Manufacturing & Service Operations Management

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Introduction to the Special Issue on Research at the Interface of Finance, Operations, and Risk Management (iFORM): Recent Contributions and Future Directions

Volodymyr Babich, Panos Kouvelis

To cite this article:
Volodymyr Babich, Panos Kouvelis (2018) Introduction to the Special Issue on Research at the Interface of Finance, Operations, and Risk Management (iFORM): Recent Contributions and Future Directions. Manufacturing & Service Operations Management 20(1):1-18. https://doi.org/10.1287/msom.2018.0706

MANUFACTURING & SERVICE OPERATIONS MANAGEMENT
Vol. 20, No. 1, Winter 2018, pp. 1–18
ISSN 1523-4614 (print), ISSN 1526-5498 (online)
http://pubsonline.informs.org/journal/msom/

Introduction to the Special Issue on Research at the Interface of Finance, Operations, and Risk Management (iFORM): Recent Contributions and Future Directions

Volodymyr Babich,[a] **Panos Kouvelis**[b]

[a] McDonough School of Business, Georgetown University, Washington, DC 20057; [b] Olin Business School, Washington University in St. Louis, St. Loius, Missouri 63130

Contact: vob2@georgetown.edu, http://orcid.org/0000-0001-8973-2838 (VB); kouvelis@wustl.edu, http://orcid.org/0000-0002-8800-4537 (PK)

Received: October 8, 2017
Revised: October 22, 2017
Accepted: October 22, 2017

https://doi.org/10.1287/msom.2018.0706

Abstract. Interface of finance, operations, and risk management (iFORM) is a relatively new research area dealing with timely, complex, and boundary-spanning issues in a variety of settings from start-ups to global enterprises. iFORM research addresses ways to better integrate physical, financial, and informational flows by combining the operational choices of the firm with its financial decisions, and merging information flows between the firm and its customers and suppliers with informational flows between the firm and its investors. We report on the main research themes of the recent iFORM research, based on, and going beyond, papers that appeared in the *Manufacturing and Service Operations Management* iFORM special issue. We highlight the main emerging contributions in the area. Among the most frequently addressed issues in current research include the following: supply chain finance, such as trade credit and buyer-intermediated finance and their effects on supply chain performance; agency problems, such as risk shifting and managerial short-termism and their influence on operational decisions; contracting between the firm and its investors and how it alters contracting with supply chain partners; and supply risk management in the form of dealing with commodity price fluctuations and supplier performance issues. We suggest four promising directions of future iFORM research: supply chain finance, integrated risk management, start-up and entrepreneurial financing, and asset pricing with supply chains.

Keywords: interface of operations • finance • risk management • supply chain finance • integrated risk management • crowdfunding • supply chains and asset pricing • trade credit • reverse factoring • operational hedges • financial hedges • future research

1. Introduction

As an illustration of the importance of the interface of finance, operations, and risk management (iFORM) practice consider the following example. Walmart has reported $63 billion in accounts payable on its balance sheet as of January 31, 2017.[1] This amount eclipses other short-term debt ($4 billion) and exceeds even long-term debt ($42 billion). It is comparable with the retained earnings ($89 billion) and the book value of equity ($78 billion). Accounts payable amount constitutes 32% of the Walmart's total assets ($199 billion). Accounts payable is another term for trade credit, which is a contract between a supplier and a buyer allowing the buyer to delay payments for the orders received from the supplier. According to the Bank for International Settlements (2014), trade finance accounts for more than $12 trillion out of $18 trillion in exports (or imports) annually. For decades, trade credit has been the single most important form of short-term financing for firms in the United States and worldwide. Rajan and Zingales (1995) reported that accounts payable constituted 15% and current debt liabilities only 7.4% of assets for firms in their sample. Almost a quarter of a century later, Hill et al. (2017) observed that trade credit constituted 12% of assets and short-term debt constituted 6% of assets. Trade credit has been extensively researched in finance and operations management (OM). It is of the paramount importance for the OM community because trade credit affects operational decisions, such as inventory management, supplier selection, and procurement contracting. For example, Fisman (2001) provides empirical evidence that operational performance and availability of trade credit are correlated: firms with access to trade credit were less likely to experience stock-outs and have higher capacity utilization (see Babich et al. 2012 for discussion).

Trade credit practice and research fall under the umbrella of the rapidly developing field of supply chain finance, which itself is one of the key areas of practice and research at the interface of finance, operations, and risk management (iFORM). Motivated by important practical applications, iFORM research output has been booming. In this paper we shall endeavor to define iFORM research and discuss criteria for evaluating it. We provide a snapshot of recent iFORM research in Section 2, based on the papers that appeared in this special issue of *Manufacturing and Service Operations Management* (*M&SOM*). We suggest several promising direc-

tions of future research in Section 3 and draw conclusions in Section 4.

Let us begin by answering the following question: "What is iFORM research?" iFORM research deals with better integration of physical and financial flows by endogenizing not only the operational choices of the firm and its agents, but also their financial decisions. While OM models are reasonably good in accounting explicitly for implications of operational decisions on financial cash flows, the financial constraints, uncertainties, contracts, and decisions by investors are usually taken as exogenous. OM models (for the most part) skip over the complexities of the following questions: If financing is needed, who will provide it? What are the objectives and information that a financial institution has? What will be the cost of capital to finance inventory and does it depend on incentive conflicts between firm and potential investors? What happens if a firm's default is possible and how will this affect the firm's operational decisions prior, during, and after the bankruptcy? How does the choice of financial risk management affect choices of production facility locations? As all researchers know, modeling choices are driven by the necessity of taming the complexity of real-life problems. In many practical situations, when OM managers are not evaluated using firm-value-based metrics and when large corporations enjoy easy access to well-functioning financial markets, ignoring "finance" or even "risk management" does little harm to the effectiveness of "operations." But that does not mean that there is no value of understanding the interplay between the three, in general. In fact, as we argue in Section 3, in some circumstances, this value is tremendous. The field of iFORM research has demonstrated this numerous times already.

Our goal for this special issue of *M&SOM* on the interface of finance, operations, and risk management (iFORM) was to encourage the development of iFORM ideas and to promote new research directions that address issues at the interface of operational, financial, and enterprise risk management decisions in meaningful ways. In our call for papers for this special issue, we listed a number of iFORM research topics trying to be as inviting and inclusive in topics and methodology as possible, and recognizing that this is not going to be an exhaustive list:

> (1) supply chain finance; (2) interactions between financial claimholders and operational claimholders of a firm; (3) moral hazard and asymmetric information problems that arise when financial and operational claimholders interact; (4) novel channels of financing operational decisions; (5) propagation of financial information in supply chains; (6) the effects of operational decisions of firms (financial and nonfinancial) on financial markets and financial markets' efficiency; (7) the use of financial markets to inform operational decisions; (8) novel financial and operational risks and their management; (9) meaningful applications of data analytics to operations–finance and operations–risk management interfaces; (10) insurance and supply chain risks; (11) risk issues and hedging in commodity procurement; (12) revenue management: risk and financial implications of dynamic capacity planning and pricing strategies; (13) special finance and operations interface topics in industries such as financial services, energy, commodity trading, shipping, and logistics; (14) operational and financial approaches in managing disruption and catastrophic risks in global supply chains.

Our special issue welcomed submissions of "groundbreaking and boundary expanding ideas" and we encouraged "both theoretical and empirical analyses." The response from the community to our call for papers to this iFORM special issue has exceeded all our expectations. We received over 70 submissions from academic researchers and practitioners from around the world. Researchers specializing in OM, finance, economics, operations research, and risk management sent in their manuscripts. All submitted manuscripts underwent the rigorous *M&SOM* review process. This process has produced 11 accepted papers, from which 9 papers were selected to appear in the special issue, based on a very close fit with the issue's themes.

While reviewing the submissions, we had to reflect on the traits of good iFORM research, the styles of iFORM research, and the best ways of appreciating the contribution of an iFORM paper. The following are our insights based on this experience. First, good iFORM research must be good research. What constitutes good research? Opinions on this can differ, but we were guided by *M&SOM*'s criteria of "novelty, rigor, and relevance" (to quote Chris Tang, the editor-in-chief). Second, the topic of iFORM research should find an audience in both OM and finance communities. Third, the authors should present meaningful interactions between OM and finance considerations. These are the necessary traits of good iFORM research papers. In addition to these, the best iFORM research papers contribute to the discourse in all disciplines, provide rigorous foundations for future research and applications, and successfully blend methodologies and ideas from multiple disciplines. These are the criteria we used when reviewing submissions and selecting papers to be included in the special issue. In the next section, we shall discuss the nine special issue papers.

2. Research Articles in the Special Issue

2.1. Article Summaries

The following is a brief summary of the articles included in this special issue, with highlights of OM, finance, and risk management (RM) issues, OM/finance/RM interactions, and main takeaways. Table 1 summarizes this information.

