

Coordination of material supply chains under multidimensional stochastic risks

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ABSTRACT

This paper investigates optimal decision-making and coordination in a material supply chain under multidimensional stochastic risks, including uncertain demand, yield, and processing activities. By analyzing a system consisting of a manufacturer and a supplier, we derive the unique optimal purchasing and stocking decisions that maximize the expected profit of the integrated supply chain. A wholesale price contract is proposed to coordinate decentralized participants, incorporating risk allocation through a linear combination of production cost risk and sales profit risk. The key findings indicate that elevated risk dimensions lead to an increase in optimal order and inventory quantities. However, they also result in a reduction in system profit and a narrowing of the coordination price range. Numerical analyses demonstrate that, when faced with heightened multidimensional risks, enterprises should increase safety stocks and ordering levels to maintain supply stability. At the same time, supply chain members should negotiate wholesale prices within a more restricted interval to achieve effective coordination. Contract flexibility and risk sharing become more significant in maintaining efficiency under high-uncertainty conditions. Sensitivity analysis demonstrates the robustness of the proposed mechanism, emphasizing its flexibility in profit sharing under stochastic conditions. This study contributes to supply chain risk management by providing a generalized contract framework that aligns decentralized decisions with centralized optimization, thereby ensuring stability and efficiency in high-risk industrial environments.

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