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Modeling Disruption in a Fresh Produce Supply Chain

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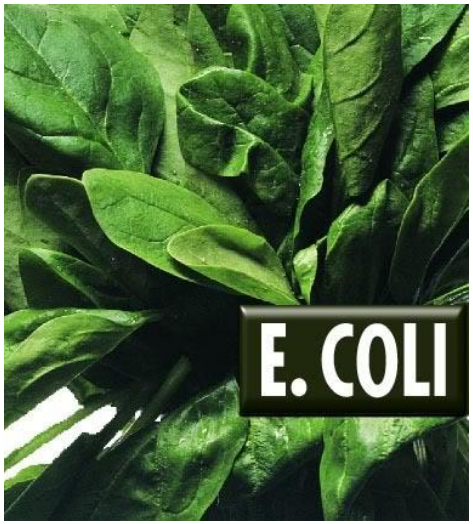
Fresh produce contamination



Previous research

- Uniqueness of fresh produce supply chains
- Factors that influence fresh produce supply chain disruptions
  - Traceability, transparency, testability, time, trust, and training (Roth et al., 2008)
  - Traceability, product type, communication, topological structure, exposure to contamination (Apte, 2010)
- Disruption management mathematical models

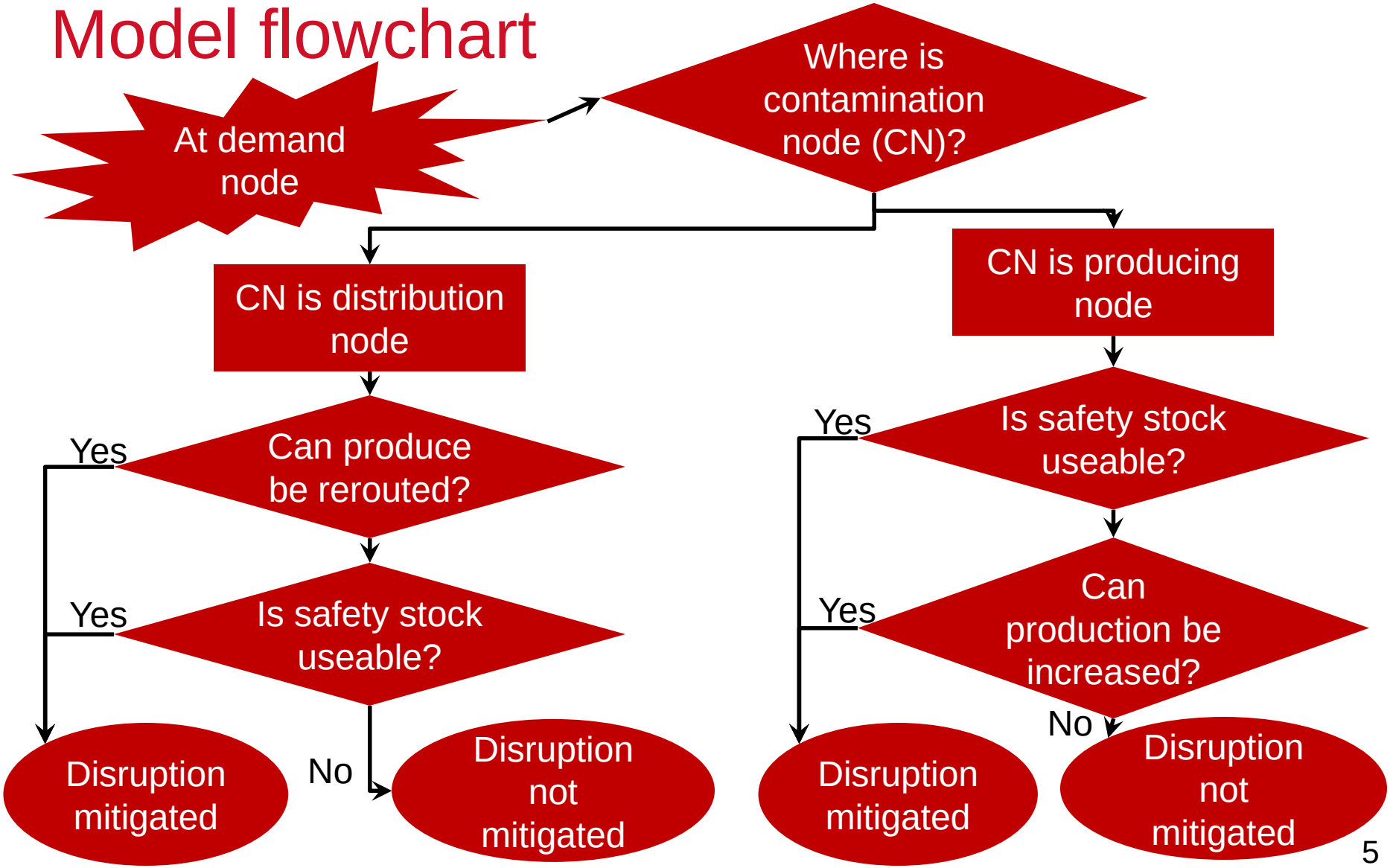
Roth, A. V., Tsay, A. A., Pullman, M. E., and Gray, J. V. (2008). Unraveling the food supply chain: Strategic insights from China and the 2007 recalls. *Journal of Supply Chain Management, 44*(1), 22-39.

