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Emerging Technology & Advances in Supply Chain Finance & Risk Management

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Contents

Introduction and Conceptual Overview of Contents

On May 13-14, 2018, The Boeing Center for Supply Chain Innovation at the Olin Business School, Washington University in St. Louis organized the fourth mini-conference on Supply Chain Finance & Risk Management. The conference was by invitation only to the world-class academicians and researchers in the field, and over 40 such prominent thought leaders in the field attended it. There were 18 research presentations, and panel sessions on future research directions and on developments of teaching material for the field. At the same time, we announced that an edited volume of short paper versions of presented results in the conference and other relevant research on the conference theme was going to be prepared. We solicited submissions, and after a rigorous review process, the submitted material was edited and accepted for appearing in the volume. What you now have in your hands is the outcome of this process. We believe it best reflects the state-of-the-art in research thought leadership in supply chain finance and risk management, and it contains great expository pieces on how advanced technologies are shaping supply chains and risk management within them. You will also find ideas on how supply chain finance and risk management can be best taught in our classrooms.

We have divided the volume into three parts, each part reflecting a major discussion theme in our conference and an active research area of the field. These three parts are:

Part 1: Supply Chain Finance
Part 2: Financial Hedging and Commodity Risks
Part 3: Operational Strategies and Risk Management.

We will provide below a quick exposition of material in each part of the volume to facilitate the selection of articles the reader might be more interested in focusing on as they efficiently search for the most relevant topics to their own interests.

Part 1 of the volume deals with the broad area of supply chain finance and programs that will better allow for working capital management within supply chains. The first two papers are focused on understanding ways to better finance supply chain needs, while the third paper projects the challenges and capabilities of Blockchain technology when applied in complex global supply chains. The last paper presents an innovative way to use the popular "beer game" to introduce concepts of financial constraints in supply chain management and the study of the "bullwhip effect" within it.

In "Material and Cash Flow in Two-Tier Supply Chain with Trade Credits and Defaults" a one-warehouse multiple retailer distribution system is analyzed, and the decisions involve inventory replenishment and trade credit offerings. Pre-shipment financing programs are the subject of study of "Financing Suppliers under Performance Risk." The two schemes looked carefully at are purchase order financing, with financial institutions issuing loans to suppliers based on purchase orders, and buyer-direct-financing, with the buyer also lending directly to the supplier. Blockchain technology has been the darling of both the finance and the supply chain communities in terms of the potential of its applications in creating credible cryptocurrencies and increasing the visibility of global supply chains. In "Blockchain and other Distributed Ledger Technologies in Operations", the reader is given a basic understanding of the technology, and then the discussion focuses on how it can help in managing operations and supply chain processes. In an objective way, the paper also points out the "bottlenecks" in successful implementation of the technology and issues that may reduce its projected impact. Finally, "Cash Beer Game" offers insights on an innovative way to use the popu-

lar online "Beer Game," which is used to demonstrate "bullwhip effect" within complex supply chains, to teach interactions between constrained financial flows (capital constraints result in borrowing bank loans) and inventory and ordering decisions within a four stage serial supply chain. It can be used as a nice experiential introduction to supply chain finance issues for undergraduate or graduate courses on the subject.

Part 2 of the volume introduces concepts of hedging financial and operational risks due to uncertain commodity prices, fluctuating exchange rates, and volatile interest rates. Emphasis is placed on understanding how financial hedges can be used for hedging relevant supply chain risks in a way that reflects the modern view of financial risk management, it is not speculative, and exploits the opportunity of hedging not at a single firm level but across the whole supply chain. An excellent exposition of issues and strategies of supply chain hedging appears in "A Framework of Hedging Decisions for Supply Chain Partners." Offering a more pragmatic managerial approach in bringing risk management concerns in traditional production planning settings under demand uncertainty, the "Data and Risk Analytics for Production Panning" explains how pre-set profit targets subject to relevant risk measures around deviations from such targets is an effective way to deal with such issues. The paper offers interesting insights into the simultaneous production plan and hedging strategy for a pre-set profit target.

