Figure Captions:

Figure 1: Sea-Land Interface of Maritime Transportation Systems
Figure 2: Framework for Risk Assessment of Seaport Operations
Figure 3: Generic Model for Disruption of Seaport Operations
Figure 4: Fuzzy Triangular Membership Function
Figure 5: Example of Converting Fuzzy Ratings to 5 Non-normalized grades
Figure 6: A Specific Model for Disruption Risks of a Seaport Operation
Figure 7: Sensitivity Analysis of the Model Output to the Variation of Each Sub-Criterion
Define a scaling system for likelihood and severity using fuzzy numbers

Estimate weight of each attribute in the hierarchy

Check the consistency of the matrices

CR ≤ 0.10

Define a scaling system for likelihood and severity using fuzzy numbers

Calculate risk of disruption based on the likelihood and severity of the identified factors

Implement ER to synthesise the risk results

Obtain a crisp number for the risk synthesis

Perform sensitivity analysis

Decision making

Are results logical?

FIGURE 3
Disruption Risks of Seaport Operations

Operational Risk Factors
- Port Equipment/Machinery Failure
- Vessel Accident/Grounding
- Cargo Spillage
- Human Related Error

Security Risk Factors
- Sabotage
- Terrorism Attacks
- Surveillance System Failures
- Arson

Technical Risk Factors
- Lack of Equipment Maintenance
- Lack of Navigational Aid Maintenance
- Lack of IT System Maintenance
- Lack of Dredging Maintenance

Organisational Risk Factors
- Labour Unrest
- Dispute with Regulatory Body
- Berth Congestion
- Gate Congestion
- Storage Area Congestion

Natural Risk Factors
- Geologic/Seismic
- Hydrologic
- Atmospheric

- General Cargo
- Containerships
- Bulk Carriers
- Short-sea/RoRo Vessel
- Oil Field Supply Vessel

- General Cargoes
- Bulk Cargoes
- Hazardous Cargoes
- Petroleum Products

- Seafarers
- Stevedores
- Pilotage
- Port/Terminal

- IT System
- Equipment
- Control System

- Attack on Port Facilities
- Sinking of a large Vessel in a Port Channel

- Earthquake
- Tsunami

- Heavy Rainfall
- Flooding
- Snow

- Hurricane
- Cyclone

FIGURE 4
FIGURE 5
FIGURE 6

Disruption Risks of a Seaport Operation

- Operational Risk Factors
  - Port Equipment/Machinery Failure
    - Vessel Accident/Grounding
    - Cargo Spillage
    - Human Related Error
  - Security Risk Factors
    - Sabotage
    - Terrorism Attacks
    - Surveillance System Failures
    - Arson
  - Technical Risk Factors
    - Lack of Equipment Maintenance
    - Lack of Navigational Aid Maintenance
    - Lack of IT System Maintenance
    - Lack of Dredging Maintenance
  - Organisational Risk Factors
    - Labour Unrest
    - Dispute with Regulatory Body
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