Maritime Security and Regulatory Risk-Based Models: Review and Critical Analysis

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Plan

Background: port and maritime security regime
Engineering risk-based models: precursor & risk analysis of maritime security
Supply chain risk based models: Interplay between supply chain risk & security
Economic appraisal and cost impact of security

Current work
- Benchmarking and productivity change due to procedural security
- Analysis of robustness of the port and maritime network
- New models for the assessment of security investment

Conclusion and discussion
Maritime security: main programmes and initiatives

**International:** IMO ISPS Code, WCO framework, IMO/ILO Code of Practice

**US regime:** C-TPAT, 24-Hour Rule, CSI, OSC, etc.

**Other initiatives:** AEO, Swedish Stair-Sec, Canada/ Mexico 24-h rule, FAST, APEC /STAR, US-New Zealand SEP, etc.

**Private programmes:** SST, ISO 28000, BASC, TAPA, etc.

**Future programmes:** SFI.
Risk assessment and management: framework and basic principles

**Scope:**

- Conventionally, risk can be defined as being the chance, in quantifiable terms, of an adverse occurrence.

- Risk therefore combines a probabilistic measure of the occurrence of an event with a measure of the consequence, or impact, of that event.

- When introducing the risk factor, the concept and measure of uncertainty must be considered.

**Process:**

Risk assessment: what can go wrong, the probability of it going wrong, and the possible consequences

Risk management: what can be done, the options & trade-offs available between costs, benefits & risks

Risk impacts: Management and policy decisions on future options and undertakings.

**Methodology:**

Incident (s) → Critical event → Consequence

FTA → ETA
## Methodology:

<table>
<thead>
<tr>
<th>Sequence dependent</th>
<th>Consequence analysis</th>
<th>Cause analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Tree Analysis</td>
<td>Markov Process</td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sequence independent</td>
<td>Failure Mode and Effects</td>
<td>Fault Tree Analysis</td>
</tr>
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<td></td>
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</tbody>
</table>
Risk assessment and management: application in maritime security: FSA

- Step 1: Hazard Identification
- Step 2: Risk Assessment
- Step 3: Risk Control Options
- Step 4: Cost & Benefit
- Step 5: Decision Making
1. Select a scenario

2. Determine facility consequence level

3. Determine if scenario requires mitigation strategy

4. Assess impact of mitigation strategy

5. Implement mitigation strategy (protective measures)

Repeat process until all unique scenarios have been evaluated
Shortcomings of conventional models in the context of maritime security

**Reporting systems and maritime security:**

- Event reporting and warning thresholds
- Reliability and validity of information resulting from fears of regulatory action
- Dissemination of reported information given sensitivity of and restrictive access to data
- False negative and false positive errors

**Maritime security and reporting procedures:**

- Exemption from regular customs inspections when trading within the same economic block
- Errors in filing detailed data/documentation
- No standardised system for ICT and port community systems (e.g. ASYCUDA, EDIFAT)
- No standardised system for container security/integrity (e.g. container seals)
Interplay between maritime security and supply chain risk

Objectives

Trade control, regulation, facilitation,
Overall cost reduction and ultimate customer satisfaction
Efficient physical movement (e.g. transport) and associated operations (e.g. warehousing) of goods and people

Trade Channel
Trading nations and their government agencies (customs, health authorities, designated authority and RSO in the context of ISPS, transport regulators, etc.)

Supply Channel
Cargo-owners (suppliers, manufacturers, shippers/receivers) and sub-contracting firms along the supply chain

Logistics Channel
Non-cargo owning facilitators and intermediaries contracted by supply chain members (ocean carriers, ports/terminal operators, logistics providers, shipping agents, NVOCCs, etc.)