Table 1. Summary of Articles with Highlights of OM, Finance, and Risk Management Issues

Authors	Title	OM features	Finance/RM features	OM/finance/RM interactions, main takeaways
Panos Kouvelis and Wenhui Zhao	Who Should Finance the Supply Chain? Impact of Credit Ratings on Supply Chain Decisions (2018)	Buyer–supplier contracting (wholesale price, order quantities)	Trade credit, bank loans to both buyer and supplier, credit ratings, default risk linked to major events (measured by credit ratings), and adverse demand realizations	The authors jointly determine procurement contracts and trade credit terms and find that retailers may prefer to work with suppliers whose ratings are either lower or higher than a range of values to suppliers whose credit ratings are in that range.
Hsiao-Hui Lee, Jianer Zhou, and Jingqi Wang	Trade Credit Financing Under Competition and Its Impact on Firm Performance in Supply Chains (2018)	Supply chain links	Amount of trade credit financing	Supply chains connect companies together. Buyer characteristics affect supplier's trade credit. Without knowing supply chains we could only study characteristics of companies themselves.
Shiming Deng, Chaocheng Gu, Gangshu Cai, and Yanhai Li	Financing Multiple Heterogeneous Suppliers in Assembly Systems: Buyer vs. Bank Finance (2018)	Buyer with multiple suppliers (supplier components are complementary)	Suppliers have free money (borrow from the bank or from the buyer)	Because costs to bank, buyer, and free money are different, the order quantities and other quantities that interact with them will depend on the difference. Under buyer finance the assembler charges the lowest possible interest rate (lower than the bank's risk free interest rate).
Christopher Tang, S. Alex Yang, and Jing Wu	Sourcing from Suppliers with Financial Constraints and Performance Risk (2018)	Supplier may or may not deliver products (supply risk)	Bank financing, financial constraints, and financial frictions due to asymmetric information about supplier effort efficiency, the choice of the source of financing (bank vs. buyer)	The buyer can ensure that the supplier exerts the first-best effort and banks can free ride on this when information is symmetric. Buyer-provided financing is not always strictly better than bank-provided financing even when there is asymmetric information and the buyer has full information (buyer financing is not worse, they are equal), if the loan needed is not large.
Francis de Véricourt and Denis Gromb	Financing Capacity Investment Under Demand Uncertainty: An Optimal Contracting Approach (2018)	Newsvendor capacity investments	Optimal contracts between investors and the firm on the cash flows from the firm's operations in the presence of moral hazard	Capacity could exceed the first-best level. Extending the prior work of Innes (1990), debt is the optimal contract. Firms should use cash then external debt.

Table 1. (Continued)

Authors	Title	OM features	Finance/RM features	OM/finance/RM interactions, main takeaways
Jie Ning and Volodymyr Babich	R&D Investments in the Presence of Knowledge Spillover and Debt Financing: Can Risk Shifting Cure Free Riding? (2018)	Technology choices, industry equilibrium technology choices, free riding on other firm's efforts	Debt contracts, moral hazard in the firm of the risk shifting by firm insiders at the expense of firm outsiders	Risk shifting counteracts free riding producing equilibrium investments that are the first-best for the industry. Two mechanisms are (1) all firms in the industry are taking the same action and (2) firms specialize in R&D vs. exploiting existing technology. Two benefits of debt are as a moderator of free-riding incentive and as a commitment device in dynamic interactions. Firms may prefer to be debt financed even if internal funds are available.
Guoming Lai and Wenqiang Xiao	Inventory Decisions and Signals of Demand Uncertainty to Investors (2018)	Order quantity (representing inventory policy) decisions, demand uncertainty, information about demand uncertainty	Agency problems in the form of managerial short-termism between managers and external investors	Inventory decisions are a signaling device. When short-termism is endogenous, inventory decisions can be first-best. Operational characteristics matter. Whether a manager lowers or raises inventory to conceal information depends on the newsvendor fractile. Selling shares and changing inventory become substitutable signals of demand uncertainty.
Panos Kouvelis, Danko Turcic, and Wenhui Zhao	Supply Chain Contracting in Environments with Volatile Input Prices and Frictions (2018)	Procurement contracts, raw material cost fluctuations, contract defaults by buyer and seller, assembly system	Raw material cost fluctuations, working capital constraints, financing costs	Coordinating contracts must account for capital constraints and capital costs. Without financing costs, coordinating contracts must be two-part (transfer and penalty for failure), which must be contingent on the stochastic evolution of the commodity prices. Coordinating contracts have to redistribute financing costs.
Jie Ning and Matthew Sobel	Production and Capacity Management with Internal Financing (2018)	Capacity management, production decisions	Dividend policy, self-financing constraints, dynamic cash management	Self-financing constraints tie together operational decisions of two otherwise independent facilities. The authors derive a linear decomposition of the value function into a weighted sum of state variables. This simplifies computations of the optimal policy and the value function. Multipliers in the decomposition are real option values on the firm decisions.

The first four papers of our special issue are focused on supply chain finance. The first two deal with supplier-led financing (trade credit). The next two papers deal with buyer-led financing.

One of the more important questions in the supply chain finance literature is which of the parties in the supply chain (supplier, buyer, or financial services provider/bank) should finance the needs of the supply chain. In the typical transaction cycle the buyer orders end market goods, the supplier procures input material and produces the goods, and then, after delivery to the buyer, the end market goods inventory are sold and financial remittances are made to the supplier according to the supply chain contract. The commonly identified financing needs are for the "purchase order" of the supplier in procuring and processing the materials, and then for financing trade credit extended to the buyer. The common approach is that suppliers finance their purchase orders through bank loans and trade credit to the customer is financed by trade credit from the supplier (see empirical evidence and economic arguments behind such practices in Burkart and Ellingsen 2004 and Giannetti et al. 2011). Kouvelis and Zhao (2012) provide a theoretical argument, via selling to a newsvendor with limited working capital model to establish that this should indeed be the case. Furthermore, they prove that the supplier should extend trade credits at cheap rates to the buyer (open account financing at zero interest rate is possible), and the buyer will exclusively use trade credit to finance all inventory requirements.

Previous analytical work focuses only on the specific transaction risks of the buy/sell relationship within the chain (mostly demand uncertainty) and does not account for other factors in the risk profile of a firm that might affect its ability to repay loans and other financial obligations, and subsequently the rates they might have when borrowing. Financial service firms do account for other such risk factors in the "borrower's credit ratings," with low ratings increasing the borrowing costs of the firm (Kisgen and Strahan 2010). The first paper in this special issue, "Who Should Finance the Supply Chain? Impact of Credit Ratings on Supply Chain Decisions" (Kouvelis and Zhao 2018), offers a game theoretic modelling framework on who should finance inventories, and at what rates, in the presence of differential credit ratings of the supply chain parties. The key OM features of this paper are the wholesale price contract between a buyer and a supplier and order quantity decisions. The finance features include the use of trade credit and bank loans. The bank loans are used by both buyer and supplier. Bank financing terms are set in a competitive equilibrium and are based on the credit rating signal, which is observable to all parties. Loan default risk depends on both major events (which credit ratings capture) and adverse demand realizations (which are not reflected in credit ratings). The authors combine OM and finance when determining simultaneously procurement and trade credit contracts' terms. Kouvelis and Zhao (2018) show that there exists a supplier's credit rating threshold such as if the supplier's credit rating is above it, the supplier offers zero interest trade credits and the buyer only uses trade credits to finance its inventories. Otherwise, the supplier charges a strictly positive interest rate and a combined use of trade credits and bank loans is a cheaper way to finance inventories than pure trade credit. The supplier's credit rating threshold is affected by factors such as the buyer's working capital, the product's profit margin, and the buyer's credit rating. An interesting result of the paper is that while it is always beneficial for a supplier to work with good credit ratings buyers, this is not necessarily true for the buyer. There is a "credit-rating hole" such that suppliers with ratings outside of this hole are preferred by the buyers. The suppliers in the hole are in most cases "medium" credit rating suppliers, but in some cases all suppliers above a credit threshold might be in the hole. When the buyer commits very little working capital toward the transaction, the buyer may prefer to work only with "low" credit rating suppliers. Such suppliers have to offer trade credit rate higher than the retailer's bank loan, thus inducing the buyer to borrow with credit rating from the bank. However, these suppliers offer lower wholesale prices, which makes the buyer better off. This paper extends the earlier work by the authors on trade credit by adding considerations of major failures that are reflected in credit ratings. By considering a system where both supplier and retailer take loans from the bank this paper moves the discussion closer to the general equilibrium framework often employed in corporate finance theoretical papers.

A very interesting empirical study of the impact of trade credit financing on firm performance in supply chains is the second paper in this special issue: "Trade Credit Financing Under Competition and Its Impact on Firm Performance in Supply Chains" (Lee et al. 2018). The key OM feature in this paper are supply chain links, while the key finance feature is the amount of trade credit. The interactions between OM and finance is in the fact that supply chain links connect companies' economic and strategic fates. The authors find that suppliers with smaller market shares and buyers with larger market shares are associated with greater trade credit amounts. Smaller suppliers facing strong competition use the trade credit as a competitive tool, while dominant buyers in their product markets have the bargaining power to demand more trade credit or better trade credit terms. Furthermore, the paper decomposes trade credit financing into two parts: an industry average trade credit level representing common practices and an abnormal component measuring deviation from

industry practices. While average trade credit benefits both parties involved (supplier and buyer), abnormal trade credits are plausibly driven by competition in the industry and could be associated with poor buyer performance. The paper nicely complements previous analytical studies on the topic (Burkart and Ellingsen 2004, Kouvelis and Zhao 2012). This paper contributes to a fast growing literature in OM and finance that explore the role of supply chains in asset pricing and risk management. Examples of papers in these literatures are Cohen and Frazzini (2008), Wu and Birge (2014), Wu (2015), and Agca et al. (2017).

The paper "Financing Multiple Heterogeneous Suppliers in Assembly Systems: Buyer vs. Bank Finance" (Deng et al. 2018) asks the following question: Should different players in an assembly system (one assembler sourcing from multiple suppliers) be financed by bank loans or by buyer-led financing services? It is quite common in the automotive and aerospace industry for strong end-product market manufacturers to pay early or to provide loans to their suppliers to alleviate financial hardship in dealing with financing their purchase orders. Through a game theoretic model the authors characterize the equilibrium solutions for different financing schemes. They offer necessary and sufficient conditions under which buyer financing is preferable to bank loans. Under buyer finance the assembler charges the lowest possible interest rate (lower than the bank's risk free interest rate), and is even willing to offer it when its own capital opportunity cost is higher than the risk free rate. The assembler offering buyer finance might incur financing losses in order to gain higher inventory support and lower component purchasing prices from its suppliers. The key OM features of this paper is a procurement system comprising a buyer with multiple suppliers, where supplier-provided components are complementary (that is, the buyer needs all components to make a product). Among finance features are free internal supplier capital, loans to suppliers from banks and from the buyer. This paper finds that order quantities depend on the difference in the cost of capital to the supplier, to the bank, and to the buyer.

