AN APPROACH FOR MODELING SUPPLIER RESILIENCE

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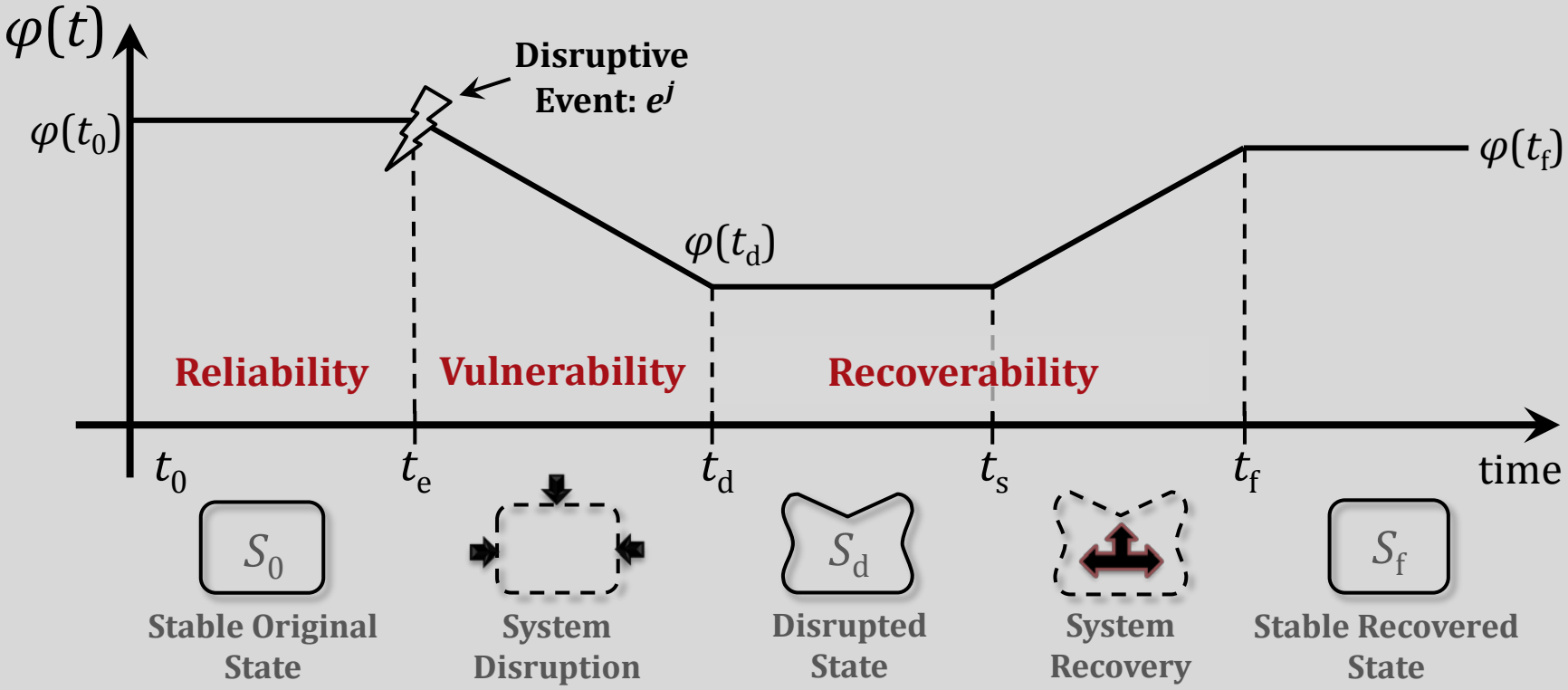
THE BASIC IDEA

- We want a means to **evaluate and select suppliers** based on **typical criteria**…
  - e.g., quality, delivery, performance history, and price
- …as well as introducing **resilience-based criteria**
  - e.g., ability to withstand disruptions, ability to recover timely from a disruption

THE BASIC IDEA

- We describe **resilience** with



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  - The views expressed here do not necessarily reflect the official policies of the Naval Postgraduate School

- Two journal articles in progress
  - Nowicki, D., I. Hernandez, J.E. Ramirez-Marquez, W. Randall, B. Sauser, and C. Kochan. Supply Chain Resilience Metrics with Economic Considerations.
  - Hosseini, S., K. Barker and J.E. Ramirez-Marquez. Availability-Driven Approach for Resilient Supplier Selection.

