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PORT RISK ANALYSIS AND MANAGEMENT :
AN EMERGING RESEARCH THEME

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Recent initiatives

- Maritime Policy & Management Special Issue 2014, issue 7
  - Dealing with uncertainty and volatility in shipping and ports
- Accident Analysis and Prevention Special Issue 2016 (papers under review)
  - Risk Management in Port and Maritime Logistics

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EVALUATING PERFORMANCE OF A PORT-CENTRIC TRANSPORTATION NETWORK UNDER DISRUPTION RISKS

Outline

- Motivation and introduction
- Modeling port disruptions with Markov Chain
- Modeling port processing system
- Numerical example
- Implications

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Motivation and introduction

- A rising trend of disruptive events in ports
- Jasmine Siu Lee Lam & Shiling Su (2015) Disruption risks and mitigation strategies: an analysis of Asian ports, Maritime Policy & Management, 42:5, 415-435
- Some major examples:
  - 2015 Tianjin port explosion
  - 2002 10-day labor lockout at 29 Western US seaports: backlogs last for months
  - 1995 and 2011 Japanese earthquakes
  - The threat of terrorism activity and consequence are widely acknowledged

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Motivation and introduction

- Example: due to the earthquake, traffic flows in the port of Kobe redirected to nearby hub ports such as Busan, Shanghai and Kaohsiung, some of which never returned even long after the cargo-handling capacity was restored.
- Two observations:
  1. the consequence of a disruption can sometimes be irreversible for the affected port
  2. the port network as a whole can be considerably adaptive to counter adverse situations
- Implication: Important to understand how a port –centric network is affected by disruptions, and what their options are.

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Motivation and introduction

- Questions
  - How can we model major port disruptions in network operation simulation
  - Can some port development strategies (e.g. terminal capacity utilization, port collaboration) be beneficial to risk management?
  - What managerial and policy insights does this model provide?
- Objective
  - investigate the long-term impact and management of port disruption risks.

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Initial thoughts

- Port strategies to manage port disruptions
- Can the dynamic port strategy of adjusting terminal capacity utilization play a part in risk mitigation of port disruptions?
- Can port network strategy: port collaboration, play a part in risk mitigation of port disruptions?

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Modeling port disruptions with Markov Chain

- The states of a port in the network model can be defined as the extent to which the port is disrupted.
- A finite number of states can be introduced with each one representing a certain degree of disruption, which corresponds to a port capacity level, or a fraction of total port capacity under normal state.
- Assume port *k* has a finite number of states, then the state vector for port *k* being in state *i* is

$$X_n^{(k)} = (0,\ldots 0, \underset{\substack{\downarrow \\ i\text{th entry}}}{1}, 0,\ldots 0)^T.$$

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Modeling major disruptions with Markov Chain

- Each port in the network is treated as a system that has two possible states
- If only major disruptions are taken into account
  - Two possible states: *open* and *closed*
- The port operates at its full capacity when its status is *open*, i.e. normal state, and ceases operation when its status is *closed*.

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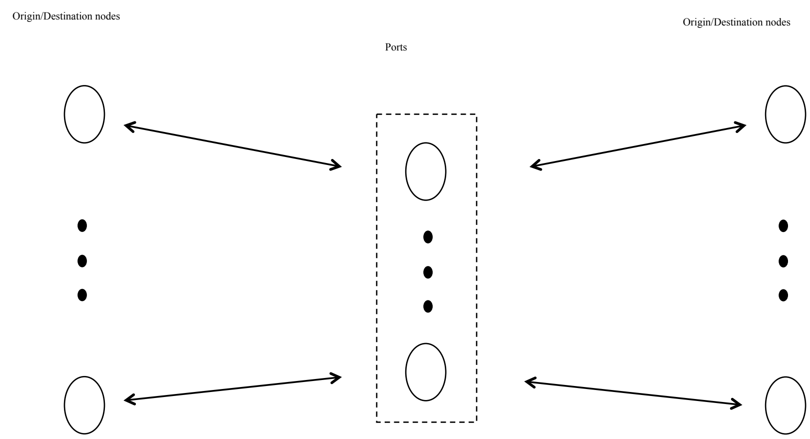
Modeling port processing system



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Modeling port processing system

- The *position* attribute ϕ consists of two parts: location θ_1 and priority θ_2

  where $\theta_1 \in \{-L, \ldots, -1, 0, 1, \ldots, n\}$

  $\theta_2 \in (0,1)$
- Using shipment update function

  $M(\phi \mid X_t, n_t):$

  Given the port status and queue length, to model port processing system

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Port processing system assumptions

- Homogeneous products
- No crossover
- FIFO

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Performance measure

- Long run average reward criteria: service level, ports' cost, shippers' cost
- Service level: on-time delivery ratio
- Cost
  - Ports: opportunity cost
  - Shippers: transportation cost, port fee, depreciation cost