Continuing on the subject of buyer-led financing within a manufacturer–supplier chain, the paper "Sourcing from Suppliers with Financial Constraints and Performance Risk" (Tang et al. 2018) explicitly compares two financing schemes. The first, purchase order financing allows banks to offer loans to suppliers by considering the value of purchase orders issued by reputable buyers and assessing the risk of the supplier delivering the order successfully. The second, buyer-direct financing has the buyer (manufacturer) issuing both sourcing contracts and loans directly to the suppliers. The key OM feature is the possibility that a supplier may not deliver products as promised. The risk of nondelivery depends on the effort the supplier exerts. The key finance features are financing constraints of the supplier, which can be alleviated by securing either bank financing or buyer financing. There are two sources of capital market frictions: the supplier's effort is unobservable, which creates a moral hazard problem; and buyer–supplier pair has private information (relative to the outside investors) about the supplier's effort cost. OM and finance interact in the choice of effort by the supplier and the choice of procurement and financing contracting terms. The authors find that the buyer can ensure that the supplier exerts the first-best effort when information about the supplier's effort cost is symmetric between the bank and the buyer. Even when information is asymmetric, with the buyer being better informed, the buyer-provided financing need not be strictly better than the bank financing. When the supplier's capital needs are small, the two sources of financing are equivalent. However, when the supplier is extremely financially constrained it is hard for the manufacturer to signal information about the supplier to the bank via the sourcing contract, and buyer-led financing performs better. The paper makes it clear that, as we know from finance research, the buyer-led financing gains its advantages mostly through the manufacturer's informational advantage over the bank's on the supplier's delivery performance, and it is less about controlling the offered interest rates. It is an interesting research piece along recent efforts to analyze information asymmetry and moral hazard concerns in supply chain finance decision issues.

Similar to Tang et al. (2018), the three papers that follow explicitly consider agency issues that arise between the firm's insiders and the outside investors. Finance theories recognize the potential for under- and over-investment in the presence of financial frictions or moral hazard (Jensen and Meckling 1976, Myers 1977, Holmstrom and Tirole 1997). The paper "Financing Capacity Investment Under Demand Uncertainty: An Optimal Contracting Approach" (de Véricourt and Gromb 2018) revisits the issue of optimal capacity investment in a newsvendor world, with demand uncertainty, limited cash, and effort-dependent demand. The key OM feature of this paper is the newsvendor model (for capacity investments) with effort. The key finance feature is the design of the optimal contracts between investors and the firm in the presence of the moral hazard. The OM and finance interact in that payoffs financing contracts distribute come from the newsvendor model and capacity investments depend on financing contracts. The authors find that, in equilibrium, capacity investments could exceed the first-best levels. Furthermore, the paper argues that the optimal capacity decreases with the firm's cash. This paper extend the influential paper by Innes (1990), by adding operational capacity considerations. As such, it fits in the finance literature on capital structure. The paper is part of a

growing iFORM literature that studies effects of moral hazard and information-based costs on OM decisions (e.g., other papers in this issue such as Lai and Xiao 2018 and Ning and Babich 2018, and the recent work of Chod and Zhou 2014).

Agency costs of debt have been studied in the economics and finance literature, with a clear understanding that debt creates a conflict between the lender and the borrower and results in a risk shifting behavior on the part of the shareholder value maximizing firm. The paper "R&D Investments in the Presence of Knowledge Spillover and Debt Financing: Can Risk Shifting Cure Free Riding?" (Ning and Babich 2018) revisits this question for firms that consider financing of R&D projects in the presence of knowledge spillover effects. The OM features of this paper are technology choices, industry-level equilibrium technology choices, and free riding on other firm's efforts. The finance features are debt contracts under moral hazard, which takes the form of risk shifting by a firm's insiders at the expense of a firm's outsiders. The OM and finance interactions and the main findings in this paper are that risk-shifting incentives may counteract free-riding incentives producing an equilibrium outcome that is the first best for the industry. This is surprising because free riding and risk shifting by themselves adversely affect a firm and an industry. There are two mechanisms by which first-best outcomes are derived. In the first mechanism, all firms in the industry end up taking the same investment action. In the second, firms specialize, some investing in risky technologies, others investing in safe projects. The authors of this paper contribute to the discussion in finance on the role of debt. They point out two benefits of debt: as a moderator of free-riding incentive and as a commitment device in dynamic interactions. Because of these benefits of debt, firms may prefer to be debt-financed, even if internal funds are available. In the literature, the use of external debt financing is typically associated with costs and inefficiencies. In contrast, this paper shows that debt can be valuable. The authors are able to generate these insights because in this paper they model interactions between several firms as well as between firms and investors, unlike the majority of finance papers that only consider interactions between a firm and investors. This is the direction where iFORM researchers, with their expertise in interfirm interactions, can be particularly successful.

A fundamental question that arises when someone considers moral hazard issues in supply chains is how managerial objectives misaligned with long-term shareholder profit optimization affect the inventory policies of firms. The paper "Inventory Decisions and Signals of Demand Uncertainty to Investors" (Lai and Xiao 2018) offers an insightful theoretical model that addresses the question. The main OM features of this paper are order quantity decisions (representing inventory policy), the demand uncertainty, and information about the demand uncertainty. The key finance feature is the agency problem in the form of managerial short-termism. OM and finance interact because the inventory ordering decisions can be used by managers as a signaling device. The authors characterize pooling and separating equilibria in the game between managers and investors. They find that a manager may reduce inventory to increase the stock price. When short-termism is endogenous, inventory decisions can be first best. The authors find that the operational characteristics matter. If a newsvendor's critical ratio is high, a manager will lower inventory to conceal true level of the demand uncertainty. If a newsvendor's critical ratio is low, a manager will raise the inventory level to conceal information. Selling shares and changing inventory are substitutable signals of the demand uncertainty. This paper contributes to an extensive literature in finance, economics, and accounting on short-termism (e.g., Bebchuk and Stole 1993, Bebchuk et al. 2008). Various solutions have been proposed to combat short-termism. As this paper illustrates, doing something about inventory policies can be added to this arsenal of short-termism solutions.

The eighth paper in this special issue addresses problems of supply chain contracting within a supply chain that has both stochastic input costs—due to fluctuating commodity prices—and demand uncertainty. Supply chain literature has understudied the impact of fluctuating commodity prices both from a risk management and a supply chain contracting perspective. While the previous work of Turcic et al. (2015) addressed the role of financial hedging in dealing with supply discontinuity in the presence of fluctuating commodity prices, the paper "Supply Chain Contracting in Environments with Volatile Input Prices and Frictions" (Kouvelis et al. 2018) provides a thorough treatment on contracting issues in supply chains with stochastic input costs with or without financing frictions. The OM features of this paper are procurement contracts, raw-material cost fluctuations, contract defaults by the buyer and the seller, and the assembly system structure. The finance features of this paper are raw-material cost fluctuations, working capital constraints, and financing costs. The OM and finance intersection arises because the coordinating contracts must account for capital constraints and fluctuating commodity prices. The paper analyzes a class of single price, multi-instrument contracts with default penalties. The main takeaways of this paper are the observation that coordinating contracts must be contingent on the stochastic evolution of the commodity prices (indexing) and appropriate penalties are to be inserted for cases of failure to supply or produce. Without

financing costs, index and penalty (I&P) adjusted revenue sharing and two-part tariff contracts are coordinating and can arbitrarily allocate profits within the supply chain. The pass-through contract for these settings is noncoordinating and dominated by the coordinating ones. However, in the presence of financing frictions (firms have limited working capital, need to borrow bank loans, and failure to repay debt results in costly bankruptcy) the necessary and sufficient conditions for coordination require not only indexing and failure to supply penalties, but also wholesale prices and penalties that depend on the working capital of the firms in the supply chain. In other words, the coordinating contracts must redistribute financing costs as well. Such contracts might be harder to implement, and thus it makes sense to work with easier-to-implement contracts, such as I&P revenue sharing and the pass-through contract. The paper informs us that I&P revenue sharing, even though noncoordinating for an environment with financing frictions, is versatile and works particularly well when both the supplier and buyer have low working capital and need to heavily borrow for meeting their supply chain transaction needs. The pass-through contract has a financing advantage when a small undercapitalized supplier works with a recourse-rich buyer. This paper fits nicely into the extensive literature in finance on risk management in the presence of commodity prices. This literature cites capital costs and constraints as the root of the value of risk management (Froot et al. 1993). This paper extends this logic to supply chain procurement contracting. It emphasizes the fact that risk management within a single firm is not sufficient, and to obtain the full benefit, we must apply risk management across the supply chain. The use of the right contracts to reflect fluctuating commodity prices can improve the efficiency of the supply chain and inform us on the need and extent of use of financial hedges.

The last paper in our issue, "Production and Capacity Management with Internal Financing" (Ning and Sobel 2018) offers a dynamic model of integrated decisions on capacity investment (or disinvestment), production (with flexibility in choosing among facilities and products to produce), and cash management (with some of the cash used for issuing dividends). This paper also highlights the importance of financing constraints and dynamic self-financing policies. The OM features of this paper are capacity management and production decisions. The finance features are the dividend policy, the self-financing constraint, and the dynamic cash management. One of the OM and finance interactions is that self-financing constraints tie together the operational decisions of two, otherwise independent, production facilities. The main takeaways of this paper are the proof of linear decomposition of the value function for this dynamic problem into a sum of state variables multiplied by coefficients that depend only on external parameters. This simplifies the computation of the optimal policy and the value function. The authors provide interpretations of multipliers in the value function decomposition as real-option values on the firm's decisions. This allows the authors to explore the stochastic characteristics of the value function. More generally, this work presents a path to efficiently computing optimal policies for an important class of Markov decision processes (MDP) problems (Ning and Sobel 2017). With respect to the optimal policy of their model, the authors show that an "invest, stay put, disinvest" (ISD) policy continues to remain optimal for partially irreversible investments, but internal financing changes the ISD thresholds. Under mild assumptions, an internally financed firm is less likely to issue dividends or to expand capacity compared with a firm with access to the perfect capital market. Although the rest of the papers in the special issue looked at some form of external financing, we know that in practice most of the financing in the firms is internal (Tirole 2005) as this paper studies. Together with other papers in the special issue, such as Ning and Babich (2018) and Kouvelis et al. (2018), this paper illustrates that the richness of dynamic settings produces important and surprising insights.