Supplier selection criteria

TOPSIS

Illustrative example

Concluding remarks

SUPPLIER SELECTION

- Raw materials and component parts can amount to **70% of the cost** of a finished product [Stueland 2004]
- As such, it's important to **select suppliers** effectively
  - Particularly selecting **resilient suppliers** in light of (seemingly routine) disruptions

SUPPLIER SELECTION CRITERIA

- Dickson [1966] introduced 23 supplier selection criteria still found in literature today
  - e.g., quality, delivery, performance history, price
- Recently, Hosseini and Barker [2016] introduced a few resilience-based selection supplier criteria
  - e.g., absorptive, adaptive, and restorative capacities

SUPPLIER SELECTION CRITERIA

- In this example, we consider **four criteria** in the comparison of **backup suppliers**
  - Availability (or the improvement in availability achieved by a backup supplier)
  - Recovery time (or how quickly a backup supplier can become engaged to provide component parts)
  - Quality
  - Delivery rate

AVAILABILITY CRITERION

- The calculation of availability is done with a variation on the Multi-Echelon Technique for Recoverable Item Control (METRIC) [Sherbrooke 2004, Nowicki et al. 2012]

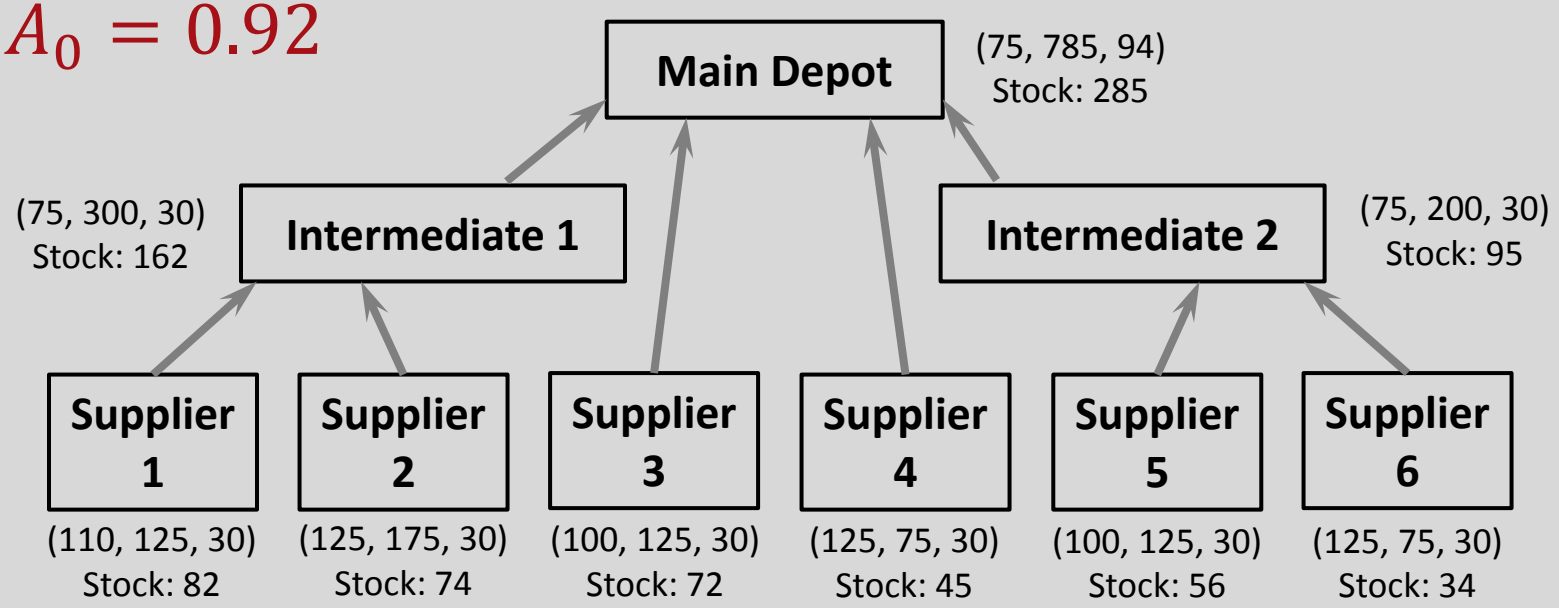
- The idea with METRIC is to find a **mix of suppliers** to achieve a desired **availability** of the end system

$$\text{Availability} = \frac{\text{uptime}}{\text{uptime} + \text{downtime}} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