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Numerical example

- Tokyo and Yokohama
  - Assume same hinterland, identical cost and time for inland transportation
- Using empirical data to model port status with Markov chain
- Strategies:
  - Varying terminal utilization
  - With or without port collaboration

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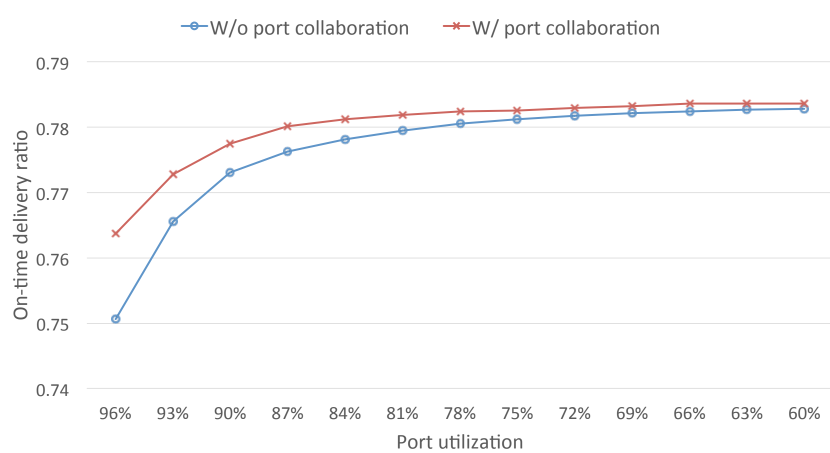
On time delivery ratio under different policy scenarios



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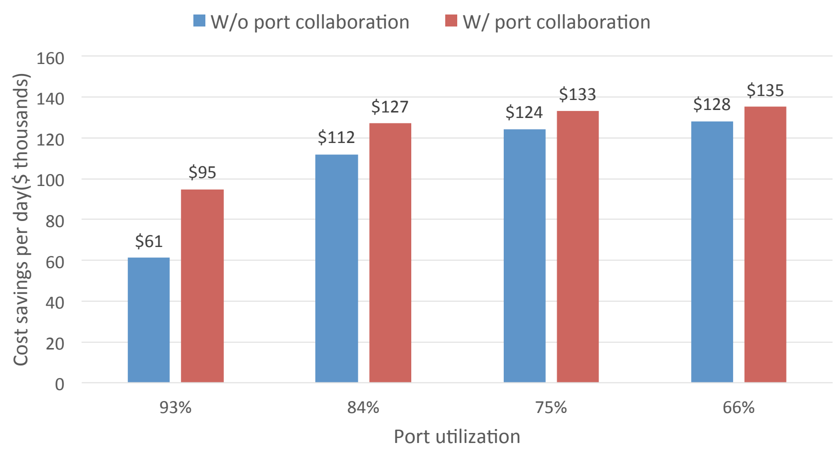
Cost savings for ports



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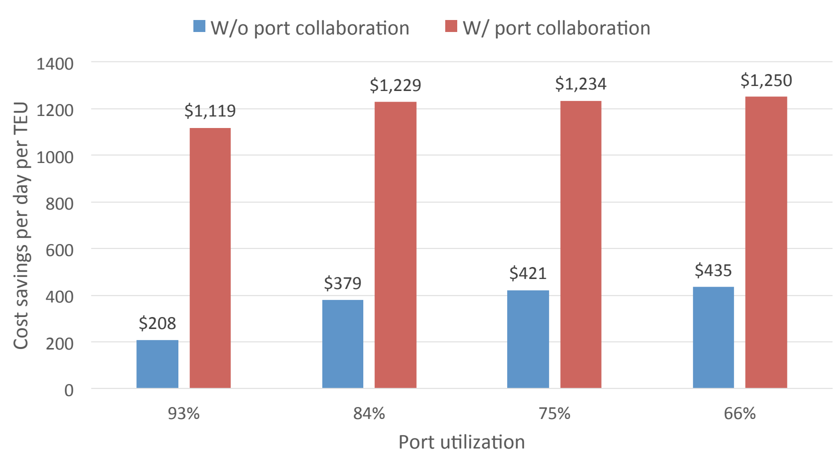
Cost savings for shippers



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Managerial and policy implications

- For a highly utilized port network, even disruptions of small scale can cause significant delays in shipments and port congestions in the subsequent periods
- Lower port utilization generally improves the performance of the port network
- The participants in the transportation network are generally better off when there is port collaboration
- The greatest increases in on-time delivery ratio occur when port utilization is high, corresponding to a relatively congested port network

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Managerial and policy implications

- Risk management decisions in a real-time/period-wise environment
- Other stakeholders such as shipping companies, cargo owners and intermodal operators are clearly impacted by the decisions of port terminals – a communication platform is needed.
- Port capacity, productivity and cargo flow data should be made available through authoritative agencies such as port authority to facilitate research on maritime disruption risks
- Viability of using port utilization and port collaboration as risk mitigation strategies

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