Commodity price uncertainties were the risk topic that attracted the most attention in Part 2. "Risk Management in Commodity Processing Firms: An Equilibrium View" studies the problem of a commodity processor who is subjected to both supply and demand shocks and chooses the optimal production quantity. It identifies an optimal production and hedging policy and offers intuitive insights into the nature of an optimal operating policy. Getting more into the details of hedging policies, "Quadratic Hedging of Commodity and Energy Cash Flows" studies how quadratic hedging can be used to effectively hedge exposures to commodity prices, with special interest of energy market applications, in the presence of incomplete markets. A very interesting overview and a conceptual framework on explaining drivers of profitability of commodity processors is offered in "Optimal Positioning in the Derivative Market: Review, Foundations, and Trends".

Topics and solution approaches reflecting the more traditional treatments in the contemporary literature of operational and supply chain risks are part of the potpourri collection of Part 3. "Corn, Soybean or Fallow: Dynamic Farmland Allocation under Uncertainty" deals with commodity risks in agribusiness supply chains, and offers a technical production planning decision treatment in coming up with optimal planting decisions. As the title implies, "Disruption Risk Management in Serial Multi-Echelon Supply Chains: Where to hold Risk Mitigation Inventory and Reserve Capacity" looks into inventory placement and reserve capacity decisions within serial supply chains subjected to random disruptions. Traditional quality risks with procurement settings and how could be better managed through financial incentives offered to the involved decision agents is the topic of "Financial Incentives to Avoid Major Quality Problems in a Supply Chain". Finally, the issue of getting first-best investment levels from buyers and suppliers in a bilateral chain with renegotiation processes is the topic of "Specific Capacity Investment in Supply Chains with Renegotiation".

We hope you will enjoy the rich treatment offered in our edited volume of newly defined problems from current challenges, and thought-provoking approaches and solutions in dealing with them. Furthermore, you will enjoy reading the rich implications for future research directions in efforts to master the new complexities and uncertainties of the global business environment and better understand the impact of advanced technologies in global supply chains.

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Material and Cash Flow in Two-Tier Supply Chain with Trade Credits and Defaults

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ABSTRACT

We develop a supply chain finance and inventory model to understand how trade credit terms affect a firm's financing costs and inventory decision along the supply chain. In particular, we study the following question: how should a warehouse (or distributor) receiving trade credits from an external supplier share and extend the trade credit terms to her customers (i.e. retailers)? How does this financial flow affect the replenishment decisions (i.e. material flow) in the system? We use the classical echelon inventory approach to synthesize the effects of trade credits in a one-warehouse-multi-retailer system. Payment default from retailers are considered and trade credit limit is used as a risk management tool. Interestingly, we show that longer credit terms from the external supplier may not necessarily translates into longer credit terms for the retailers in some supply chain environments.

Mabel C. Chou, Chung-Piaw Teo and Yuan-Guang Zhong (2019), "Material and Cash Flow in Two-Tier Supply Chain with Trade Credits and Defaults", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 119–134. DOI: 10.1561/0200000081.

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Financing Suppliers under Performance Risk

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ABSTRACT

This chapter focuses on the relative efficiency of two innovation pre-shipment financing schemes that enable suppliers to obtain financing for production: *purchase order financing* (POF, under which financial institutions offer loans to suppliers by considering the value of purchase orders) and *buyer direct financing* (BDF, under which manufacturers lend directly to suppliers). Both schemes are closely related to suppliers' *performance risk* (whether the supplier can deliver the order successfully). When the manufacturer and the bank have symmetric information regarding the supplier's operational capabilitiy, we find that even though POF and BDF yield the same payoffs, BDF allows more flexibility in contract terms. However, when the manufacturer has superior information, BDF leads to higher payoffs when the supplier is severely financially constrained. The relative benefit of BDF is more pronounced when the supply market contains a larger fraction of inefficient suppliers, when efficiency gaps between suppliers are greater, or when the manufacturer's alternative sourcing option is more expensive.

Christopher S. Tang, S. Alex Yang and Jing Wu (2019), "Financing Suppliers under Performance Risk", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 135–151. DOI: 10.1561/0200000091.

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Blockchain and other Distributed Ledger Technologies in Operations

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ABSTRACT

Blockchain is a form of distributed ledger technology (DLT) that has grown in prominence, although its full potential and possible downsides are not yet fully understood, especially with respect to Operations Management (OM). This manuscript contributes to filling in this gap. We identify three research themes in applying Blockchain technology to OM, illustrated through several applications to OM problems. Elsewhere, in a companion article (Babich and Hilary, 2018), we provide a conceptual framework for the role of Blockchain and other DLT in OM, along with specific examples of research questions, and we demonstrate how research in economics can inform research in OM on Blockchain applications. Finally, we discuss possible future uses for the technology.[1]

[1] This article is inspired by "Distributed Ledgers and Operations: What Operations Management researchers should know about Blockchain technology," a longer manuscript by the same authors is forthcoming at M&SOM.