Apte, A. (2010). Supply chain networks for perishable and essential commodities: Design and vulnerabilities. *Journal of Operations and Supply Chain Management, 3*(2), 26-43.

What's new with this research?

- Build a model that quantifies the effects of a contamination in fresh produce supply chain
- Translate qualitative factors that influence vulnerability into a mathematical model
- Quantify benefits of disruption management strategies for contamination of fresh produce
- Apply model to Dole's supply chain during 2006 *E. coli* contamination

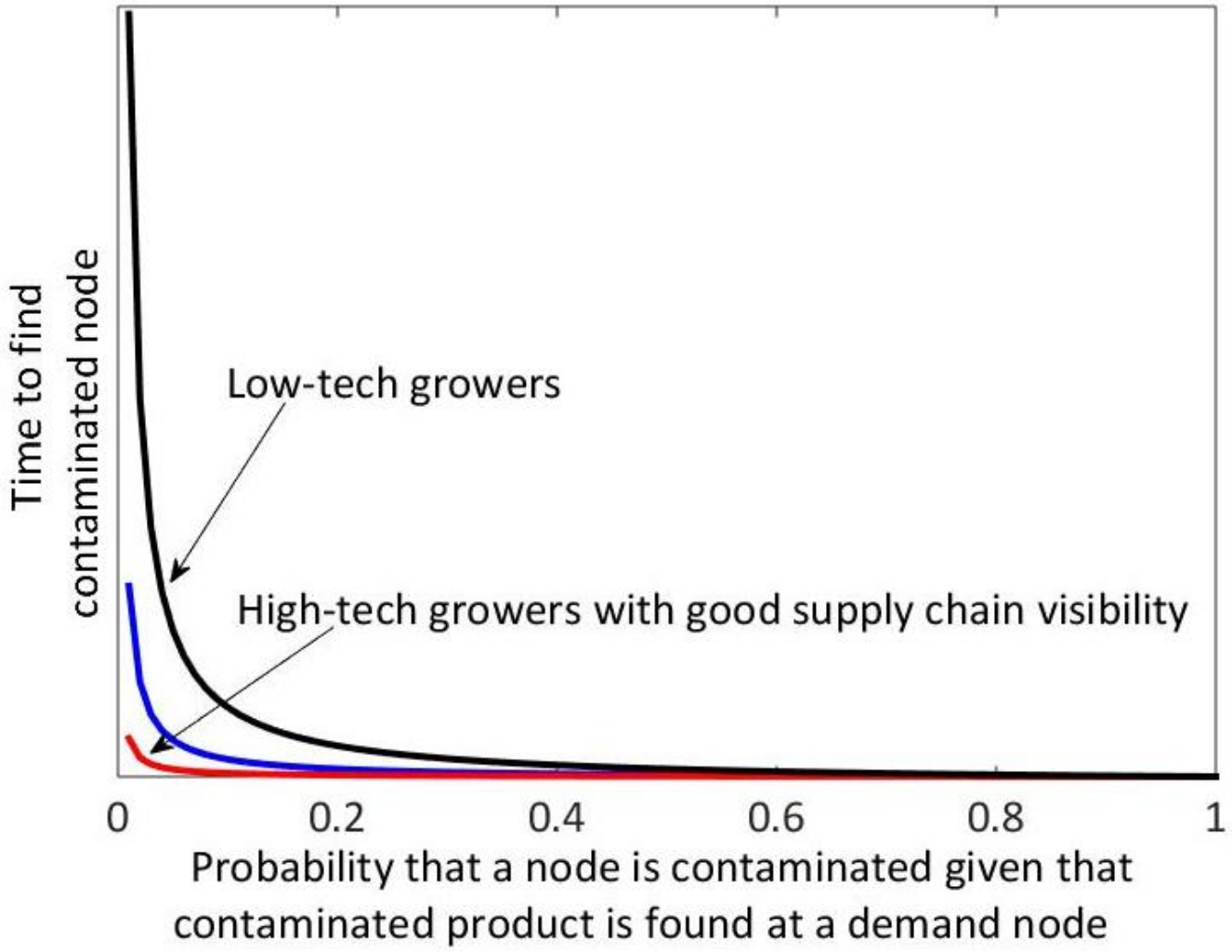
Model flowchart



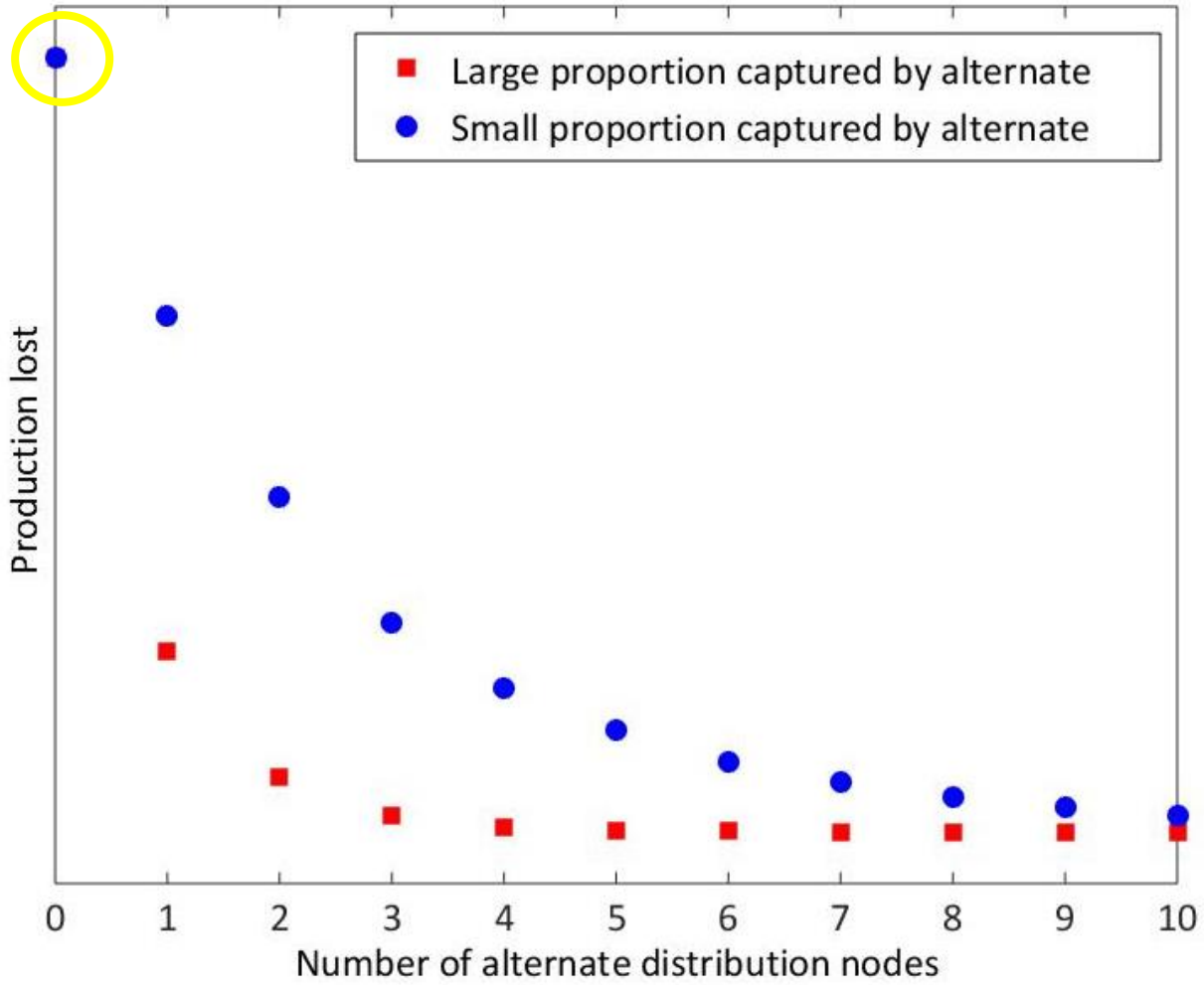
Measure of impact

- Lost sales compared to sales without contamination
- Sum of three components
  1. Supply chain closed which searching for source of contamination (traceability)
  2. While relying on safety stock (perishability of safety stock, rerouting production, customer demand)
  3. After safety stock depleted (rerouting production, increase production, customer demand)