Information flows
Payment flows
Physical flows

International Maritime System Network

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Multi-level / multi-layer security system

- C-TPAT
- WCO Framework / ISO 28000
- CSI
- 24-H Rule
- Bioterrorism Act
- U.S. MTSA
- ISPS B
- ISPS A

Increasing levels of security

Increasing levels of maritime network coverage

Trade channel
Cargo traffic security

Logistics channel
Vehicle or facility security

Supply chain
Shipper to receiver
Supply chain security
Economic evaluation and appraisal: Cost assessment models

- **Econometric analysis** measures the impact of a regulation such as through a production or a cost function;

- **Productivity studies** look at efficiency gains from the implementation (or absence) of a regulation;

- **General equilibrium models** examine the impacts of a regulation on changes of output / employment under perfect competitive market conditions;

- **Engineering and actuarial** approaches both look at the added cost for equipment/procedure installation;

- **Expenditure analysis** relies on market surveys of additional costs borne by various stakeholders (both direct participants and indirectly affected parties).
Economic impacts: Estimates

Martin Associates (2001) estimated that the West Coast port lockout in the fall of 2002 would cost the U.S. economy $1.94 billion a day, based on a 10-day shutdown of port facilities.

By the time the labour dispute had been resolved, Anderson (2002) has estimated a total economic cost of $1.7 billion, based on a 12-day shutdown.

Other competing studies (Pritchard, 2002; Rivera, 2002; Zuckerman, 2002) were reporting that the above figures were overestimated.

Lee and Whang (2005) use a hypothetical case study to model the benefits of reduced lead times and inspection levels in the context of SST. Their results show substantial cost savings in SST over the conventional process, as well as significant gains in the level and quality of service.

Babione et al (2003) examined the impacts of security initiatives on import and export container traffic of the US port of Seattle. Their findings suggest that specific measures such as the 24-hour rule and C-TPAT would have lesser impacts in the longer run.
Cost impacts: Regulatory risk assessment

**Regulatory Assessment (ISPS)**
- U.S N-RAT (USCG)
- UK RIA (CGA)
- Australia /APEC
- OECD, RAND

**Reaction driven**
- Pre-implementation
- Based on N-RAT model (e.g. aggregation)
- Not valid for post-ISPS management

**Industry Assessment Framework**
- None?
PORT SECURITY WAR GAME—ECONOMIC IMPACT

Exhibit 4

Day 1: Ports of Los Angeles and Savannah shut down

Day 4: Customs closes all ports and border crossings

Day 20: Railcar explodes in Chicago; 24 hour stand-down

Day 26: Ports return to normal schedule, inspection rate

Day 52: Vessel backlog cleared

Economic Loss ($Billions)

Day

0 5 10 15 20 25 30 35 40 45 50 55 60

Source: Booz Allen Hamilton

Backlog Loss
Cost impacts: Simulation (NISAC port operations simulator)
## Cost impacts: Post-implementation

<table>
<thead>
<tr>
<th>Example of average terminal security fees</th>
<th>$/TEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Ports (P&amp;O Ports operated)</td>
<td>3.8</td>
</tr>
<tr>
<td>Belgian ports</td>
<td>10.98</td>
</tr>
<tr>
<td>Denmark</td>
<td>61</td>
</tr>
<tr>
<td>Dutch ports</td>
<td>10.37</td>
</tr>
<tr>
<td>French ports</td>
<td>10.98</td>
</tr>
<tr>
<td>Italian ports</td>
<td>9.76</td>
</tr>
<tr>
<td>Latvian ports</td>
<td>7.32</td>
</tr>
<tr>
<td>Norwegian ports</td>
<td>2.44</td>
</tr>
<tr>
<td>Spanish ports</td>
<td>6.1</td>
</tr>
<tr>
<td>Irish ports</td>
<td>8.54</td>
</tr>
<tr>
<td>Swedish ports (Gothenburg)</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>UK ports</strong></td>
<td></td>
</tr>
<tr>
<td>Felixstowe, Harwich and Thames port</td>
<td>19 for import and 10 for export</td>
</tr>
<tr>
<td>Tilbury</td>
<td>12.7</td>
</tr>
<tr>
<td>Vancouver</td>
<td>2.7% increase in harbour dues</td>
</tr>
<tr>
<td>TSI Terminal handling charges</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td></td>
</tr>
<tr>
<td>Charleston, Houston and Miami</td>
<td>5</td>
</tr>
<tr>
<td>Gulf seaports marine terminal conference</td>
<td>2</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>6.25</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
</tr>
<tr>
<td>HK</td>
<td>6.41</td>
</tr>
<tr>
<td>Mexico</td>
<td>10</td>
</tr>
</tbody>
</table>