2.2. Overarching Themes

The nine articles in the special issue, while covering a diverse set of topics, have several unifying themes. To emphasize these, we have submitted the abstracts of these articles to a word-cloud tool.[2] The result, after discarding noninformative words (e.g., "firm") is in Figure 1.

Four papers in the special issue study problems related to the use of trade credit or buyer financing: Kouvelis and Zhao (2018), Deng et al. (2018), Lee et al. (2018), and Tang et al. (2018). The popularity of this topic is not surprising, in light of the fact that trade credit and buyer financing requires deep understanding of supply chains, procurement contracting, and financial contracting. With the rapid growth in practice of supply chain finance in the past decade, we suspect that the interest in this area will not wane any time soon. Perhaps analytics of supply chain finance could be the next wave of research. New developments in fintech, especially blockchain technology, will also spur research advancement in both OM and finance.

Four papers in the special issue considered agency problems, financial contracts between the firm and its investors, and the interactions of these contracts with operational decisions: Lai and Xiao (2018), Tang et al. (2018), Ning and Babich (2018), and de Véricourt and Gromb (2018). This indicates a shift of interest from

Figure 1. (Color online) Overarching Themes of the Special Issue Articles

bankruptcy-costs-based explanations of imperfections in capital markets to explanations that rely on incentives and asymmetric information. Both explanations of capital-market frictions have empirical validity, but they occasionally produce conflicting predictions. The modern theory of corporate finance appears to favor the incentive and asymmetric information explanation. An earlier example in OM of application of this approach is Chod and Zhou (2014). The OM community have been studying the questions of incentives, contracting, information for many years, using the same methodology of contract theory and information economics that is used to study financial contracts. Therefore, there is a natural affinity between problems of contracting in OM and in finance. We expect the trend of using the incentive-based financial frictions in iFORM papers to continue.

The topic of contracting, either between firms in a supply chain or between firms and investors, is universal in the special issue. Similarly, all papers have given some consideration to financing constraints. Four papers in the special issue explicitly consider the question of the distribution of cash flows from firms to shareholders: Ning and Sobel (2018), Ning and Babich (2018), de Véricourt and Gromb (2018), and Lai and Xiao (2018).

Almost all papers explicitly derive financing rates, based on some capital market equilibrium assumption. Most papers assume that investors are perfectly competitive. This is a common assumption in finance literature. A good justification for this assumption is a recognition that there are many more investors out there than firms and that it is much easier to find another person willing to invest capital than another entrepreneur with a good product idea. At the same time, not all capital markets are perfectly competitive. Supplier financing (i.e., trade credit) or buyer financing is done by an entity that has at least some bargaining power. Similarly, some investors, such as venture capitals (VCs) are not at the same as regular investors in capital markets and VCs can offer more than just capital. Thus, there are circumstances when investors have bargaining power and we need to reflect this in the model. But for most iFORM applications, a perfectly competitive capital market is probably a good first-order approximation.

Two papers use an assembly system structure: Deng et al. (2018) and Kouvelis et al. (2018). This elevates the complexity of the contracting problem, because the buyer has to manage relationships with multiple suppliers or multiple components. Of course, this problem has been studied in OM. But from the finance perspective having multiple inputs affects the buyer's risk profile. Investors, who are considering financing the buyer, must understand the nature of the relationship of the buyer with multiple suppliers and the production process inside the buyer firm. This complexity creates opportunities for the buyer firm to take advantage of the external investors. Understanding the nature of the production, assembly, and the supply chain is the key to understanding the risk of the investors—particularly the risk of expropriation by firm insiders. These papers are moving the academic community closer to understanding these important questions.

While many papers in this special issue study interactions among firms along the supply chain, one paper stands apart by analyzing interactions among firms in the same industry: Ning and Babich (2018). These interactions take the form of knowledge spillover: if a successful technology has been developed by one firm, it is adopted by other firms in the industry at a very small cost. Knowledge spillover has its positive side, because a successful technology is quickly disseminated. But knowledge spillover has a negative side (long studied in the economics literature), because firms in the industry become reluctant to invest in new technologies and would rather wait for others to take the risks and free

ride on the success. As it turns out, the use of debt can tame the negative forces of free riding. Fundamentally, though, this paper is just like other papers in the special issue in considering the role of information, incentives, and coordination both among firms and between firms and their external investors.

Two papers are explicitly tackling the problem of supply risk: Kouvelis et al. (2018) and Tang et al. (2018). In Kouvelis et al. (2018) supply risk is twofold. First, there are commodity-input price fluctuations. Second, due to these fluctuations suppliers may choose to renege on the contracts (if an alternative of selling in the spot market becomes attractive enough). In Tang et al. (2018) suppliers can experience a production process failure and they can control the probability of this adverse event through effort. In both cases, supply risk is an important part of the risk portfolio for the investors who decide to finance the buyer firm. Understanding this risk is paramount both for potential investors and for the firms who are trying to attract these potential investors. In finance, risk and return, adverse events, and profit opportunities, are more than just tied together. They are as inseparable as the two sides of the same coin. The same applies to iFORM research.

3. iFORM Future

Cartoonist Bil Keane wrote in a 1994 cartoon (he might have been reusing this quote): "Yesterday's the past, tomorrow's the future, but today is a GIFT. That's why it's called the present" (Keane 1994). Papers published in this special issue are the present of iFORM research. Soon, they will become the past, and in this section we would like to look into the future. There are several areas where finance, operations, and risk management blend together naturally: supply chain finance, integrated risk management, start-ups, entrepreneurship and financing, and asset pricing with supply chains.

3.1. Supply Chain Finance

Supply chains are all-encompassing systems of originating, sourcing, producing, distributing, selling, delivering, and after-sales support activities of products and services a firm offers to its customers. Supply chains, by their nature, are decentralized systems where multiple firms and functional managers are involved in the long sequence of activities and decision making that supports them. The focus on integrated supply chain management has been about the coordination of relevant flows within the sequence of activities for the improvement of the total efficiency and profitability of the supply chain. If possible, this happens in a way that leads to a "win–win" outcome for all firms and their customers. In OM, we study physical flows of materials and tangible products, informational flows between decision makers, and the resulting financial flows as products and services are exchanged, according to contractual arrangements.

OM supply chain academic literature has been heavily involved in the following: describing supply chain processes as flow systems (e.g., the "bullwhip" literature), and suggesting ways and practices that integrated supply chain management can be implemented. With respect to the latter, the literature's emphasis has been on how we can integrate physical and information flows: dealing with information asymmetries among supply chain firms, improving forecasts and credibly sharing them, and sending the right signals to drive efficient flows in the supply chain. There has also been some discussion on how moral hazard in managerial behavior might harm supply chains. When risks (uncertain scenarios with negative outcomes for the firm or the supply chain) are dealt within our literature, they have mostly been counteracted with "operational hedges," such as, material buffers, excess capacity, safety times, operational flexibility to postpone decisions or to reallocate resources among activities or customers of the supply chain.

What OM literature has not considered fully, at least not until recently, is the integration of physical, financial, and information flows, along the supply chain and between firms in a supply chain and investors. This is the subject of supply chain finance (SCF). According to the Global Supply Chain Finance Forum,[3] SCF is defined as "the use of financing and risk mitigation practices and techniques to optimize the management of the working capital and liquidity invested in supply chain processes and transactions." The SCF practice has recently blossomed, enabled by new technologies (e.g., cloud-computing and blockchain), new financial technology specialists ("fintech"), and a strong interest in selling new products by banks (Santander), technology firms (IBM), logistics providers (UPS), and big corporations (e.g., Walmart, HP, and Unilever).

There are three main questions in the supply chain finance research area:

Financing. How can one overcome capital constraints of firms in a supply chain? Financing solutions can be divided into "supplier-led" (e.g., trade credit) and "buyer-led" (e.g., reverse factoring).

Supply chain contracting in the presence of financial frictions. What is the effect of financial frictions (e.g., limited working capital, transaction costs, taxes, bankruptcy costs) on contracts and the implementation of operational strategies? Similar to the traditional supply chain coordination literature, the SCF contracting studies incentive coordination among firms, information asymmetries, and moral hazard issues.

Integrated operational and financial risk hedging. How do operational and financial risks in global supply chain interact and what combination of operational and financial tools can be used to manage those risks?

Some elements of SCF practice and research have a long and distinguished history in finance and OM. Trade credit contracts is an example of that. Others are very new and are just developing as new technologies become available. Blockchain technologies applied to supply chains is an example of that. In the following paragraphs we describe some of the traditional approaches (which still very much present an opportunity for researchers) and outline several ideas for future research along the financing and supply chain contracting directions. Due to its differing nature, existence of voluminous contributions, and direction of future research, we defer the discussion of integrated operational and financial risk hedging to Section 3.2.

