Designing a Supply Chain Resilient to Major Disruptions and Supply/Demand Interruptions

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GLOBAL SUPPLY CHAIN VULNERABILITIES

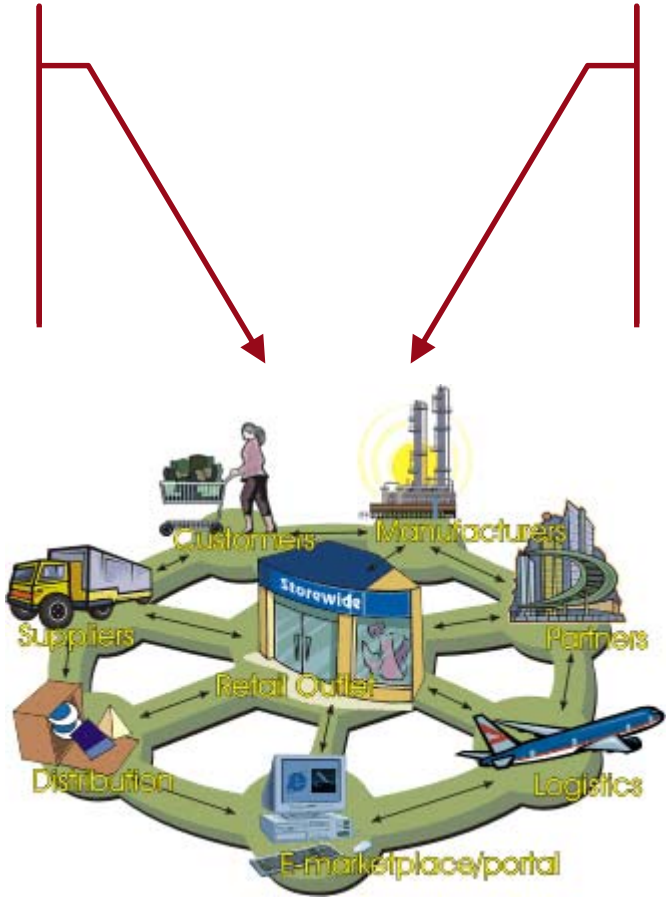
Global supply chains are vulnerable to two types of risks.

Operational risks
(Tang 2006; Esmaeilikia et al 2014)

inherent interruptions, e.g. Uncertainties of supply and/or demand

↑ Probability of occurrence

↓ Degree of impact



Disruption risks
(Tang 2006; Esmaeilikia et al 2014)

Major natural and man-made disasters

↓ Probability of occurrence

↑ Degree of impact

GLOBAL SUPPLY CHAIN VULNERABILITIES

These risks call for different types of risk management responses.

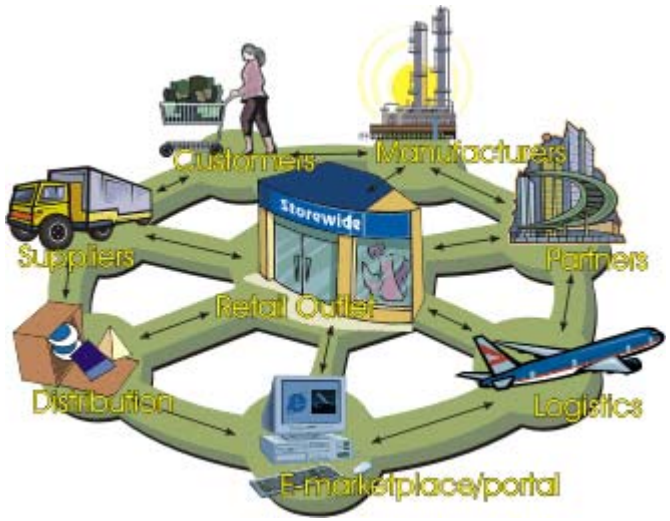
Operational risks
(Tang 2006; Esmaeilikia et al 2014)

↑ Probability of occurrence

↓ Degree of impact

Risk management response:
(Daskin et al 2002)

Fewer number of large facilities in the network



Disruption risks
(Tang 2006; Esmaeilikia et al 2014)

↓ Probability of occurrence

↑ Degree of impact

Risk management response:
(Snyder et al 2006)