Volodymyr Babich and Gilles Hilary (2019), "Blockchain and other Distributed Ledger Technologies in Operations", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 152–172. DOI: 10.1561/0200000084.

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Cash Beer Game

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ABSTRACT

This article introduces a new online simulation game called *Cash Beer Game*, which is an augmented version of the standard Beer Game by including cash flows. In addition to the inventory ordering and shipping activities, each player pays cash for the ordered inventory to her upstream partner and receives cash from her downstream partner. The goal of this game is to explain the interactions between material, information, and financial flows in a supply chain and help students understand the impact of financial flows on the inventory decision. The resulting bullwhip effect can be compared between teams and with that of the standard Beer Game for the same team.

Kevin Shang (2019), "Cash Beer Game", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 173–188. DOI: 10.1561/0200000088.

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A Framework of Hedging Decisions for Supply Chain Partners

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ABSTRACT

We study cash flow risk hedging in a bilateral supply chain of a supplier and a manufacturer that use internal cash to invest in production efficiency improvements. The associated production efficiency function is convex in capital investment. We offer a conceptual framework for understanding supply chain cash hedging strategies by decomposing the difference of a firm's expected profit of hedging versus not hedging into a sum of two terms: the cost reduction effect and the flexibility effect of hedging. We find that the correlation of cash flow risks of supply chain partners significantly affects the hedging decisions of firms via impacts on production efficiencies. When the cash flows of firms are independent, the cost reduction effect favors hedging, whereas the flexibility effect favors not hedging. A firm is more likely to hedge when the supply chain is more profitable or its supply chain partner hedges. When the cash flows of firms are correlated, the cost reduction and flexibility effect of hedging may complement each other and support the same hedging choice. The impact of market size on firms' hedging decisions is contingent on the cash flow correlation.

Panos Kouvelis, Xiaole Wu and Yixuan Xiao (2019), "A Framework of Hedging Decisions for Supply Chain Partners", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 189–200. DOI: 10.1561/0200000082.

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Data and Risk Analytics for Production Planning

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ABSTRACT

We examine the classical productional planning model, where a capacity decision that has to be made at the beginning of the planning horizon is the primary means to protect against demand uncertainty. We provide a critique on the model focusing on its profit maximizing objective, its underlying assumptions on demand and related forecasting scheme, and its overall business relevance (or the lack thereof); and we do so in the context of data, risk and analytics. Specifically, we will consider minimizing a shortfall risk relative to a profit target, with a demand model that captures impacts from the financial market and can be learned from data sets that are application specific. With a jointly optimized production and hedging strategy, we show the new model outperforms traditional approaches in risk mitigation as well as in expected profit.

Liao Wang and David D. Yao (2019), "Data and Risk Analytics for Production Planning", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 201–218. DOI: 10.1561/0200000086.

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Risk Management in Commodity Processing Firms

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ABSTRACT

We introduce an equilibrium view of profit hedging in a representative commodity processing industry. The commodity processor takes shocks to the supply of the primary commodity and the demand for the processed commodity as given and chooses the optimal quantity of production. Such a model generates an endogenous stochastic profit stream for the processor, which is possibly substantially different than input and output prices. Thus, absent financial instrument specifically on the spread, hedging input or output prices alone may only provide poor partial hedging to the processor.

Hamed Ghoddusi (2019), "Risk Management in Commodity Processing Firms", Foundations and Trends® in Technology, Information and Operations Management: Vol. 12, No. 2-3, Special Issue on Emerging Technology & Advances in Supply Chain Finance & Risk Management. Edited by P. Kouvelis, L. Dong and D. Turcic, pp 219–239. DOI: 10.1561/0200000093.

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Quadratic Hedging of Commodity and Energy Cash Flows

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ABSTRACT

Commodity and energy prices are notoriously volatile. Firms routinely trade financial contracts to hedge their cash flows that are exposed to this source of risk. When markets are incomplete, which is typical in practice, eliminating such risk is impossible and attention must thus shift to its partial mitigation. This paper reviews quadratic hedging, which is an appealing financial risk management approach for this setting, considering a single commodity or energy cash flow that occurs on a given future date and assuming that financial hedging is based on trading a risk less bond and a futures contract. This work formulates this hedging problem as a Markov decision process, derives the optimal policy using stochastic dynamic programming, and characterizes the initial optimal bond position. Further, it highlights related current and potential future research.