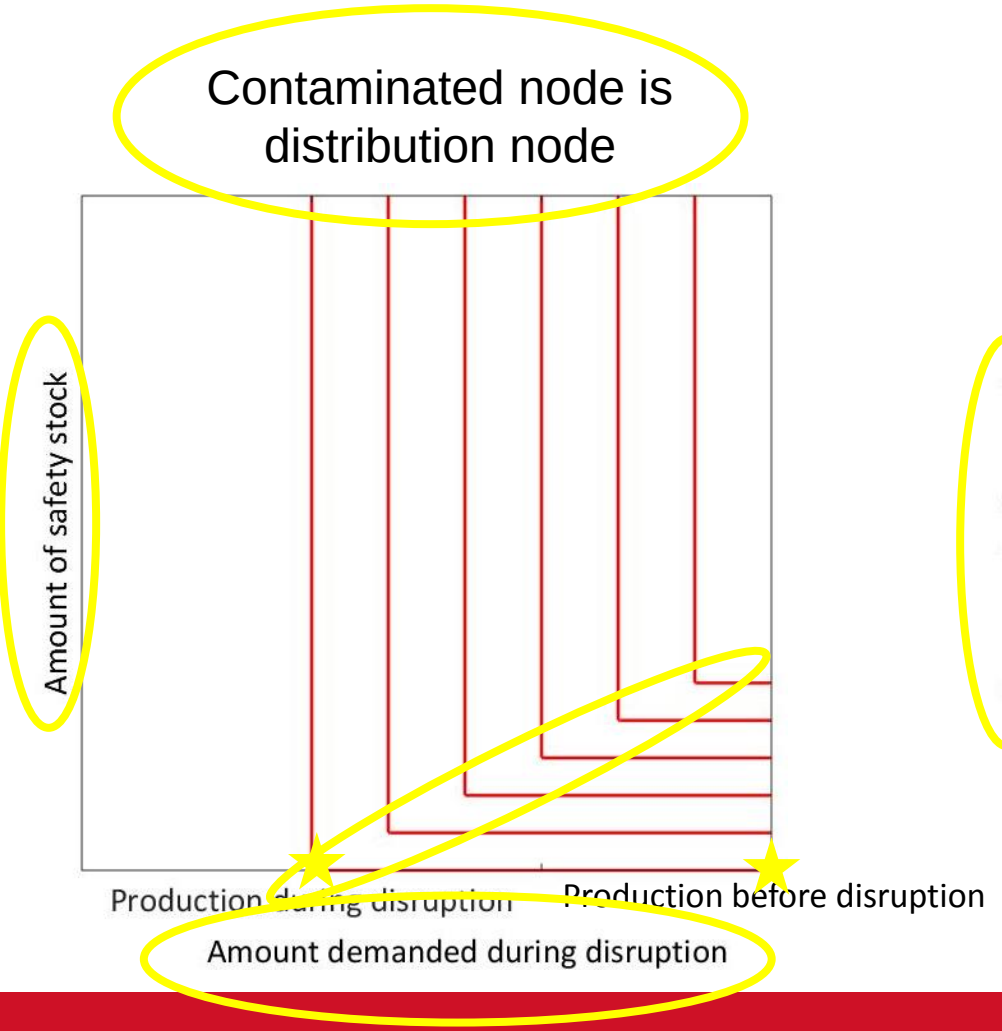
Traceability and prior probability

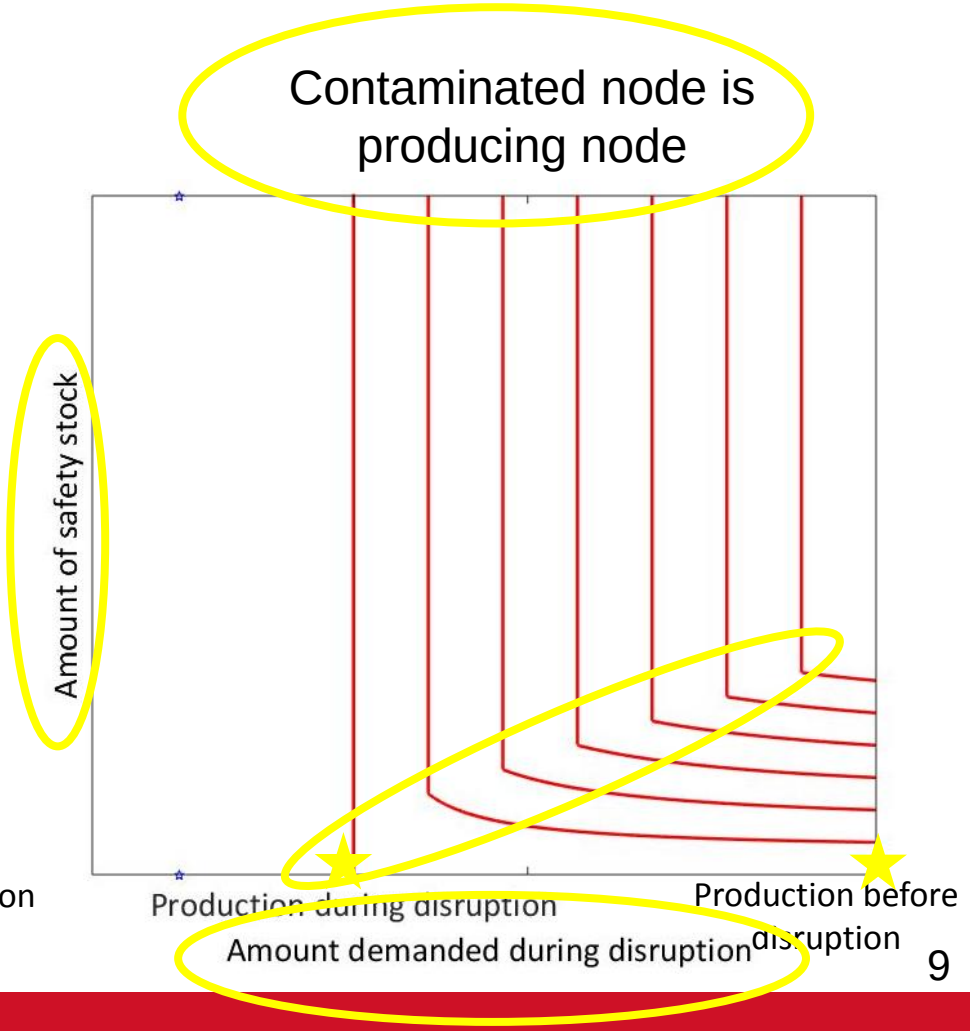


Topology of supply chain



Safety stock and demand

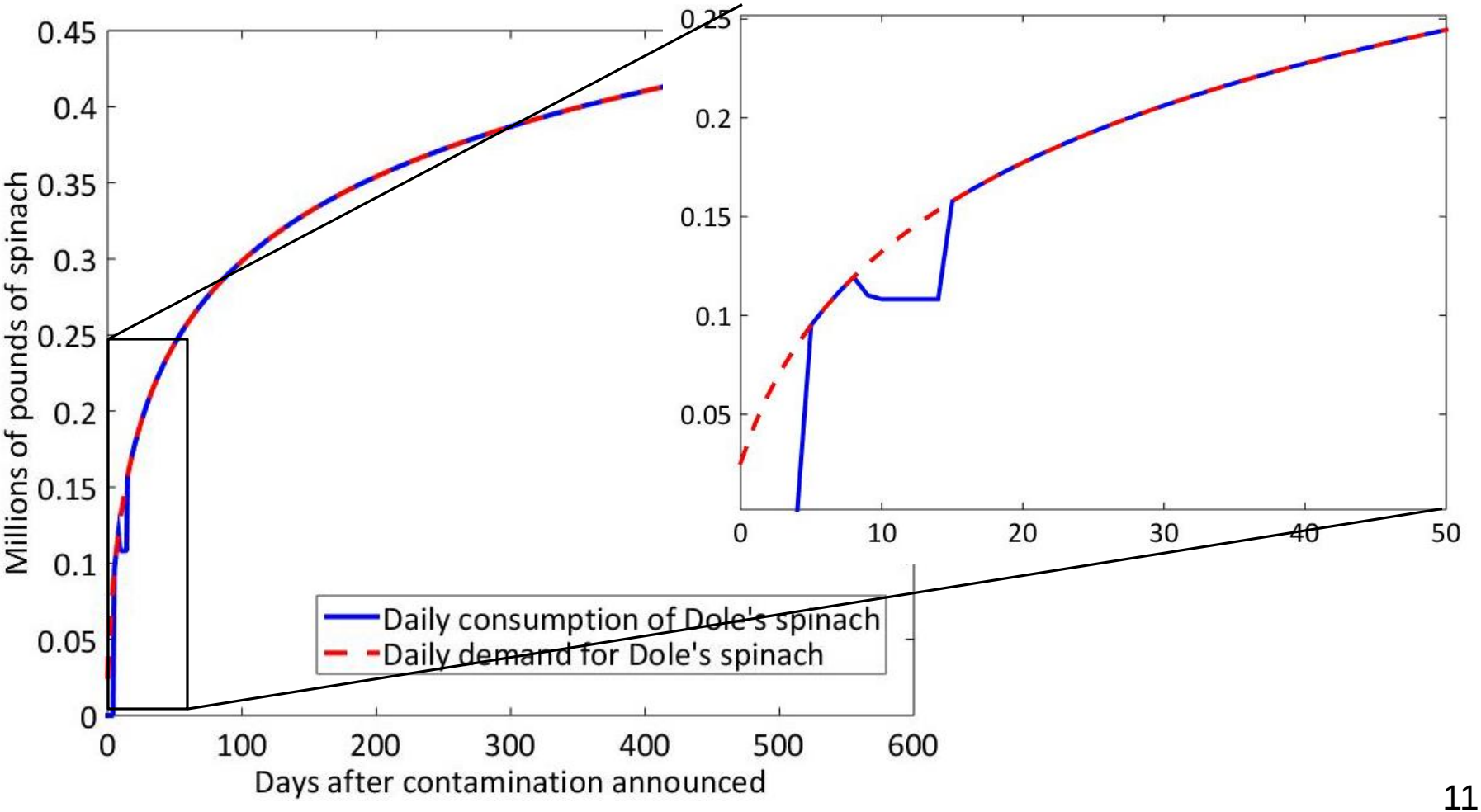




E. coli in bagged spinach

- *E. coli* discovered in bagged spinach in September 2006
- Source of contamination traced back to Natural Selection Foods, a supplier to Dole
