Optimal Mechanisms to Match Supply and Demand in Contemporary Supply Chains

Reporting

Project Information

OPTCHAIN

Grant agreement ID: 268455

Status
Closed project

Start date
8 February 2012

End date
7 February 2016

Funded under
FP7-PEOPLE

Overall budget
€ 100 000

EU contribution
€ 100 000

Coordinated by
MIDDLE EAST TECHNICAL UNIVERSITY
Turkey

Final Report Summary - OPTCHAIN (Optimal Mechanisms to Match Supply and Demand in Contemporary Supply Chains)

Emerging production and information technologies have increased competition and consumer expectations, this leads to ever-shrinking product lifecycles, volatile and unpredictable markets. In addition, natural disasters, accidents, supply disruptions increased the risk in today's global and long supply chains. Keeping costs down and customers satisfied in a global marketplace requires companies to proactively manage supply and demand using state of art techniques, technologies and practices. This project describes a research program for building novel optimization models and efficient solution mechanisms that enable contemporary supply chains to optimally match demand and supply through demand management and sourcing decisions.

Demand selection allows the firm to decide whether it should pursue highly profitable, yet risky, orders

over less profitable, but possibly more stable orders. Selecting the set of demands that best utilize the resource is referred to as stochastic knapsack problems. The resource may correspond to a machine, vehicle, manufacturing facility, or production line with limited capacity. The fellow has developed effective algorithmic approaches for a class of stochastic knapsack problems that maximizes expected profit allocating items with random sizes to a knapsack. This class of problems has numerous applications in the allocation of resource capacity to items seeking to utilize this capacity. On the other hand, maximum expected profit objective is only meaningful when the resource allocation decision is executed repetitively and the decision maker is risk neutral. If the risk is not considered, the solution may lead to high expected profit in the long run with the possibility of disruptive losses in the short run. In order to incorporate risk in this problem, the fellow Conditional Value-at-Risk (CVaR) objective as a risk measure. She described an efficient and high-performing heuristic method based on the optimality conditions. For the general case, linear optimization models are formulated using a scenario-based approach. An extensive numerical study evaluated the efficiency and quality of the proposed solution methods, identified optimal selection strategies and examined the sensitivity of the solution output to varying levels of risk and penalty cost.

In addition to flexibility on the demand side, the fellow has focused on supplier related decisions as a mechanism for matching supply with demand. She has explored the challenges associated with having multiple global suppliers introducing sourcing risks which may result in an inability to meet demand on time. She also incorporated both fixed ordering costs and capacity limits into the newsvendor problem with multiple unreliable and non-identical suppliers. She developed an exact algorithm to solve the problem optimally and a heuristic algorithm to solve the problem efficiently. Through structural properties of the optimal solution and a numerical study, she provided useful managerial implications regarding optimal sourcing strategies in complex supply chains.

The researcher later examined optimal procurement strategies of firms where supplies can be purchased via traditional (forward) contracts, option contracts or spot markets. To reflect the supply side risks in contemporary supply chains, primary suppliers are subject to supply uncertainties (disruptions and/or random yields). Such models can be used to quantify the benefits that can be achieved by utilization of spot markets, and option contracts in hedging risks of supply shortages and demand volatility. For the special case of normally distributed random variables, optimality properties were developed. A broad numerical study examines the sensitivity of procurement strategies to key problem parameters such as, risk attitude, demand and spot price volatilities, correlation between demand and spot prices and terms of option contracts.

The traditional newsvendor model objective is based on risk neutrality maximizing expected long term returns. When supply risks are present and customer demand is volatile, considering risk aversion in procurement selection models makes sense as maximizing expected profit would result several consecutive large losses which could be devastating for a firm. She contributed to the state of knowledge by presenting various optimization models for the optimal selection of supply portfolio under a variety of risk measures and concluded that CVaR provides promising results. Scenario-based procurement models are developed, such models can be used to model range of real-life situations involving multiple demand/supply uncertainties. The numerical study showed that, proposed solution methodology can be solved efficiently, and provide reliable outputs, thus solution methods can safely be adopted by practitioners with various risk attitudes. Furthermore, she offered valuable insights to managers guiding them in their portfolio selection decisions through analytical results and a broad numerical study.

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The fellow has also worked on novel optimization models and solution techniques that can help businesses to achieve the maximum performance from a given production system by simultaneously selecting customer demands, procurement quantity, spot market purchase and option contract usage. Such models provided substantial value through its ability to determine the optimal fit between demand levels and supply capacities and to quantify the benefits of an integrated view.

With the support of the Marie Curie IRG grant, Dr. Merzifonluoglu has developed a research program for building novel optimization models and efficient solution mechanisms that enable contemporary supply chains to optimally match demand and supply. The resulting modeling, analysis, and algorithmic development have also contributed advances in applied optimization theory and large-scale problem solving.

The outcomes of the project are insightful for managers when taking significant tactical and strategic decisions such as market and supply portfolio selection. This will help companies to strengthen their

competitive standing in the global marketplace. Furthermore, with better supply and demand match in supply chains; uncertainties, product prices, lead times and supply shortages will decrease, and companies will be able to serve with higher service levels. Therefore, not only companies will enjoy higher profit margins but also customers will receive improved service.

During this project, the fellow has supervised one MS student and several undergraduate students. She has taught several courses at the undergraduate level and the graduate level. She has published journal articles based on the outcome of this research project. She has been granted the habilitation /aggregation by the interuniversity council of Turkish Higher Education system. She has also completed her application package to receive her tenure at the host. More information about the researcher and the project can be reached at the following address: https://blog.metu.edu.tr/myasemin/optchain-project.

Last update: 14 July 2016
Record number: 186939