While economics and finance literature offers a variety of theoretical justifications and rich empirical evidence for the use of trade credit (see Smith 1987, Lee and Stowe 1993, Long et al. 1993, Petersen and Rajan 1997, Biais and Gollier 1997, Giannetti et al. 2011, Klapper et al. 2012, Barrot 2016), OM researchers offer new insights by modelling detailed and strategic interactions of the firms in the supply chain. OM research in trade credit has a long history, from early works by Baranek (1967) and Haley and Higgins (1973) to recent papers by Gupta and Wang (2009) and Babich and Tang (2012) (for quick references to work in this area, see Babich et al. 2012, Kouvelis and Zhao 2012). The usual stylized model in this literature is that of a bilateral supply chain of a monopolist supplier selling to a newsvendor or a monopolist retailer with trade credit terms set as a part of the supply chain contract (which is most often a wholesale price contract). The questions that have been asked are of three kind to a large extent: (1) motivation for trade credit practices, (2) optimal trade credit terms (interest rate and payment delay period), and (3) implications for competitive and financial performance of the firms.

In a recent theoretical development, Kouvelis and Zhao (2012) suggest that the strategic supplier prefers to offer cheap trade credit to better price the wholesale price contract and have the retailer order larger order quantities for the same price. Yang and Birge (2017) emphasize the risk-sharing role of trade credit and the need for suppliers to balance the operational benefits of risk sharing with the distress cost associated with trade credit default. Chod et al. (2017b) argue for trade credit as in-kind finance rather than the cash financing of bank loans being a more efficient way to signal private information about the borrowing firm's quality. Efforts to uncover new perspectives on motives and extent of use of trade credits will need to look at models more complex than the bilateral monopoly supply chains. While, on the one hand, working with multiple suppliers can help the retailer to relax the retailer's financing constraints (Babich et al. 2012), on the other hand, a supply pool serving the same retailer might be concerned about how the use of their trade credits are freeing up financial constraints the retailer might be using to do more business with other retailers, a free-riding issue recently raised in Chod et al. (2017a). Along the same line of reasoning, it is important to look into multiproduct settings that the suppliers are serving their buyers, and understand how their product portfolio might be affecting the trade credit terms they offer. In answering these questions one has to take into account the retail end product competitive structure, the commodity or differentiated nature of supplied parts, and the financial constraints and potential distress costs suppliers may face themselves. Similarly, retailers might want to look into how their supply pool overlaps with those of their direct competitors, and how such overlap affects their preference for suppliers and trade credit services they receive from them.

Another question that recently attracted interest from OM researchers is the optimal trade credit terms (both interest rate and payment delay period), and whether trade credit should be cheaper than bank loans. An argument can be made that in an environment of full information, the best financing solution for a bilateral supply chain with a newsvendor–retailer is to have the supplier fully finance the retailer through trade credit (Kouvelis and Zhao 2012). However, this might not be the case when supplier and retailer have different risks, different credit ratings, and different financing costs (Kouvelis and Zhao 2018), or they have different market power (Yang and Birge 2017). In such cases, retailers use a combination of bank loans and trade credits as empirically observed by Rajan and Zingales (1995), and trade credits may be more expensive than bank loans (see Ng et al. 1999). There are opportunities to offer further insights in the settings where the retailers have pricing control of their end markets or the ability to influence the demand, if there are multiple suppliers or competing retailers under different forms of end-product market competition. Furthermore, questions of the firm's capital structure and the associated agency problems (Tirole 2005) add new layers of complexity on the trade credit terms question.

Fundamental questions about the overall benefits of trade credit practices, which firm appropriates most of the benefits, and the overall improvements in efficiency of supply chains have been studied in the recent OM literature. When the supplier is the Stackelberg leader (Kouvelis and Zhao 2012, Yang and Birge 2017) most of the benefits go to the supplier, but retailers can still benefit as the supply chain efficiency improves. In a recent paper, Peura et al. (2017) study the horizontal competition benefits of trade credit practices of competing suppliers in a Bertrand price competition setting, and conclude that trade credit has a softening competition effect and increases the profitability of firms with similar financial status. However, when

the status is different, the stronger firm may predate the weaker competitor. This research direction can be further explored with richer models that look at trade credit practices where competition at both supplier and retailer level is affected as a result of the financing practices and the credit risks of the involved firms. Then, explore how firm profitability and competitive advantages are affected by the trade credit practices, financing constraints, and default recovery capabilities. Although there is evidence of the effects of supplier competition on trade credit (e.g., Giannetti et al. 2011), we have barely scratched the surface of understanding the competitive and supply chain efficiency implications of the financing contracts within financially constrained industry settings.

While supplier-led financing has received a great deal of attention in the literature, the buyer-led practices, such as reverse factoring or buyer direct financing, have been thinly investigated. Reverse factoring practices are motivated by the desire of powerful buyers to improve their cash-to-cash cycles, by extending payment delays to their suppliers while also recognizing the increase in financing costs for their smaller undercapitalized suppliers. Some of the early works are focusing on the information asymmetry between the supplier and the bank (Lekkakos and Serrano 2016, Tanrisever et al. 2015), and they imply that either the supplier's or the supply chain's benefits are decreasing in the payment term extension. Tunca and Zhu (2017) analyze a model with the buyer specifying both wholesale price and order quantity and employing reverse factoring to reduce financing costs for its suppliers. They find that these financing practices lead to both lower interest rates, compared to commercial loans, lower wholesale prices, and generate higher profits for both the supplier and the retailer. It will be fruitful to look into the validity of such results under different supply chain contracts, more balanced market power between firms, differential credit ratings, in the presence of supplier and buyer competition, and conduct studies of industry equilibria.

Supply chain contracting and coordination issues under financial constraints is an understudied area. Recent work by Kouvelis and Zhao (2015) considers the setting with a supplier and a newsvendor–retailer, in the presence of general bankruptcy costs and investigates coordination-related issues. For these settings quantity discount and payback contracts often fail to coordinate, but the revenue sharing contracts prove to be substantially more versatile. Under variable default costs, the coordination requires sharing of the financing needs of the firms in the supply chain. This is difficult to implement in a decentralized chain of independent firms. In the case of fixed default costs, it is difficult to even identify the first-best strategies, and there are situations where—as Kouvelis and Zhao (2015) show—the decentralized system may perform better than the centralized one. Many unanswered questions remain for this basic setting, when financial frictions enter the picture. More complex settings, with monopolistic pricing or horizontal competition, will require modeling ingenuity to achieve problem tractability. Future research has to look into other interesting contracting issues in the presence of risks other than the usual demand risks (e.g., supply risks, fluctuating material costs, macroeconomic uncertainties, lead time, and disaster risks), while addressing not only the long-term profit optimization but also the risk management aspects.

3.2. Integrated Risk Management

The urgency of seeking comprehensive risk management concepts and tools has motivated substantial research of the iFORM field and has led to the emergence of the "integrated risk management" research area. This area embraces a multidisciplinary research approach that builds upon recent developments in finance, decision theory, operations research, and supply chain management to better manage complex, highly interacting, and diverse global supply chain risks.

Traditionally OM literature has looked into operational risk mitigation strategies dividing these strategies into four categories (Hopp 2011): buffering (safety stock, excess capacity, safety lead-times); pooling (flexibility in technology and operational processes, common components, transshipment, postponement); contingency planning (virtual buffering through a preplanned set of actions, backup supply, multisourcing, diversified supplier portfolio with emergency supply allocation); and crisis management (real-time organizational response to unanticipated events). Our literature stays active in enriching this literature with some great expository reviews provided in Van Mieghem (2012) and Tomlin and Wang (2012).

The focus of the operational risk management work lately has been on operational flexibility applications in specific industries. For example, Boyabatlı et al. (2011) considered a coproduction system with two output quality levels (boxed beef and ground beef) in a meat processing environment, and analyzed the impact of market conditions on optimal sourcing decisions. Dong et al. (2014) analyzed early procurement, production, and upgrading decisions of an oil refinery facing price uncertainty in both input and output markets. They investigated two types of flexibility: range flexibility (ability to process crude oil of diverse quality) and conversion flexibility (ability to convert low quality crude to high quality crude oil). Conversion flexibility prior to subsequent blending decisions is very important for this setting, but it has wide applications in other coproduction and blending-type environments. Chen et al. (2017) demonstrated the value of quality-upgrade

flexibility for a coproduction system with yield uncertainty in the presence of uncertain demand with immediate applications to agribusiness, semiconductor production, and steel processing. Further research along those lines is promising and it can make a strong impact on industry applications. For such applications it is important to fully account for relevant commodity markets and price evolution in order to understand the decision logic and quantify the value of exercising operational flexibilities in real-time, data-rich, and market environments.

Financial hedging of demand, currency, commodity, and other supply chain risks has been understudied in OM literature. Interesting work looks into the complementarity/substitution aspects of financial hedges and operational risk mitigation strategies (see Chod et al. 2010). However, the fundamental question if financial hedging should be used for managing operational risks was left to corporate finance theory insights mostly informed by single firm and financial friction justifications (for an exemplary reference, and reference therein, see Froot et al. 1993). Only recently the work of Turcic et al. (2015) advanced a supply chain theory of hedging, by accounting for the role of firms within the supply chain, product structure, and strategic interactions, as moderated by the supply chain contract agreement. Turcic et al. (2015) offer a refined justification for nuanced hedging behaviors of firms within complex supply chains. They use a stylized supply chain comprising a supplier and a newsvendor–buyer under a wholesale price contract, with the buyer exposed to both his own commodity consumption and also to other commodities the supplier is using. The authors find that such input-material risks are reflected in the wholesale price. Buyers tend to like financial hedging used by suppliers because it lowers wholesale prices and eliminates supply-discontinuity risks. Therefore, if buyers have the power, they will impose a hedging regime within the chain. However, suppliers may not always prefer hedging—except in cases of high-volume, good-margin business with their buyers—and are concerned with buyer defaults when commodity prices are volatile and margins in the end-market are slim. This work reveals that both the nature of the contract and the actions of the counterparty affect the hedging behavior. Under a wholesale price contract, either both firms hedge their directly consumed commodities or neither of them does. In the subsequent work published in this special issue, Kouvelis et al. (2018) argue that in a bilateral supply chain, with a monopolist buyer and in the absence of frictions, modified revenue-sharing contracts coordinate the chain and no financial hedging is needed, but pass-through-type contracts require the buyer to financially hedge all commodities in the chain relevant to its products. The introduction of financial frictions destroys the coordinating aspects of revenue sharing contracts, and the use of financial hedges improves the performance for firms in the chain. Under a revenue-sharing contract, each firm hedges all commodities and their hedging behavior is dependent on the behavior of the counterparty (either both hedge or no-one hedges). In future research, a much better understanding of the use of financial hedges for a multiplicity of operational risks is needed, and both modelling of detail-rich settings and field work to elucidate the logic and success of such practices is valuable.