- Fresh and bagged spinach was pulled from shelves for 5 days
- Spinach from California unavailable for an additional 10 days

Dole's production of spinach



Conclusions

- Model different elements in a supply chain that affect vulnerability
  - Traceability: length of time supply chain is closed
  - Communication and essentialness of product: demand during disruption
  - Topology: ability of supply chain to reroute production
- Can help supply chain managers quantify benefits of different disruption management strategies
  - Optimal value of safety stock
  - Communication to keep demand high
  - Useful for risk management: cost and uncertainty

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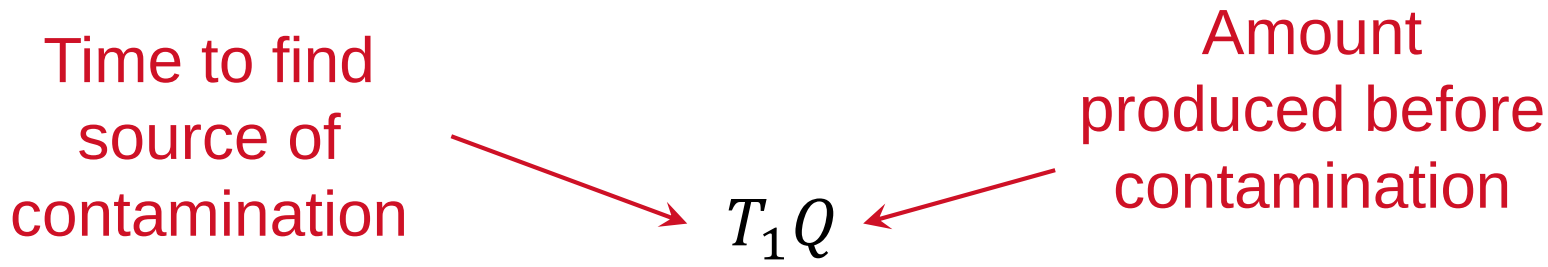
Backup