AVAILABILITY CRITERION

- For a set of supplier cost, **reliability**, and **maintainability** characteristics, end item availability can be calculated

$A_0 = 0.92$

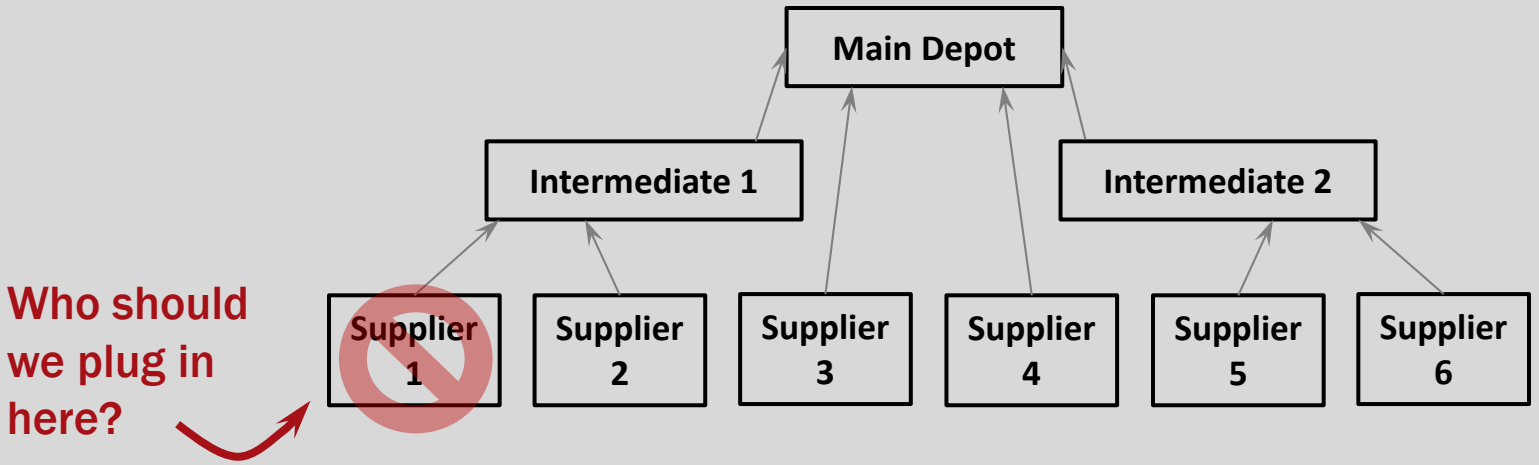


AVAILABILITY CRITERION

- When **demand exceeds inventory** on-hand at the supplier level, back orders occur
- Availability is calculated as the proportion of orders when demand can be met with the supplier mix
  - That is, a perfectly "**available**" final product ($A_0 = 1$) has no back orders
- An "optimal" supplier mix according to availability is found using the METRIC algorithm by Nowicki et al. [2012]

AVAILABILITY CRITERION

- We're interested in finding a **backup supplier** that helps us withstand a supplier disruption
  - Or a supplier that **minimizes** a dip in availability



OTHER CRITERIA

- Recovery time
  - Amount of time taken to engage an alternative supplier to improve availability
  - When combined with “improvement in availability,” provides a measure of resilience
- Quality
  - Ability of a supplier to meet specifications
- Delivery rate
  - Percentage of successful delivery schedules met

Supplier selection criteria

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MULTI-CRITERIA DECISION ANALYSIS

- We have **multiple criteria**
- And we can **weight** each of those criteria according to their importance in supplier selection

- So we need a **multi-criteria decision analysis** technique to rank suppliers

MULTI-CRITERIA DECISION ANALYSIS

- We choose a technique called **TOPSIS**
  - Technique for Order Preferences by Similarity to an Ideal Solution
  - Common in supplier selection problems
- Based on the idea of a **compromise solution**
  - Closeness to the best solution, distance from the worst solution

MULTI-CRITERIA DECISION ANALYSIS

- What we do with TOPSIS: compare several **alternatives** across **multiple weighted criteria**