There is a stream of research in OM modeling risk preferences of the decision maker in its objective (e.g., Bouakiz and Sobel 1992, Chen et al. 2007). Interestingly, empirical work in OM (Ning et al. 2018) confirms risk-averse behavior in business-to-business (B2B) settings, using data of contracts for printing services. Recent work identifies how operational strategies get affected when risk concerns do not enter the objective as mentioned above, but are stated as risk constraints (such as VaR or CVaR). In recent research, Kouvelis and Li (2017) argue, using a newsvendor-like inventory framework with uncertain demand correlated with tradeable assets, and with available financial derivative markets on the underlying asset, that the risk measurement framework used has a profound impact on the interaction of operational decisions and financial hedges. This work is the first to offer an integrated (combined operational and financial hedges) risk management approach to the newsvendor setting with VaR constraints, and a fresh perspective on the role of each hedge. Under the mean–variance or expected utility maximization both inventory and financial hedges have to be used for risk control, and thus these two types of decisions are highly interdependent. In contrast, in a VaR (or CVaR) constrained formulation of the risk management problem, financial hedges alone can control profit risks, even when the demand only partially correlates with the price of the financial tradeable asset, and thus, inventory can be used solely for profit maximization.

Efforts to consider integrated operational and financial hedging in complex, dynamic, single-firm decision-making environments under exchange rate or commodity risks, and typically under mean–variance framework, appeared in a stream of recent papers (see Ding et al. 2007, Kouvelis et al. 2013, Goel and Tanrısever 2017, and references therein). Pursuing more realistic aspects of such risk management problems to incorporate spot price evolution, institutional details, and transaction costs of hedge markets, and potentially expanding the scope to include the relevant coordinated operational and hedging policies of inputs and outputs of firms within decentralized supply chains are worthwhile future research directions.

3.3. Start-ups, Entrepreneurship, and Financing

Start-up is a stage in the life of a company, when financial and operational decisions cannot be separated. Entrepreneurs are bound by numerous constraints: on their capital, on their time, and on their expertise. In particular, their operational choices, such as whether to produce in-house or outsource, from whom to procure, how much inventory to carry, etc., are limited by the capital. Conversely, how entrepreneurs spend this limited capital today affects how quickly their start-up grows, how much capital it can access in the future, whether it stays in business, and the entrepreneurs' "cash-out" strategy. Beyond the theoretical arguments for the unified approach to operations and finance, in practice, start-ups often simply do not have sufficient human resources to implement the "divide-and-conquer" approach of putting dedicated managers in charge of finance, OM, strategy, marketing, and other functions. The entrepreneurs usually must do all of these themselves.

For these reasons, the iFORM community has been studying start-ups and entrepreneurship for some time now. For example, Babich and Sobel (2004) analyze capacity and financing decisions of a pre-IPO firm and the optimal timing of the initial public offering (IPO) decision. Swinney et al. (2011) compare start-up (with survival objective) and mature firms (with profit maximization objective) and study competition between start-ups, and between start-ups and mature firms.

A new direction for iFORM is a type of start-up financing, called crowdfunding, which has attracted a great deal of attention in the popular press and in the academic literature recently. Crowdfunding is a process by which entrepreneurs raise capital from investors via on-line platforms directly, rather than through financial markets and financial intermediaries. The growth in crowdfunding has been a remarkable and worldwide phenomenon. In the early days of crowdfunding, in 2010, the total amount raised through crowdfunding was a mere $880 million. In 2014 that number rose to $16 billion and in 2015 it became $34.4 billion (according to Massolution 2015), which is comparable with the amount of VC financing.

There are four types of crowdfunding, depending on the form of payment/reward to the investors: donation, reward, equity, and debt. The best-known crowdfunding platform—Kickstarter—facilitates reward- and donation-based crowdfunding and it was launced in 2009. Prosper Marketplace, one of the oldest debt-crowdfunding platforms, was launched in 2006. Equity crowdfunding is a more recent development (in the United States, the law governing equity crowdfunding was passed in 2012).

To understand how the crowdfunding process works and why it is relevant for iFORM, it helps to review an example. Babich et al. (2017) describe a Kickstarter campaign for "C.H.I.P. The World's First Nine Dollar Computer." The C.H.I.P. campaign started on May 7, 2015. To attract investors (called "backers" by Kickstarter), the entrepreneurs posted multiple levels of rewards. For example, for a $9 contribution, a backer was promised one C.H.I.P. computer. For a $19 contribution, a backer was promised a C.H.I.P computer and a VGA adapter. For $24, a backer was promised a C.H.I.P. and an high-definition multimedia interface adapter, and so on. There were 11 levels of rewards in total. The campaign had a $50,000 goal. This is important because, according to Kickstarter's rules, the money raised during the campaign is disbursed to the entrepreneurs only if the campaign goal is met; otherwise, this money is returned to the backers. The C.H.I.P. campaign was successful for the entrepreneurs, raising $2,071,927 from 39,560 backers. But was this a successful investment for the backers? A large fraction of campaigns on Kickstarter is for products that are still in their development stage. In particular, for C.H.I.P., the shipments of rewards were scheduled to begin in May 2016, eleven months after the end of the campaign in June 2015. The gap was needed to complete prototype testing, to source components, and to manufacture the product. Research shows that for the vast majority of successful campaigns, the entrepreneur misses the deadlines for fulfilling promises to the backers (Mollick 2014). The C.H.I.P.'s backers have suffered a similar fate. Judging by the comments on Kickstarter (as of August 2017), some backers are yet to receive their C.H.I.P. computers and quite a few backers complained about the quality of the computers they did receive.

Crowdfunding is an example of a future iFORM topic. It is relevant for entrepreneurial finance. Crowdfunding is another option of raising capital, complementing traditional sources (such as borrowing from friends and family), securing small bank loans, soliciting angel investors, pitching ideas to venture capitalists (VCs), and using trade credit. Interestingly, Babich et al. (2017) show that crowdfunding alters interactions between the entrepreneur and the traditional financing sources, such as banks and VCs. Babich et al. (2017) predict (and this has been confirmed empirically) that, surprisingly, a successful crowdfunding campaign may result in a loss of VC financing.

Crowdfunding is clearly relevant to operations, especially the questions of how to convert ideas into products, how to make and fulfil promises to the backers, how backers can assess product and process quality, how backers and platforms can screen-out fraud, and how entrepreneurs can signal quality (e.g., Chakraborty and Swinney 2016). One can also view crowdfunding campaigns through the prism of revenue management and dynamic pricing. Several recent

papers in OM have studied questions related to the design of campaign rewards, their dynamic management, and the information discovery (e.g., Alaei et al. 2016). Crowdfunding is also relevant for new product-development research, because entrepreneurs use backers' feedback to improve product design.

Beyond finance and operations, crowdfunding is relevant for marketing and other disciplines. Crowdfunding serves as a new advertisement and sales channel. Crowdfunding is a great platform to study the psychology of the investors. There is data available that allows researchers to perform the analytics of crowdfunding. Crowdfunding has connections with sustainability, because many "green" projects are funded through crowdfunding. Crowdfunding requires new legal frameworks, and so on. In summary, crowdfunding is an excellent research opportunity to merge methodologies and ideas from multiple disciplines.

3.4. Supply Chains and Asset Pricing

Asset pricing in finance is an economic theory that explains how investors price a stream of cash flows (usually from financial assets). Asset pricing theory stands on the foundations built by Nobel-Prize-winning work. We are going to argue in this section that OM and iFORM research can contribute to asset pricing theory and practice in a meaningful way.

Asset pricing theory uses the following as inputs: the description of investors' preferences, the descriptions of information and investment choices available to investors, the institutional knowledge about financial markets, the information about cash flows generated by companies, and the predictions about the general equilibrium, investor actions. It combines these inputs with the markets' data and applies sophisticated econometric methods to describe factors that determine asset prices.

Similar to other economic theories, asset pricing strives to provide a parsimonious model that fits empirical observations. Despite the ostensible complexity of the problem, the fundamental pricing equation of asset pricing theory is deceptively simple (Cochrane 2001): $p_t = E[m_{t+1}x_{t+1}]$, where p_t is the current price, x_{t+1} are future random cash flows, and m_{t+1} is the "special sauce" called the stochastic discount factor or pricing kernel, which reflects investor's preferences, their investment universe, etc. This simple equation generates all asset pricing models in all pricing applications, including the well-known ones, such as CAPM, ICAPM, APT, and Fama–French multifactor models.

The key differences among these models is in the assumptions about the structure of the stochastic discount factor and its joint distribution with the cash flows. The factor models decompose both the pricing kernel m_{t+1} and the cash flows x_{t+1} into a linear combination of factors. For example, the Fama–French three-factor model uses the following: the return on the stock market portfolio, excess returns of small cap firms over big cap firms, excess return of high book-to-market ratio stocks over low. The race in asset pricing theory is to identify the smallest number of factors that can explain the most of the systematic variation in prices of a particular asset class. What is important for us is that, recently, supply chains began to attract attention as a source of new systematic factors.