Traceability of contamination

- Assume entire supply chain is closed while finding source of contamination



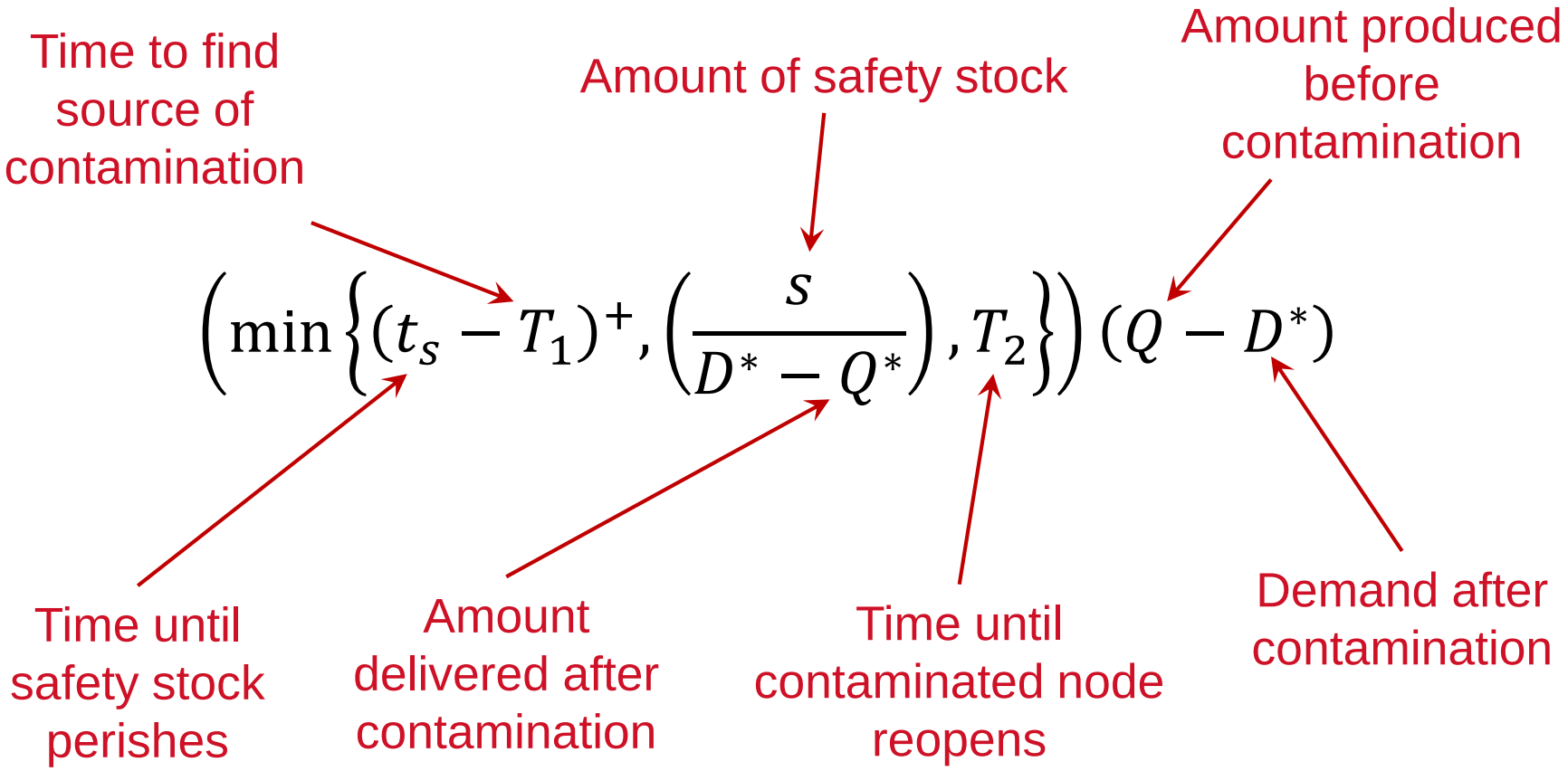
- Traceability may depend on
  - High-tech growers
  - Supply chain visibility
  - Prior probability of node being contaminated