Availability, recovery time, quality, delivery rate

Backup suppliers	Criterion 1	Criterion 2	⋯	Criterion C
Alternative 1	x_{11}	x_{12}	⋯	x_{1C}
Alternative 2	x_{21}	x_{22}	⋯	x_{2C}
⋮	⋮	⋮	⋱	⋮
Alternative B	x_{B1}	x_{B2}	⋯	x_{BC}
Weights	w_1	w_2	⋯	w_C

Weights determined by decision maker

Supplier selection criteria

TOPSIS

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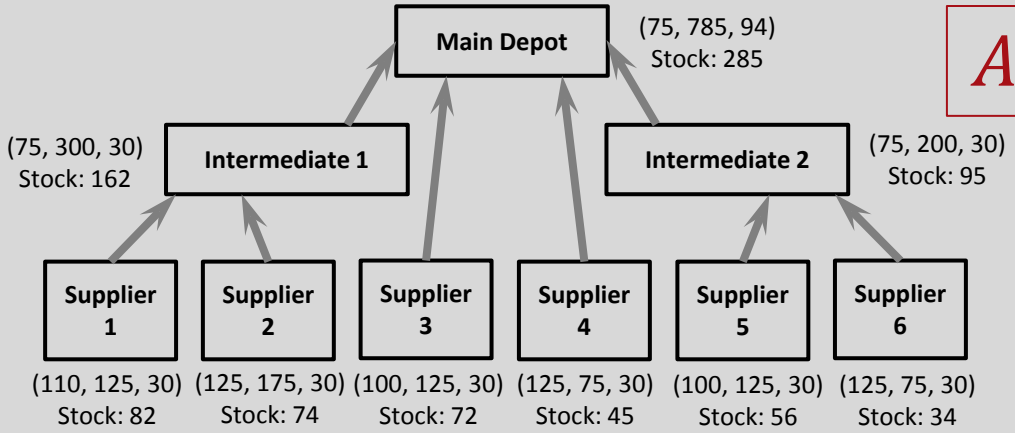
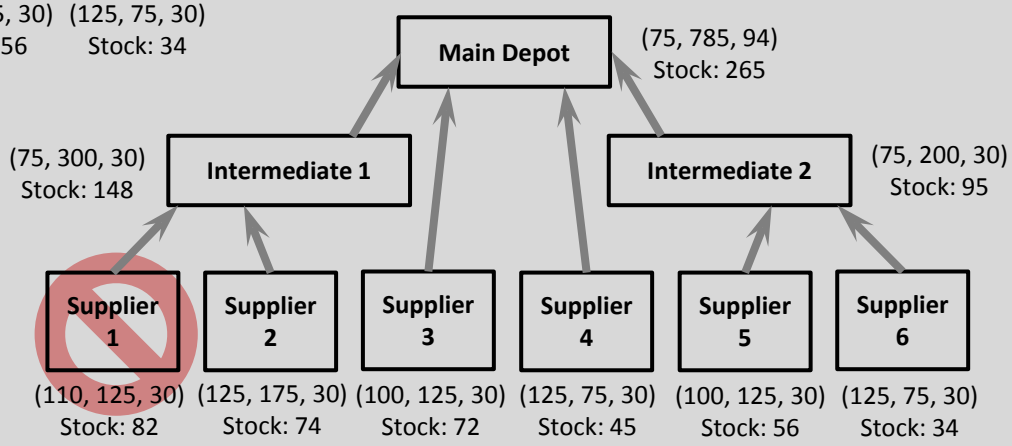
ILLUSTRATIVE EXAMPLE

- We consider a three-echelon supply chain, and assume that **supplier 1 is disrupted**