For instance, Cohen and Frazzini (2008) look at supply chain relationships and report the existence of correlation between the customer stock returns and the firm's stock returns. They find that, despite the supply chain links being public information, the supplier stock prices systematically lag behind shocks to the customer stock prices. Cohen and Frazzini (2008) can systematically predict the abnormal supplier stock returns—based on the customer lagged returns—and they can create a trading strategy that exploits this lag. Cohen and Frazzini (2008) attribute their results to the "investor ignorance." Wu and Birge (2014) use a different data set for supply chain links and a different time period for their analysis and find that the "investor ignorance" effect with respect to shocks to the customer stock prices has disappeared. Wu and Birge (2014) are still able to detect the effect from the shocks to the supplier stock prices.

Supply chains are used by Agca et al. (2017) to explain comovements of credit default swap (CDS) spreads. They find that jumps in the CDS spread of a company is associated with CDS spread changes in the same direction for its customers and suppliers. The effect applies to higher tiers of the supply chains as well. They document that bad credit shocks propagate faster through higher supply chain tiers than good shocks, indicating increased investor attention to bad credit news in the supply chains. Agca et al. (2017) find that supply chain attributes, such as duration of supply chain link, trade credit given by the supplier to the customer, and the percentage of total sales that a customer represents, intensify contagion.

Prior research documented the role of supply chains in bankruptcy waves (Hertzel et al. 2008, Houston et al. 2016, Kolay et al. 2016). Researchers looked at supply chain network characteristics, such as network centrality (Wu and Birge 2014, Yang and Zhang 2016), customer concentration (Cen et al. 2017, Campello and Gao 2017), and network distance from the event firm (Wu 2015).

There are two reasons why supply chain networks are drawing an increasing amount of attention in finance and economics. First, the financial crisis of 2008–2009 brought to the forefront the saliency of the systematic risk of a network of interconnected entities (like banks). Second, the data on supply chain connections became more easily available (see Agca et al. 2017 for discussion).

Asset pricing with supply chains is another example of a future iFORM topic. We believe that OM researchers with their understanding of the intricacies of physical, financial, and informational flows in supply chains have a competitive advantage in this area. So far, the only information used in the studies (discussed previously) was regarding the existence of supply chain relationships between companies, the network structure, and accounting metrics. The next level of analysis can leverage OM knowledge of how supply chain networks are formed, how they evolve, what investments firms make in their supply chain partners, how value is generated and shared, and what decisions are made. The key question in all studies is how these OM considerations affect investors, what do investors know, and how they react in equilibrium. Conversely, one can use information from financial markets to affect supply chain decisions.

4. Conclusions

As this special issue illustrates, unexplored questions at the interface of finance and operations motivated rigorous studies: theoretical, computational, and empirical. The authors came up with a rich collection of innovative solutions, interesting conclusions, and managerial insights. Even more importantly, the current answers lead the way to more questions and highlight the need for more creative research in answering them. Who should finance the supply chain? Definitely not just the bank, but some mixture of the bank and the suppliers' trade credits or the bank and the retailers early payments. But while this is true for the bilateral supply chains of the supplier and the buyer, does the answer extend to more complex supply networks and in the presence of competition at the supplier and the buyer level? Will all of the hypotheses from theoretical studies be validated when met with the available data on trade credit practices, reverse factoring, and buyer financing initiatives in complex chains? Similarly, the surprising findings from the empirical studies raise new questions that might require new theoretical foundations. Is there a reason for why strong deviations from the average trade-credit rates by suppliers tend to penalize their buyers and potentially even the supply chain? What are the important factors that, in theory, will provide the explanation for these observations?

Information asymmetry plays a predictable role in the buyer-intermediated supply chain financing schemes, with buyers enjoying informational advantages over banks and leveraging this information to offer better rates through their own financing programs. But could informational advantages be reversed if banks work with a large pool of suppliers or if they have established a relationship with suppliers as they operate reverse factoring programs? How can new technologies enabling shorter payment lead times and increasing visibility across supply chains (e.g., through distributed open ledgers) influence financing practices?

Agency issues between insiders and outsiders of the firm or different classes of investors can destroy value (e.g., through undesirable behavior such as risk shifting, under-investment, over-investment, failure to liquidate). How do such issues translate to supply chain financing and how do they affect operational decisions of suppliers and buyers of the firm?

Crowdfunding, in various forms, is changing how entrepreneurs develop, finance, and promote their ideas and products. How does crowdfunding affect the entrepreneurs' operational decisions, such as interactions with contractors? As the data about crowdfunding campaigns—and, more importantly, about long-term successes of failures of projects that attempted crowdfunding—is accumulated over time, what can we learn about the operational determinants of entrepreneurial success?

Asset pricing is at the core of finance research and practice. Can we use extensive OM knowledge of supply chains to identify systematic pricing factors that would meaningfully complement the existing asset pricing models? We are optimistic that the supply chain lens will offer a more systematic perspective on how cash flows are generated and the way they create value.

We know a lot about how commodity prices and other supply risks come into play, and how, in some cases, firms will effectively manage them through financial hedges. But should we think about hedging such risks one transaction at a time (as a significant portion of OM literature tends to do), or should firms aggregate transactions at a firm or at least a division level and worry more about hedging the aggregate cash flow fluctuations with the right contracts?

When a rich set of questions leads to interesting insights and ideas for new practices, but it also generates new questions and ideas for more research, this is indicative of a vibrant research field studying relevant and important problems. This is exactly what we observe with the iFORM research. There are many lessons coming out from iFORM work that can and should be taught to executives who operate in the boundary-spanning roles in operations and finance. We need more iFORM research, as we delve deeper into issues arising from complex strategic, operational, financial, and risk management decisions, in all settings from start-ups to global enterprises.

Acknowledgments

The authors would like to thank everyone who contributed to this special issue. First, thanks to everyone who submitted their work to the special issue. Thanks to the anonymous referees, who contributed their time and sound judgement to provide timely and constructive feedback on the submissions. Thanks to the associate editors, who shouldered the main burden of the review process: John Birge,

Onur Boyabatli, Rene Caldentey, Jiri Chod, Maqbool Dada, Francis de Véricourt, Laurens Debo, Lingxiu Dong, Vishal Gaur, Karan Girotra, Haresh Gurnani, Genaro Gutierrez, Roman Kapuscinski, Burak Kazaz, Harish Krishnan, Victor Martinez-de-Albeniz, Ozalp Ozer, Kamalini Ramdas, Vinod Singhal, Matthew Sobel, Bradley Staats, Robert Swinney, Terry Taylor, Tunay Tunca, Danko Turcic, Jan Van Mieghem, Owen Wu, and Wenhui Zhao. Thanks to Frances Moskwa, the managing editor of *Manufacturing and Service Operations Management*, for managing the process and quickly responding to all questions. The authors are grateful to Chris Tang, the editor-in-chief of *Manufacturing and Service Operations Management*, for encouraging them to organize this special issue and for providing constant motivation and inspiration.

Endnotes

[1] See https://finance.yahoo.com/quote/WMT/balance-sheet?p=WMT, accessed September 20, 2017.

[2] See http://www.wordart.com.

[3] See http://supplychainfinanceforum.org/.

References

Agca S, Babich V, Birge J, Wu J (2017) Credit risk contagion along the supply chain: Evidence from the CDS market. Working paper, George Washington University, Washington, DC.

Alaei S, Malekian A, Mostagir M (2016) A dynamic model of crowdfunding. Ross School of Business Working Paper 1307, University of Michigan, Ann Arbor.

Babich V, Sobel MJ (2004) Pre-IPO operational and financial decisions. *Management Sci.* 50(7):935–948.

Babich V, Tang CS (2012) Managing opportunistic supplier product adulteration: Deferred payments, inspection, and combined mechanisms. *Manufacturing Service Oper. Management* 14(2): 301–314.

Babich V, Tsoukalas G, Marinesi S (2017) Does crowdfunding benefit entrepreneurs and venture capital investors? Working paper, McDonough School of Business, Georgetown University, Washington, DC.

Babich V, Aydin G, Brunet PY, Keppo J, Saigal R (2012) Risk, financing, and the optimal number of suppliers. Gurnani H, Mehrotra A, Ray S, eds. *Managing Supply Disruptions* (Springer-Verlag Ltd., London), 195–240.

Bank for International Settlements (2014) Trade finance: Developments and issues. Report No. 50, Committee on the Global Financial System (CGFS), Basel, Switzerland.

Baranek W (1967) Financial implications of the lot-size inventory models. *Management Sci.* 13(8):B401–B408.

Barrot JN (2016) Trade credit and industry dynamics: Evidence from trucking firms. *J. Finance* 71(5):1975–2016.

Bebchuk L, Cohen A, Ferrell A (2008) What matters in corporate governance? *Rev. Financial Stud.* 22(2):783–827.

Bebchuk LA, Stole LA (1993) Do short-term objectives lead to under-or overinvestment in long-term projects? *J. Finance* 48(2): 719–729.

Biais B, Gollier C (1997) Trade credit and credit rationing. *Rev. Financial Stud.* 10(4):903–937.

Bouakiz M, Sobel MJ (1992) Inventory control with an exponential utility criterion. *Oper. Res.* 40(3):603–608.

Boyabatlı O, Kleindorfer PR, Koontz SR (2011) Integrating long-term and short-term contracting in beef supply chains. *Management Sci.* 57(10):1771–1787.

Burkart M, Ellingsen T (2004) In-kind finance: A theory of trade credit. *Amer. Econom. Rev.* 94(3):569–590.

Campello M, Gao J (2017) Customer concentration and loan contract terms. *J. Financial Econom.* 123(1):108–136.

Cen L, Maydew EL, Zhang L, Zuo L (2017) Customer–supplier relationships and corporate tax avoidance. *J. Financial Econom.* 123(2):377–394.

Chakraborty S, Swinney R (2016) Signaling to the crowd: Private quality information and rewards-based crowdfunding. Working paper, Duke University, Durham, NC.