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Optimal Positioning in the Derivative Market: Review, Foundations, and Trends

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ABSTRACT

We review the theoretical development of optimal positioning in financial derivatives for managing corporate exposure. Our primary focus is on one-period integrated financial-operational policies featuring a bespoke financial contingent claim (or portfolio of claims) and an operational control variable. We develop a unifying theoretical framework which (a) encompasses all of existing solutions in a static set-up across the areas of of portfolio insurance, agricultural economics, and integrated financial-operational management, (b) provides researchers with a solid ground to either fill in gaps in the current literature and move forward towards a general theory of contingent claim origination. We also put forward pathways for future development, one based on current research problem, the other focusing on new methodological issue

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Corn, Soybeans or Fallow: Dynamic Farmland Allocation under Uncertainty

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ABSTRACT

This chapter develops a theoretical basis for understanding the trade-offs facing a farmer for allocating his farmland among several crops over multiple growing seasons. Specifically, we focus on the farmland allocation among two cash crops (corn and soybeans) and letting the farmland lay fallow to rejuvenate the soil and increase the revenue for the crop grown on this farmland in the subsequent seasons. In each growing period, the farmer chooses the allocation in the presence of revenue uncertainty for each cash crop, and crop rotation benefits across periods, where revenue is stochastically larger and farming cost is lower when a cash crop is grown on a rotated farmland (where the same crop was not grown in the previous period). We solve for the optimal dynamic allocation policy.

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Disruption Risk Management in Serial Multi-Echelon Supply Chains

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Disclaimer: This chapter is a short version of the article *Mitigating product shortages due to disruptions in multi-stage supply chains* that is avilable at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3072382

ABSTRACT

This research focuses on managing supply chain disruption risk using inventory and reserve capacity in serial multi-echelon supply chains. The research problem is to determine the optimal risk mitigation inventories and reserve capacities when product transformation occurs at each echelon. Disruptions at each echelon are modeled as a random process. We derive insights on the optimal location and quantity of risk mitigation inventory (RMI) and reserve capacity held in serial supply chains. We show that the downstream echelon typically holds at least as much RMI as the upstream echelon. At the same time, it is often optimal to hold additionally more reserve capacity downstream than upstream. These results hold under the assumption that inventory and reserve capacity holding costs are larger downstream than upstream. Our research also suggests that RMI is preferred to reserve capacity as a risk mitigation lever in long serial supply chains, i.e., in supply chains with a large number of echelons. This research problem is inspired by a risk management problem of a leading pharmaceutical company.

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Financial Incentives to Avoid Major Quality Problems in a Supply Chain

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ABSTRACT

Manufacturers who outsource components incur risks as well as benefits. If the supplied product has a major quality defect, the adverse effect on the manufacturer's reputation reduces its market share. This paper presents a discrete-time model of a buyer who collaborates with a sole supplier to avoid quality problems by paying a higher per-unit purchase price to the supplier and/or paying the supplier a lump sum contingent on the absence of a major quality defect. Analytical results include an optimal risk-posture policy for which the buyer should use only one of these financial incentives or the other, and computational results provide insights about the relationship of that optimal policy to various parameters.

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Specific Capacity Investment in Supply Chains With Renegotiation

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ABSTRACT

A supplier must invest and build specific capacity for its buyer to lower variable production cost long before uncertainties have been resolved. Bearing the upfront capacity and cost-reduction investment costs, the supplier under-builds the specialized capacity and under-invests in cost reduction. To resolve this issue, the supply chain partners often rely on informal agreements plus ex post renegotiation. This paper shows that neither quantity commitment only or price only initial agreement can induce the supplier to invest and build specific capacity at the channel-efficient level. The supplier will over-invest but under-build the specific capacity under quantity commitment only contracts, and will under-invest but over-build the specific capacity under price-only initial contracts. There exists an initial quantity plus price contract or option contract that induces the supplier to build the capacity and invest in cost reduction at the first-best level with or without ex post renegotiation. To improve the channel efficiency, the firms will renegotiate ex post with probability one under the quantity plus contract, but will renegotiate only if realized demand is high so that options are exercised up.

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