$A_0 = 0.92$

$A_0 = 0.80$



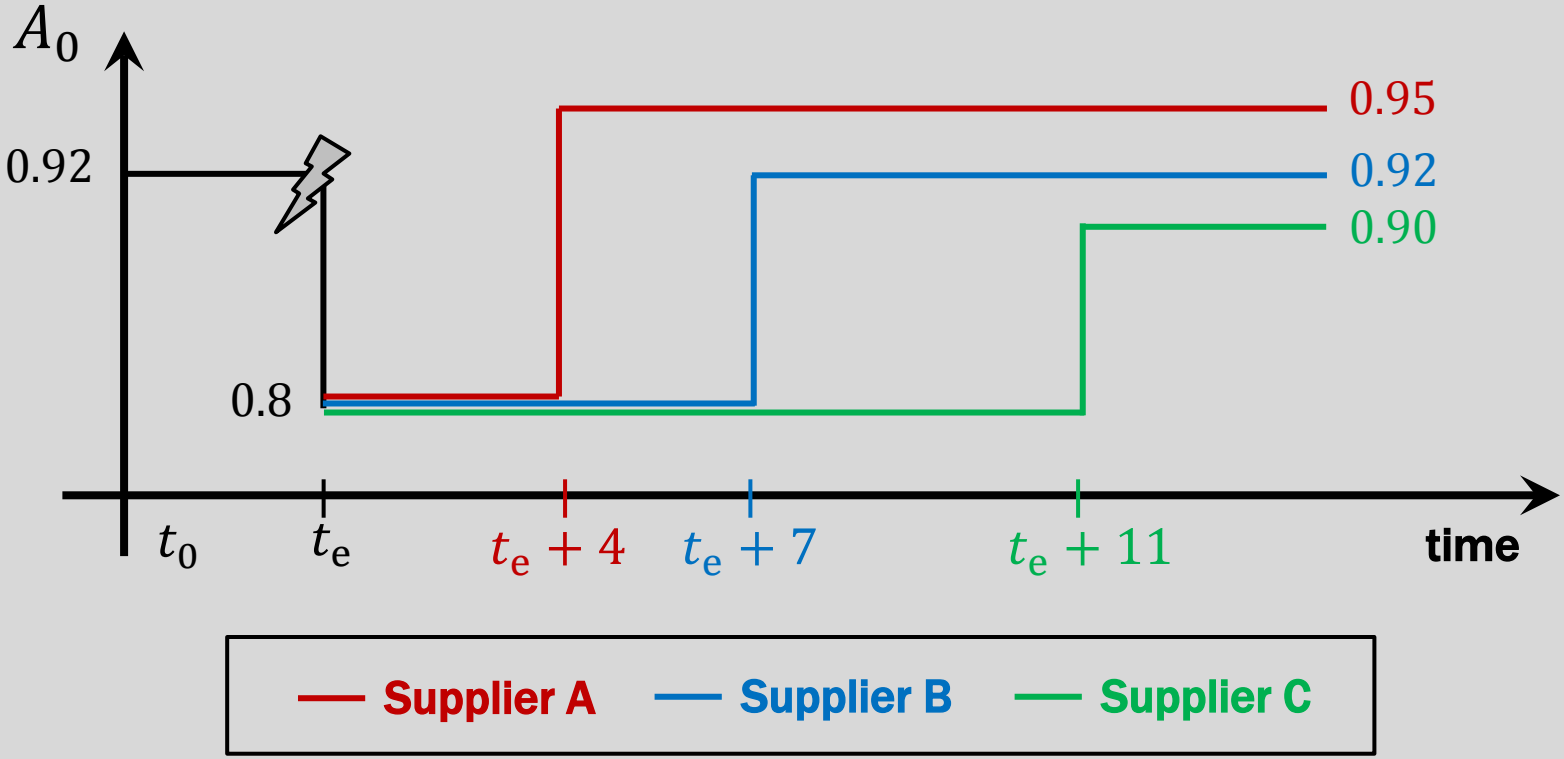
ILLUSTRATIVE EXAMPLE

- Assume that we have **three backup suppliers** (A,B,C) available to replace suppler 1

	Availability improvement	Recovery time	Quality	Delivery rate
Supplier A	0.15	4	0.97	0.82
Supplier B	0.12	7	0.83	0.98
Supplier C	0.1	11	0.89	0.91

ILLUSTRATIVE EXAMPLE

- Comparing the three backup suppliers with respect to **resilience**



ILLUSTRATIVE EXAMPLE

- Accounting for all **four criteria**, the rank of suppliers is as follows

Alternative supplier	RC_i	Rank
Supplier A	0.8934	1
Supplier B	0.5693	2
Supplier C	0.1074	3

Supplier selection criteria

TOPSIS

Illustrative example

Concluding remarks

CONCLUDING REMARKS

- This work addresses an important consideration in **supplier evaluation** and **selection**
- How can we integrate **resilience** into the supplier selection process for a backup supplier?
  - Ability to **withstand a disruption** of system availability
  - Ability to **engage timely** to provide component parts
  - As well as quality and response rate considerations

CONCLUDING REMARKS

- Rather than producing a lone resilience metric, we integrate the two resilience criteria (with the other two criteria) into **TOPSIS**
  - Criteria can be **weighted** according to importance

END OF PRESENTATION

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