has been recognized as a Top Talent of Hainan Province. His research interests lie in management science and engineering, and he has published more than 20 papers in leading international and domestic journals, including *OMEGA*, *European Journal of Operational Research*, *International Journal of Production Research*, *Applied Mathematical Modelling*, *Computers & Operations Research*, and *China Management Science*. He is also the author of one monograph. Professor Ji has led several research projects, including three funded by the National Natural Science Foundation of China (NSFC), one by the Ministry of Education of China, one by the China Postdoctoral Science Foundation, and one provincial-level project on higher education reform in Hainan. He has also participated in NSFC Innovative Research Group and Key Program projects. His work has been recognized with the Second Prize of the Outstanding Achievements in Social Sciences Award of Hainan Province.

Guoqing Zhang, PEng, is a Professor of Industrial Engineering in the Supply Chain and Logistics Optimization Research Lab at the Department of Mechanical, Automotive & Materials Engineering, University of Windsor. His research interests include supply chain management and optimization, operations research, manufacturing modeling, e-commerce, warehouse management, data-driven optimization, machine learning, and intelligent decision support systems. He has published over 100 articles in these areas. Dr. Zhang’s research is supported by NSERC, MITACS, and CFI. He has provided consulting services to several world-leading companies in the automotive, energy, airline, and food industries. In 2015, his team received the CORS Practice Prize. Additionally, he developed a solver for large-scale linear programming based on the interior point method.