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Supply chain network design under uncertainty with new insights from contracts

Key words: Supply chain network design, Contracts, Uncertainty, Conditional value at risk

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Introduction

- The classical problem of supply chain network design is reconsidered to emphasize the role of contracts in uncertain environments
- The supply chain addressed consists of four layers: suppliers, manufacturers, warehouses, and customers acting within a single period. The single owner of the manufacturing plants signs a contract with each of the suppliers to satisfy demand from downstream
- Available contracts consist of long-term and option contracts, and unmet demand is satisfied from the spot market
- In this supply chain, customer demand, supplier capacity, plants and warehouses, transportation costs, and spot prices are uncertain
- Two models are proposed here: a risk-neutral two-stage stochastic model and a risk-averse model that considers risk measures
- A solution strategy based on sample average approximation is proposed to handle large scale problems
- We show that long-term contracts alone have similar impacts to having no contracts, and that option contract alone gives inferior results to a combination of option and long-term contracts

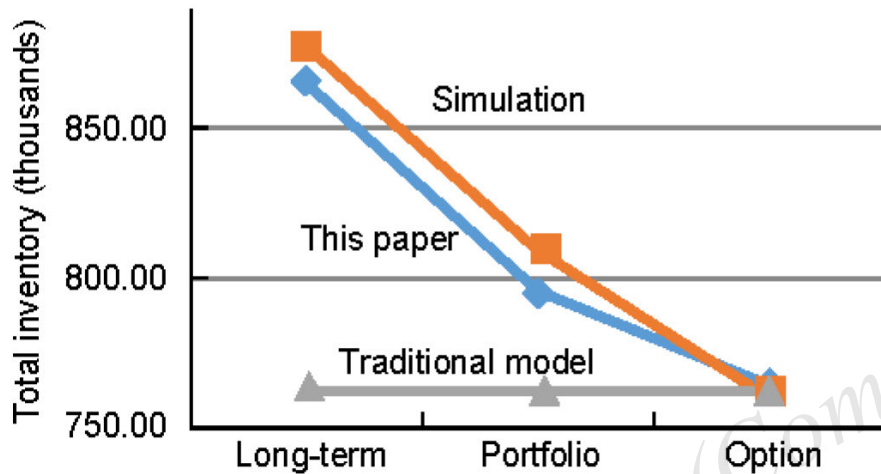
Motivation

- Although many papers in the field of supply chain network design have been published, no one has considered the impact of contracts on solutions obtained. This motivated us to consider the impact of different types of contracts on SCND costs and inventory levels under uncertain environments

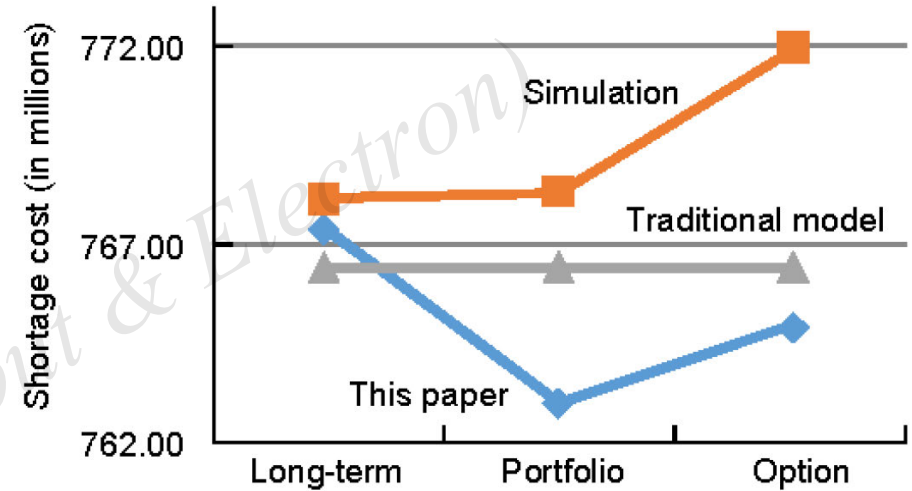
Modeling approach and solution method

- In this paper we considered two-stage stochastic programming as the modeling approach
- Also risk aversion was incorporated in the model by means of conditional value at risk as a popular measure of risk
- The solution procedure applied here is a variety of sample average approximation method to handle large scenario numbers

Test problem results



(a)



(b)

Results of traditional and this paper's models

(a) Total inventory; (b) Shortage cost

Conclusions

- For the first time, contracts considered as a part of SCND models and showed that they can have a great impact on the costs of SCND
- The model considers many realistic assumptions such as the uncertainty of parameters. Uncertain parameters considered include the demand of customers, capacity of suppliers, manufacturers and warehouses, and transportation and spot purchasing prices
- The modeling approach applied is two-stage stochastic pricing with recourse, and we have used sample average approximation to solve the model. In addition, we have developed this risk-neutral model to consider risk, with CVaR as an important risk measure. Studies of SCND considering risk measures are still rare
- To show the effectiveness of the stochastic models we compared them with their deterministic models
- It was shown that the cost of SCND is lower, on average, with stochastic solutions, the quality of solutions is higher in the stochastic model, and they show a much smaller gap to the true solution
- Finally, we analyzed the impact of incorporating contracts in the SCND model, and showed that if we do not consider contracts, especially the option contract, unrealistic costs appear in the SCND process which may mislead us to degraded solutions
- The most important result here is that portfolio solutions, which consider all types of contracts, have the best performance from all cost aspects, followed by designs with option contracts. Also, considering only long-term contracts gives results similar to those of traditional models, which consider no types of contracts