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Introduction to the Special Issue on "Risk Management in Operations"

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1. Introduction

Since the advent of the modern industrial enterprise, the management of risk has been an issue of concern to academics, policymakers, and managers alike. However, the past two decades have witnessed a sharper focus on this topic due to developments relating to concepts and techniques of risk management, in both industry and academia (Merton 1995). These developments permit the quantification of various parameters for the measurement and control of risk. Many of these concepts were strongly influenced by developments in financial economics, particularly in the areas of portfolio theory and derivatives pricing. Since the absorption and implementation of these quantitative tools has been more rapid in the context of financial assets, the financial services industry—individual trading desks, financial firms, and regulators—have been quick to integrate these risk management techniques into their current practices. At the same time, these developments have spawned a rich academic and practitioner literature to clarify, fine-tune, and extend these ideas to a broad range of financial instruments, institutions, and markets. Indeed, this is a continuing process for a large number of professionals involved in the area of risk management on a day-to-day basis.

There is growing recognition that some of the risk management concepts can be applied to the operations of firms and agencies, both private and public, going beyond financial assets. However, the developments in this broad area have not kept pace with those in the financial markets. The purpose of this special issue is to focus attention on various aspects of risk management in operations. We carry seven papers in this issue that address various aspects of this general topic. A common theme amongst them is the link between operations and finance. The papers provide different conceptual and modeling frameworks for understanding and managing risk, which we hope will spur further interest in this broad area.

When we wrote the call for papers to this special issue, we stressed that a significant facet of process management, namely risk management, remains under-developed. We presumed that, to a large extent, this lacuna is due to a lack of connection between research in operations management and finance. While excellent tools for measuring and managing risk have been developed for *financial* assets for use by commercial and investment bankers, fund managers, and credit analysts, among others, these have not often been used in decisions regarding the deployment of *real* assets that are a crucial part of any business enterprise. Since all business processes carry with them some attendant risks that may affect the whole enterprise, risk management should become a part of the business process analysis tools, across the broad range of assets. We believe that the articles in this issue contribute toward bridging the gap between the worlds of finance and operations in many ways. They also describe some of the tools that can be used to measure and manage risk.

Miller and Park (2005) analyze the role of learning within the real options framework in their paper, "A Learning Real Options Framework for Process Design and Capacity Planning." The unique feature of their approach is that real option attributes are viewed from

a Bayesian perspective. They illustrate their approach using data from a firm in the aerospace maintenance, repair, and overhaul industry, combining two paradigms, namely, valuation and Bayesian analysis. The two are somewhat varied viewpoints, because the former uses market information, whereas the latter uses the industry specialist's vantage point. In fact, due to the very nature of intra-firm decisions, operations management decisions rely considerably on the insider's knowledge about process performance. Therefore, the combination of the two approaches provides a new look into the problem of applying the real options framework in operations.

In "Economic Evaluation of Scale Dependent Technology Investments," Lederer and Mehta (2005) study the effect of using a fixed discount rate to evaluate a project in which scale impacts the financial risk. They suggest that increased scale affects the financial risk of the project through the operating leverage of the investment and points to a limitation of the operations literature that generally holds the discount rate fixed, regardless of scale. Scale has been viewed to be an important dimension affecting risk in the finance literature. Indeed, the most commonly used asset-pricing model developed by Fama and French (1992) includes size as one of the factors that explains the cross-sectional variation in financial asset returns. Lederer and Mehta highlight the scope for investigating the relevance of size in the context of the valuation of real assets. These two papers highlight the nuances involved in using the real options framework in operations management.

Hendricks and Singhal (2005) show that the level of operational risk has an impact on the long-term stock price performance in their paper, "An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-run Stock Performance and Equity Risk of the Firm." The empirical evidence gathered by them indicates that firms do not quickly recover from the negative effects of disruptions. This paper is important in that it uses rigorous theoretical analysis as a foundation to analyze a large data set to test hypotheses about risk and its effect on supply chain performance, and consequently, the returns to investors.

Kleindorfer and Saad (2005) provide a conceptual framework for "Managing Disruption Risks in Supply Chains." This paper, along with that of Hendricks and Singhal, focuses on risks arising from disruptions to normal activities. This paper is concerned with risks, which may arise from natural disasters, strikes, economic disruptions, and acts of purposeful agents, including terrorists. The authors provide a conceptual framework that touches on all aspects of disruption risk management. They describe methods using which the effect of such disruptions can be understood and quantified. They also provide empirical results from a data set covering the period 1995–2000 on accidents in the U.S. Chemical Industry. Their results corroborate the relevance of three factors as independent drivers of the observed accidents and injury rates.