Demand after contamination

- Demand for product may drop because of contamination
- New demand after contamination D^*
- Depends on
  - Essentialness of product
  - Communication to consumers
  - Trust level

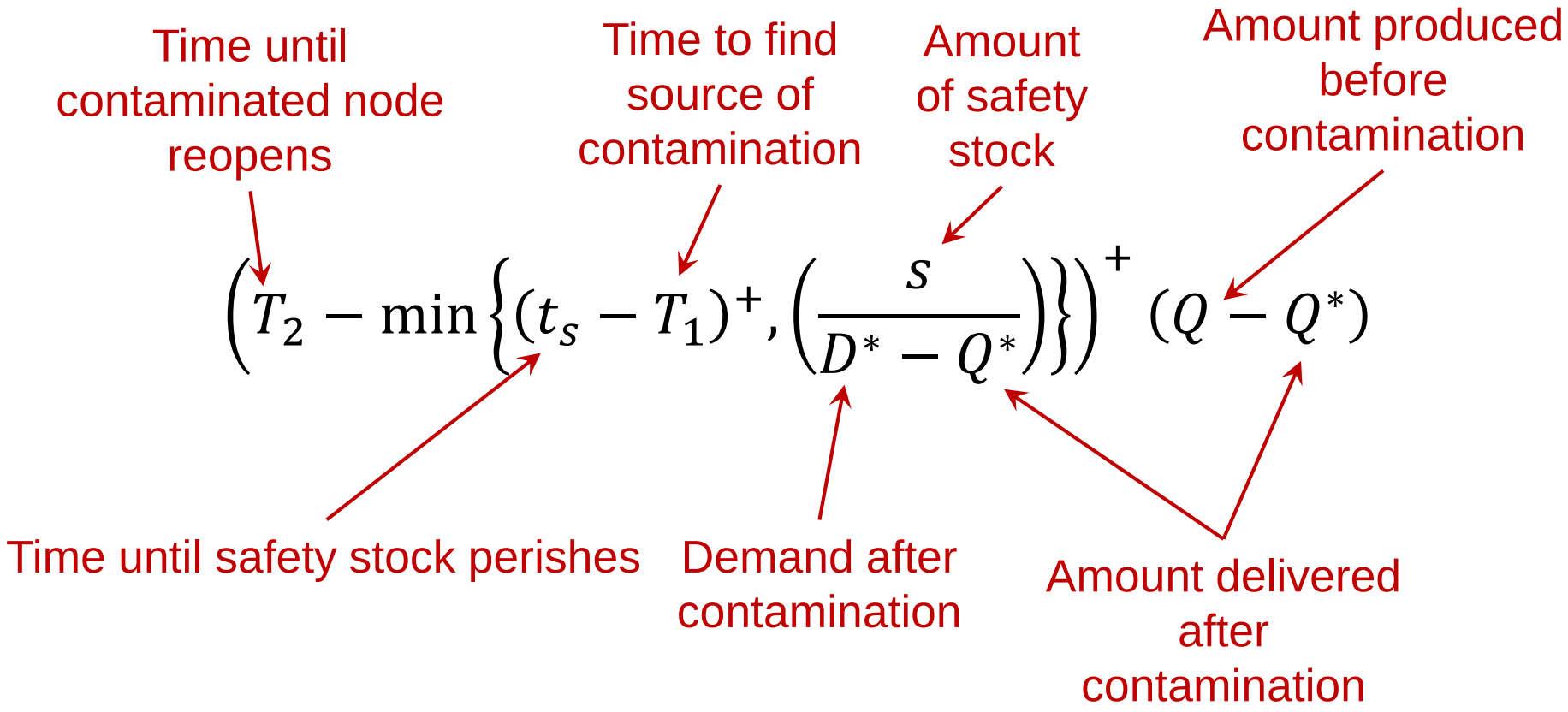
Safety stock

Safety stock may be used to mitigate disruption



After safety stock depleted

If contaminated node is distribution node



After safety stock depleted

If contaminated node is producing node