Mapping or Mitigation? The Value of Discovering Upstream Dependencies in Resilient Sourcing

Problem description

Companies often improve supply chain resilience by qualifying backup suppliers, reserving additional capacity, or holding safety stock. However, these investments may provide limited protection when suppliers share hidden upstream dependencies. For example, two seemingly independent suppliers may rely on the same production facility, raw material source, or logistics hub. A disruption at that shared source could affect both simultaneously.

Most companies know their direct suppliers but have limited visibility of upstream dependencies. Obtaining this information requires time and resources. Firms therefore face an important decision: should they invest directly in mitigating supply disruptions, or first investigate upstream dependencies to identify where those investments would be most effective?

The value of mapping is not straightforward. Investigating one supplier may provide little useful information, while investigating several suppliers together may reveal shared dependencies and change the preferred mitigation strategy. Moreover, the value of mapping depends on what is already known about the supply network.

This thesis will investigate:

- Under which conditions does discovering upstream dependencies reduce the cost of ensuring supply continuity?
- When do investigations complement one another, making their combined value greater than the value of individual investigations?
- How can firms jointly select supplier investigations and subsequent mitigation investments under a limited budget?

The research will develop a robust optimization framework that considers information acquisition and resilience investments under uncertain supply disruptions, without requiring known disruption probabilities. The methodology will be evaluated through analytical examples and computational experiments within the ReSolVe research project at ORβIT Lab.

Thesis assignment

The student will review the literature on multi-tier supply chain resilience, information acquisition, and robust optimization. The research will begin with small analytical examples to examine when mapping is valuable and how investigations interact.

The student will then develop an optimization model in which a firm first selects suppliers to investigate and subsequently chooses which backup suppliers to qualify based on the information obtained. Importantly, investment decisions can depend only on what the investigations reveal: possible upstream network structures that produce identical observations must lead to the same investment decisions. The selected strategy must maintain a specified level of supply continuity under the considered disruptions.

The assignment will consist of:

- A literature review on resilient sourcing, upstream dependencies, and optimization with information acquisition.
- Analytical investigation of small supply networks to identify conditions under which mapping is valuable and investigations complement one another.
- Formulation and implementation of an optimization model for selecting investigations and subsequent mitigation investments.
- Computational experiments comparing selective mapping with no mapping, full mapping, and simple investigation strategies.
- Sensitivity analysis of mapping costs, prior network knowledge, shared dependencies, disruption severity, and mitigation budgets.

The initial model will consider small networks, perfect investigations, supplier qualification as the main mitigation decision, and disruptions affecting at most one upstream source. Repeated investigation rounds, regulatory uncertainty, and probabilistic disruption forecasting are outside the initial scope.

The research will use synthetic supply networks and will not depend on access to industrial data. An illustrative industrial application may be considered if suitable data become available.

Student background

The project suits a student interested in operations research, mathematical optimization, and supply chain resilience. A solid background in mixed-integer programming and experience with Python are expected. Familiarity with robust optimization or network modeling is an advantage. The research team will support the student in learning the required methods.

Chair Dr. Yousef Maknoon

Supervisors To be confirmed

Research setting ReSolVe Project, ORβIT Lab, TU Delft

Start date February 2027 or by agreement

Duration MSc thesis period, to be agreed

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