Chen X, Kouvelis P, Biazaran M (2017) Value of operational flexibility in co-production systems with yield and demand uncertainty. *Internat. J. Production Res.* Forthcoming.

Chen X, Sim M, Simchi-Levi D, Sun P (2007) Risk aversion in inventory management. *Oper. Res.* 55(5):828–842.

Chod J, Zhou J (2014) Resource flexibility and capital structure. *Management Sci.* 60(3):708–729.

Chod J, Lyandres E, Yang SA (2017a) Trade credit and supplier competition. Working paper, Boston College, Chestnut Hill, MA.

Chod J, Rudi N, Van Mieghem JA (2010) Operational flexibility and financial hedging: Complements or substitutes? *Management Sci.* 56(6):1030–1045.

Chod J, Trichakis N, Tsoukalas G (2017b) A signaling theory of in-kind finance. Working paper, Boston College, Chestnut Hill, MA.

Cochrane JH (2001) *Asset Pricing* (Princeton University Press, Princeton, NJ).

Cohen L, Frazzini A (2008) Economic links and predictable returns. *J. Finance* 63(4):1977–2011.

Deng S, Gu C, Cai G, Li Y (2018) Financing multiple heterogeneous suppliers in assembly systems: Buyer vs. bank finance. *Manufacturing Service Oper. Management* 20(1):53–69.

de Véricourt F, Gromb D (2018) Financing capacity investment under demand uncertainty: An optimal contracting approach. *Manufacturing Service Oper. Management* 20(1):85–96.

Ding Q, Dong L, Kouvelis P (2007) On the integration of production and financial hedging decisions in global markets. *Oper. Res.* 55(3):470–489.

Dong L, Kouvelis P, Wu X (2014) The value of operational flexibility in the presence of input and output price uncertainties with oil refining applications. *Management Sci.* 60(12):2908–2926.

Fisman R (2001) Trade credit and productive efficiency in developing countries. *World Development* 29(2):311–321.

Froot KA, Scharfstein DS, Stein JC (1993) Risk management: Coordinating corporate investment and financing policies. *J. Finance* 48(5):1629–1658.

Giannetti M, Burkart M, Ellingsen T (2011) What you sell is what you lend? Explaining trade credit contracts. *Rev. Financial Stud.* 24(4):1261–1298.

Goel A, Tanrısever F (2017) Financial hedging and optimal procurement policies under correlated price and demand. *Production Oper. Management*. 26(10):1924–1945.

Gupta D, Wang L (2009) A stochastic inventory model with trade credit. *Manufacturing Service Oper. Management* 11(1):4–18.

Haley CW, Higgins RC (1973) Inventory policies and trade credit financing. *Management Sci.* 20(4):464–471.

Hertzel MG, Li Z, Officer MS, Rodgers KJ (2008) Inter-firm linkages and the wealth effects of financial distress along the supply chain. *J. Financial Econom.* 87(2):374–387.

Hill MD, Kelly GW, Preve LA, Sarria-Allende V (2017) Trade credit or financial credit? An international study of the choice and its influences. *Emerging Markets Finance Trade* 53(10):1–15.

Holmstrom B, Tirole J (1997) Financial intermediation, loanable funds, and the real sector. *Quart. J. Econom.* 112(3):663–691.

Hopp WJ (2011) *Supply Chain Science* (Waveland Press, Long Grove, IL).

Houston JF, Lin C, Zhu Z (2016) The financial implications of supply chain changes. *Management Sci.* 62(9):2520–2542.

Innes RD (1990) Limited liability and incentive contracting with ex-ante action choices. *J. Econom. Theory* 52(1):45–67.

Jensen MC, Meckling WH (1976) Theory of the firm: Managerial behavior, agency costs and ownership structure. *J. Financial Econom.* 3(4):305–360.

Keane W (1994) The family circus. Syndicated cartoon, issue 8–31.

Kisgen DJ, Strahan PE (2010) Do regulations based on credit ratings affect a firm's cost of capital? *Rev. Financial Stud.* 23(12): 4324–4347.

Klapper L, Laeven L, Rajan R (2012) Trade credit contracts. *Rev. Financial Stud.* 25(3):838–867.

Kolay M, Lemmon M, Tashjian E (2016) Spreading the misery? Sources of bankruptcy spillover in the supply chain. *J. Financial Quant. Anal.* 51(6):1955–1990.

Kouvelis P, Li R (2017) Integrated risk management for newsvendor with VaR constraints. Working paper, Olin Business School, Washington University in St. Louis, St. Louis.

Kouvelis P, Zhao W (2012) Financing the newsvendor: Supplier vs. bank, and the structure of optimal trade credit contracts. *Oper. Res.* 60(3):566–580.

Kouvelis P, Zhao W (2015) Supply chain contract design under financial constraints and bankruptcy costs. *Management Sci.* 62(8):2341–2357.

Kouvelis P, Zhao W (2018) Who should finance the supply chain? Impact of credit ratings on supply chain decisions. *Manufacturing Service Oper. Management* 20(1):19–35.

Kouvelis P, Li R, Ding Q (2013) Managing storable commodity risks: The role of inventory and financial hedge. *Manufacturing Service Oper. Management* 15(3):507–521.

Kouvelis P, Turcic D, Zhao W (2018) Supply chain contracting in environments with volatile input prices and frictions. *Manufacturing Service Oper. Management* 20(1):130–146.

Lai G, Xiao W (2018) Inventory decisions and signals of demand uncertainty to investors. *Manufacturing Service Oper. Management* 20(1):113–129.

Lee H-H, Zhou J, Wang J (2018) Trade credit financing under competition and its impact on firm performance in supply chains. *Manufacturing Service Oper. Management* 20(1):36–52.

Lee YW, Stowe JD (1993) Product risk, asymmetric information, and trade credit. *J. Financial Quant. Anal.* 28(2):285–300.

Lekkakos SD, Serrano A (2016) Supply chain finance for small and medium sized enterprises: The case of reverse factoring. *Internat. J. Phys. Distribution Logist. Management* 46(4):367–392.

Long MS, Malitz IB, Ravid SA (1993) Trade credit, quality guarantees, and product marketability. *Financial Management* 22(4):117–127.

Massolution (2015) 2015 crowdfunding industry report. Technical report, Massolution, Los Angeles.

Mollick E (2014) The dynamics of crowdfunding: An exploratory study. *J. Bus. Venturing* 29(1):1–16.

Myers SC (1977) Determinants of corporate borrowing. *J. Financial Econom.* 5(2):147–175.

Ng CK, Smith JK, Smith RL (1999) Evidence on the determinants of credit terms used in interfirm trade. *J. Finance* 54(3):1109–1129.

Ning J, Babich V (2018) R&D investments in the presence of knowledge spillover and debt financing: Can risk shifting cure free riding? *Manufacturing Service Oper. Management* 20(1):97–112.

Ning J, Sobel MJ (2017) Easy affine Markov decision processes: Theory. Working paper, Weatherhead School of Management, Cleveland, OH.

Ning J, Sobel MJ (2018) Production and capacity management with internal financing. *Manufacturing Service Oper. Management* 20(1):147–160.

Ning J, Babich V, Handley J, Keppo J (2018) Risk-aversion and B2B contracting under asymmetric information: Evidence from managed print services. *Oper. Res.*, ePub ahead of print January 10, https://doi.org/10.1287/opre.2017.1673.

Petersen MA, Rajan RG (1997) Trade credit: Theories and evidence. *Rev. Financial Stud.* 10:661–692.

Peura H, Yang SA, Lai G (2017) Trade credit in competition: A horizontal benefit. *Manufacturing Service Oper. Management* 19(2):263–289.

Rajan RG, Zingales L (1995) What do we know about capital structure? Some evidence from international data. *J. Finance* 50(5): 1421–1460.

Smith JK (1987) Trade credit and information asymmetry. *J. Finance* 42(4): 863–872.

Swinney R, Cachon GP, Netessine S (2011) Capacity investment timing by start-ups and established firms in new markets. *Management Sci.* 57(4):763–777.

Tang CS, Yang SA, Wu J (2018) Sourcing from suppliers with financial constraints and performance risk. *Manufacturing Service Oper. Management* 20(1):70–84.

Tanrisever F, Cetinay H, Reindorp M, Fransoo JC (2015) Reverse factoring for SME finance. Working paper, Bilkent University, Ankara, Turkey.

Tirole J (2005) *The Theory of Corporate Finance* (Princeton University Press, Princeton, NJ).

Tomlin B, Wang Y (2012) Operational strategies for managing supply chain disruption risk. Kouvelis P, Boyabatli O, Dong L, Li R, eds. *Handbook of Integrated Risk Management in Global Supply Chains* (John Wiley & Sons, New York), 79–101.

Tunca TI, Zhu W (2017) Buyer intermediation in supplier finance. *Management Sci.*, ePub ahead of print November 2, https://doi.org/10.1287/mnsc.2017.2863.

Turcic D, Kouvelis P, Bolandifar E (2015) Hedging commodity procurement in a bilateral supply chain. *Manufacturing Service Oper. Management* 17(2):221–235.

Van Mieghem JA (2012) Risk management and operational hedging: An overview. Kouvelis P, Boyabatli O, Dong L, Li R, eds. *Handbook of Integrated Risk Management in Global Supply Chains* (John Wiley & Sons, New York), 13–49.

Wu D (2015) Stock spillover and financial response in supply chain networks: Evidence from firm-level data. Working paper, University of Michigan, Ann Arbor.

Wu J, Birge JR (2014) Supply chain network structure and firm returns. Working paper, University of Chicago, Chicago.

Yang J, Zhang R (2016) Network centrality of customers and suppliers. Working paper, Board of Governors of the Federal Reserve System, Washington, DC.

Yang SA, Birge JR (2017) Trade credit, risk sharing, and inventory financing portfolios. *Management Sci.*, ePub ahead of print August 18, https://doi.org/10.1287/mnsc.2017.2799.