In recent years, catastrophic risks have gained greater attention both due to the widespread use of automated systems, as well as the perceived vulnerability of digital and global operations to random events. This concern has been accentuated by the preoccupation of regulators with the systemic consequences of the failure of an individual financial institution, in the context of increasingly inter-connected market architecture. Banks have already instituted systems that measure and report operational risk, based on the guidelines formulated by the *Bank for International Settlements*, Basle, and implemented by the central banks and other regulators in various countries, as summarized by Saunders and Allen (2002).

Sodhi (2005), in his article "Managing Demand Risk in Tactical Supply Chain. Planning for a Global Consumer Electronics Company," discusses managing demand risk in tactical supply chain planning for a global consumer electronics company. The methods proposed in the paper are meant to alleviate the risk due to the current deterministic replenishment and planning processes. He proposes the use of two risk measures, "demand-at-risk" and "inventory-at-risk," and two models that use Operations Research techniques to help manage these risks. It also discusses the modeling difficulties and the solution methodologies that are available to optimally solve such problems. The interesting aspect of this work is that it draws attention to the need for risk measures in mathematical modeling of operations, in a manner similar to those used for financial assets.

More generally, the previous three papers illustrate the potential for more theoretical and empirical research in measuring risk in operations. They also highlight the scope for quantifying risk measures that are operational in nature and that also serve as early warning signals for process problems. If these measures are to be taken seriously, it is essential that their impact on financial performance measures is clearly specified, either through a theoretical model or on the basis of empirical investigations linking process problems to their impact on financial measures. The real options framework often stops at measuring the value of an option, whereas the operational measures need to delve further into the impact on value due to process variations.

Gan, Sethi, and Yan (2005) study the effect of risk aversion on coordination in their paper on "Channel Coordination with a Risk-Neutral Supplier and a Downside-Risk-Averse Retailer." A unique aspect of their paper is the objective criterion they use: a down-

side risk measure, which is closely related to the concept of Value at Risk (VaR) that is widely used by financial institutions and regulators. VaR is a concept developed by financial professionals to capture the multivarious aspects of risk into a single metric for risk measurement and control. It essentially measures the maximum loss, at a given level of confidence, from holding a set of assets (usually financial), over a specified time horizon.

Since aversion to risk plays an important role in individual decision-making, more diversified or less risk-averse intermediaries can play an important role in achieving channel coordination. This paper adds to the growing literature in this area. The authors point out that risk mitigation has to be designed taking into account the preferences of the retailer, i.e., a risk-sharing contract in this context is one that offers the desired downside protection to the retailer and accomplishes channel coordination. More generally, frictionless financial markets mitigate the risk, to some extent, by allowing investors to construct individually optimal portfolios using a common price. However, not much research has been done on the impact of risk aversion on real operational decisions and whether and how financial markets can mitigate this risk.

In "A Portfolio Approach to Procurement Contracts", Martinez-de-Albeniz and Simchi-Levi (2005) construct a framework for modeling and studying supply contracts. The main contribution of this work is in the context of buyers using a portfolio of contracts to manage their business. The availability of different contracts, therefore, affects risk and return to the buyer. Further, the contracts can be constructed to provide a continuum of hedging possibilities. This work is similar to work on the role of introducing options to improve the completeness of financial markets, for example, by Ross (1976). In contrast to that work, the context of supply options has features that are unique to operations management, such as demand volatility and sensitivity to price, capacity limits, frictions due to operational reasons, and irreversibility of investment. There is scope for further work in this area, which incorporates these special features of operations, by using some of the recent developments in the context of financial markets. More generally, the two previous papers are in the area of valuation and analysis of decisions in incomplete markets with risk averse decision-makers, which is in itself an exciting and growing area of study.

These seven papers broadly illustrate the rich and rewarding scope for combining and modifying concepts from finance to model risk in operations. Apart from the insights provided by such work, it is also important to recognize that the need for such models can only increase with the increasing fragmentation and recombination of supply chains, increased emphasis on revenue management and its impact on the supply chain performance, and the creation of large data warehouses, to mention just three factors. The increasing fragmentation implies that the value of each component of the supply chain has to be determined more precisely and not left to chance. Further, it is important to understand whether and how market prices can be used to determine the value of nontraded components of supply chains. The growing importance of revenue management is due to the realization that market price and costs will have an impact on the supply operations; therefore, there is a need to use these prices in optimizing operational decisions. Moreover, instead of passively viewing demand risk as exogenous and even at times uncorrelated with financial market indices, it may be necessary to realize the dependencies explicitly in modeling revenues. Finally, large stores of data will allow the operations manager to research and construct useful theories about system performance that satisfy the market system's prices, as well as the preferences of the individual.

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