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*Note: Some fees are for import and export, indicating differences in costs for each direction.*
Cost estimate bias

Non-computation of supply chain disruption & redundancy costs

Cost spin-off & exponential computations of security expenses

Overlooking dissimilarities between global operators / facilities

- Various institutional / organisational systems, e.g. private vs. public, central vs. regional
- Different resource systems, e.g. financing models
- Absence of an international benchmark rate (or compensation scale) for cost computation, e.g. differences in labour pay, interest rates, depreciation, tax systems
- Unclear procedures for ISPS implementation, e.g. PFSO additional responsibility vs. PFSO additional function
Operational impacts - 24 hr rule

Carriers

- Average increase DwT at port of origin
- Cost for new data filing (passed-on to shippers)
- Cost for data errors: $5,000 penalty for the first violation, $10,000 for subsequent violations + Lost earnings in case of cargo missing schedule

Ports

- DwT increase due to advance cargo arrival
- Operational problems at ports of origin, transit & destination
- Pressure particularly felt by ports at the end of the transhipment network

Shippers

- Manifest surcharges (£25~$50)
- Advance cargo cut-off times (72~96 hrs)
- Possible cargo delay / mismatching & errors (e.g. re-stows)

Case: In 2003, the Grand alliance (OOCL, NYK, P&O Nedlloyd and Hapag-Lloyd), changed its "First Port of Call" from the Port of Seattle, USA to the Port of Vancouver, Canada.
Operational impacts - CSI & C-TPAT

CSI
Ports
• Direct cost for NII Equipment (and cost of implementation for US ports)
• DwT and operational problems
• Lost of carrier-clients if not a CSI-port, particularly for transit and transhipment ports

Shippers
• Charges for each inspection
• Increased DwT (both import & export cargo)
• Possible cargo delay, mismatching & errors

C-TPAT
Carriers, FF, brokers, 3PLs, etc.
• Cost of C-TPAT enrolment and implementation (possibly offset by fast-lane treatment)

Ports (U.S), Shippers (U.S importers)
• Cost of C-TPAT enrolment and implementation
• Container inspection rate DwT

Case: Operators at the port Colombo complaining about operational deficiencies since CSI implementation, e.g. 20% DwT increase.
Non-computation of supply chain disruption & redundancy costs

Cost spin-off & exponential computations of security expenses

Overlooking dissimilarities between global operators / facilities

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- Different resource systems, e.g. financing models
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First attempt to measure and benchmark container-terminal operational efficiency based on configuration topologies.

First attempt to measure (model) the ex-post impacts of security on port operational efficiency.

The combination of three analytical models (DEA, IDEF0, Malmquist TFP).

First Supply Chain/ Network DEA Model for ports

An attempt to account for both internal and external system’s bottlenecks and constraints.
Research Design and Procedure

Port security regulations

Container-port security framework

- ISPS for ports
- 24-hour rule
- CSI

Spatial scope of security regulations

Terminal operating sites

Terminal operating procedures

Terminal handling systems

Engineering standards

Dataset of container ports and terminals

- Panel data for ports
- Panel data for terminals

Sets of multi-input and multi-output variables

Operational performance indicators

DEA efficiency analysis

Malmquist index analysis

Malmquist index decomposition

Benchmarking container port efficiency

Total factor productivity change

Impacts of security regulations on operational efficiency and benchmarking of container terminals
Operationalisation: IDEF0 prescriptive modelling

Project: Functional modelling of container terminal operations

Used At: Imperial College

Notes: 1 2 3 4 5 6 7 8 9 10

Node: A1
Title: Operate quay site

Node: A2
Title: Operate yard

Node: A3
Title: Operate gate

Operate quay site

Operate yard

Operate gate

Terminals

Container terminal

Operate quay site

Operate yard

Operate gate

Quay crane configuration

Yard crane configuration

Storage policy

ISPS code

Driving & safety rules

Work shifts

Container status

Container size

Gate working hours

Terminal throughput

Discharged containers

Stacked containers

Transferred containers

Terminal area

Terminal capacity

Quay length

Berth’s draft

Number of berths

Inbound containers

Yard staking capacity

Number of gates

Number of gate lanes

Quay cranes

Ship-by plan

Routing & positioning

Internal trucks and vehicles

Quay cranes & handling equipment

Yard plan

Identification technology

External trucks

EDI & port community system

Node: A0
Title: IDEF0 model for import container's flow

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Operationalisation: DEA Analysis and Malmquist Index Composition