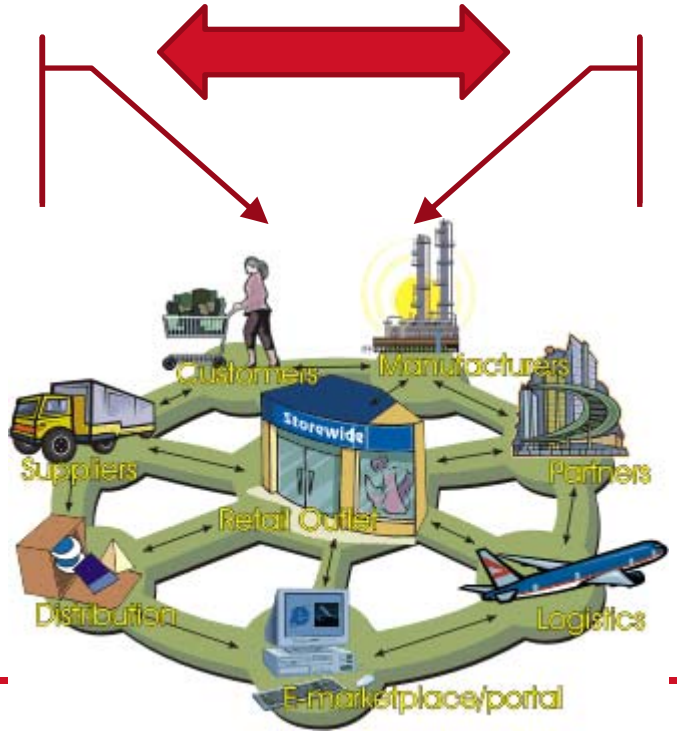
Larger number of small facilities in the network

GLOBAL SUPPLY CHAIN VULNERABILITIES

However, there are factors that introduce significant complexities to supply chain risk analysis and risk management.

- Interaction
- Budget
- Decision-maker's risk attitude
- Type of network

Operational risks
(Tang 2006; Esmaeilikia et al 2014)



Disruption risks
(Tang 2006; Esmaeilikia et al 2014)

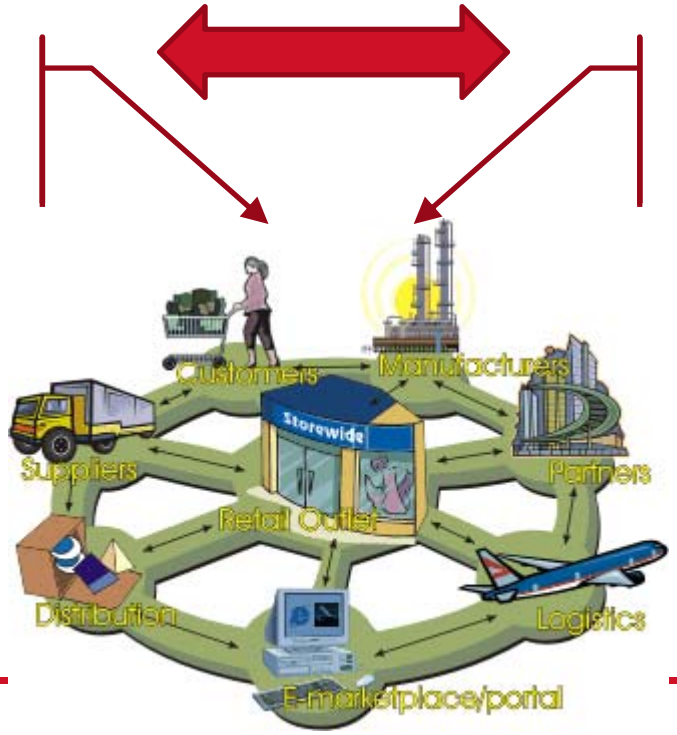
GLOBAL SUPPLY CHAIN VULNERABILITIES

This study proposes a **hybrid robust optimization model** for the design of a supply chain that is resilient to both types of risks.

Optimization Objectives

1. Minimize total cost
2. Maximizing resiliency

Operational risks
(Tang 2006; Esmaeilikia et al 2014)



Disruption risks
(Tang 2006; Esmaeilikia et al 2014)

MODEL DEVELOPMENT

- We first designed a **stochastic supply chain (SC) network design model**
- A disruption can cause either a complete facility shutdown or a reduced supply capacity
- A facility can be either partially or fully hardened requiring additional capital investments
- The probability and amount of disruption in one facility is expressed as a function of hardening degree in that facility.
- A hardened facility is more reliable and more resilient to major disruptions.
- In the presence of certain budgetary constraints, the proposed model aims to determine
  - the number of facilities to open
  - the location of facilities
  - the allocation of facilities to customers
  - the required fortification degree of each facility
  - the quantity of products shipped between reliable and unreliable facilities when a disruption occurs.
- to include robustness measures in the stochastic model to address uncertainties in demand, supply capacity and probability of disruption occurrence ➔ a **robust-stochastic optimization model**.

SUMMARY OF FINDINGS

- Data sets from Daskin (1995), three networks including a 21-node network, 32-node network and 49-node network.
- Numerical results show that:
  - supply chain resiliency can be enhanced to a large extent by only slight changes in SC configuration and insignificant increase in supply chain costs
  - different facility hardening strategies can be utilized to effectively address demand fluctuations
  - initial capital investment plays a key role in developing a resilient SC, but excessive budget injections do not necessarily result in reduced total costs in the long-term.

FUTURE RESEARCH

- The interdependency between supply chain disruptions/interruptions in different facilities and their impacts on supply chain decisions.
- Analysis of disruption/interruption impacts on SC responsiveness and agility elements such as service time and delivery lead-time (which are the critical performance metrics in fast-paced business environments).