Model assumption and orientation
- VRS technology
- Input-orientation

DEA Models
- Slack-based DEA
- Measure specific DEA
- Supply chain DEA

Malmquist index decomposition
\[ TTEC = TEC \times SEC \times TC \]
Methodology: Data and Variable selection

Panel data set for 38 ports and 60 container terminals from 2000 to 2006 is used resulting into 266 container-port and 420 container-terminal decision-making units (DMUs), respectively.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quay</td>
<td>Quay crane index</td>
<td>Crane move per hour</td>
</tr>
<tr>
<td></td>
<td>Berth index</td>
<td>Terminal throughput</td>
</tr>
<tr>
<td></td>
<td>Berth length</td>
<td></td>
</tr>
<tr>
<td>Yard</td>
<td>Yard capacity</td>
<td>Crane move per hour</td>
</tr>
<tr>
<td></td>
<td>Stacking capacity</td>
<td>Terminal throughput</td>
</tr>
<tr>
<td></td>
<td>Yard gantries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Straddle carriers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tractors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trailers/Chassis</td>
<td></td>
</tr>
<tr>
<td>Gate</td>
<td>Gate indicator</td>
<td>Terminal indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average waiting time</td>
</tr>
</tbody>
</table>

Descriptive statistics of the aggregate container terminal dataset

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal area (1000 m²)</td>
<td>25</td>
<td>4000</td>
<td>714.4</td>
<td>547.9</td>
</tr>
<tr>
<td>Terminal capacity (1000TEU)</td>
<td>230</td>
<td>10,000</td>
<td>2,219</td>
<td>2,020</td>
</tr>
<tr>
<td>Berths</td>
<td>1</td>
<td>12</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Quay site index</td>
<td>881</td>
<td>19,890</td>
<td>5,202</td>
<td>3,772</td>
</tr>
<tr>
<td>Quay crane index</td>
<td>71</td>
<td>4,860</td>
<td>468</td>
<td>642</td>
</tr>
<tr>
<td>Yard stacking capacity (1000TEU)</td>
<td>6</td>
<td>212</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Yard crane index</td>
<td>12</td>
<td>12549</td>
<td>1133</td>
<td>2184</td>
</tr>
<tr>
<td>Internal trucks and vehicles</td>
<td>2</td>
<td>390</td>
<td>55</td>
<td>57</td>
</tr>
<tr>
<td>Yard free storage (day)</td>
<td>0.5</td>
<td>16</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Gate index</td>
<td>21</td>
<td>888</td>
<td>201</td>
<td>171</td>
</tr>
<tr>
<td>Gate cut-off time (hour)</td>
<td>3</td>
<td>32</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Terminal throughput (1000 TEU)</td>
<td>101</td>
<td>8,865</td>
<td>1,517</td>
<td>1,465</td>
</tr>
<tr>
<td>Crane move (Hour)</td>
<td>20</td>
<td>82</td>
<td>31</td>
<td>7</td>
</tr>
</tbody>
</table>
Some Results

• Uncovered inherent inefficiencies in terminal operations
• Evidence of different performance levels between operating configuration
• Terminals in the same port do not depict the same trend
• Slight decline (10%) of mean efficiency of terminals after 2004
• Generalised gains in scale efficiency
• Generalised losses in pure technical efficiency
• Improvement in TC efficiency after 24 hr implementation
• Adjustments in terminal operating procedures to cope with security
• Small ports/tterminals seem to suffer the most from security
Some Results

Year-by-year (2000-6) evolution of average terminal efficiency
(Based on input-oriented efficiency ratings)
Variations in productive efficiency of YCT following changes in gate closing time policy  
(Based on CCR-I panel data analysis)
Average values of MPI and its sources of efficiency on a year-by-year basis
What's next

SFI?