Impact of Hinterland Access Conditions on Rivalry between Ports

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De Borger, Proost & Van Dender (2008)

Port A
Volume: $X_A$
Capacity: $K^f_A$

Port B
Volume: $X_B$
Capacity: $K^f_B$

Hinterland A
Volume: $X_A + Y_A$
Capacity: $K^h_A$

Hinterland B
Volume: $X_B + Y_B$
Capacity: $K^h_B$

$X = X_A + X_B$
1. Investment in port capacity reduces prices & congestion at both ports, but increases hinterland congestion in the region where the port investment is made.

2. Investment in a port’s hinterland is likely to lead to more port congestion & higher prices for port use, and to less congestion and a lower prices at the competing port.

3. Imposing congestion tolls on the hinterland roads raises port capacity investment.
• **The present paper:** Hinterland access conditions → the port and port competition

• Port congestion & capacity investment abstracted away

• Bottleneck of the logistics chain shifted to the port/inland interface
  • e.g. hinterland connection; inland transportation
• **2nd objective:** Link port competition with corridor capacity & urban mobility

• Corridor capacity:
  - Rail connection: Inland terminal (e.g. the Alameda corridor)
  - Rail competition: Monopoly or oligopoly?
  - Barge
  - Border crossing

• Urban mobility: Trucking for final, local delivery
  - Road capacity
  - Road pricing
Model

• Like De Borger, Proost & Van Dender:
  Two seaports, labeled 1 & 2, share the same overseas customers and have each a downstream, congestible transport network to a common hinterland

• Unlike De Borger, Proost & Van Dender:
  1) Port & its hinterland belong to a single region, ensuring coordination in their decisions
  2) Imperfect substitutes: allow both overlapping and captive hinterlands
Total (generalized) cost faced by users:

\[ \rho_i = p_i + D_{Ci}(K_{Ci}) + D_{Li}(V_i, K_{Li}) + t_i, \quad i = 1, 2 \]  (1)
• Corridor delay cost falls as the corridor capacity \( (K_{ci}) \) increases

• Road used by both cargo shipments \( X_i \) and local commuters \( Y_i \), we have \( V_i = X_i + Y_i \)

• Road delay cost satisfies:

\[
\frac{\partial D_{Li}}{\partial V_i} > 0, \quad \frac{\partial D_{Li}}{\partial K_{Li}} < 0, \quad \frac{\partial^2 D_{Li}}{\partial V_i^2} \geq 0, \quad \frac{\partial^2 D_{Li}}{\partial V_i \partial K_{Li}} \leq 0
\]  

(2)

• Increasing traffic volume \( V \) raises road congestion while adding capacity \( K_{Li} \) decreases road congestion, and the effects are more pronounced when there is more congestion
Total cost of local road traffic:

\[ \rho_{Li}(Y_i) = t_i + D_{Li}(X_i + Y_i, K_{Li}) \quad i = 1, 2 \]  

(a) an increase in road toll reduces local traffic;
(b) an increase in cargo traffic decreases local traffic;
(c) an increase in road capacity increases local traffic;
(d) an increase in cargo traffic will, while reducing local traffic, increase overall road traffic.
Each port’s demand depends on both its total cost and the rival port’s total cost.

\[ X_1 = X_1(\rho_1, \rho_2), \quad X_2 = X_2(\rho_1, \rho_2) \]  
(5)

Inverting (5) yields:

\[ \rho_1 = \rho_1(X_1, X_2), \quad \rho_2 = \rho_2(X_1, X_2) \]  
(6)

Using (1) and \( Y_i = Y_i^*(t_i, X_i, K_{Li}) \), equations (6) can be written as, for \( i=1,2 \):

\[ p_i = \rho_i(X_1, X_2) - D_{Ci}(K_{Ci}) - D_{Li}(V_i, K_{Li}) - t_i \equiv p_i(X_1, X_2; K_{Ci}, K_{Li}, t_i) \]  
(7)

Each port’s revenue as:

\[ \pi^i = p_i(X_1, X_2; K_{Ci}, K_{Li}, t_i) \cdot X_i = \pi^i(X_1, X_2; K_{Ci}, K_{Li}, t_i) \]  
(8)
Main results

• **Port competition**: Competition between alternate intermodal chains; while hinterland access conditions represented by corridor facilities and by inland roads

• When the ports compete in quantities, an increase in corridor capacity will:
  a) increase own port’s output
  b) reduce the rival port’s output
  c) increase own port’s revenue
Main results (cont.)

- Port competition results in higher level of corridor capacity investment than would be in the absence of competition.

- This capacity competition between regions/countries improves social welfare, but the generalized costs are still too high compared to social optimum.

- This capacity competition between regions/countries may lead to a Prisoner’s Dilemma.
Main results (cont.)

• An increase in road capacity may or may not increase own port’s output and profit, owing to various offsetting effects

• Road pricing may or may not increase own port’s output and profit

• The above over-investment result is weakened if the mode of port competition is in prices
1. **Empirical work:**

a) Which model of competition is “correct” for ports?

- **Cournot**: Firms (here, ports) commit to quantities, and prices then adjust to clear the market implying the industry is flexible in price adjustments, even in short run.
- **Bertrand**: Capacity is unlimited or easily adjusted in the short run.
- Some industries behave like Bertrand and others Cournot; as such, which model of oligopoly is applicable to a particular industry (here, the port industry) is of an empirical question.
b) Empirical test of the theoretical predictions: Hard given lack of data
c) Correlation of annual container throughput growth (market share, respectively) and changes in urban area mobility – LA/Long Beach, 1995-2006

<table>
<thead>
<tr>
<th></th>
<th>Total delay (person-hrs)</th>
<th>Delay per peak traveler (person-hrs)</th>
<th>Travel time index</th>
<th>Total congestion cost ($)</th>
<th>Congestion cost per peak traveler ($)</th>
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</thead>
<tbody>
<tr>
<td>LA+LB container throughput growth</td>
<td>-0.683* (0.029)</td>
<td>-0.649* (0.024)</td>
<td>-0.716* (0.020)</td>
<td>-0.684* (0.029)</td>
<td>-0.642* (0.045)</td>
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<tr>
<td>LA+LB container market share</td>
<td>-0.414 (0.235)</td>
<td>-0.353 (0.318)</td>
<td>-0.301 (0.398)</td>
<td>-0.405 (0.246)</td>
<td>-0.367 (0.297)</td>
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## Oakland

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<tr>
<th>Throughput growth</th>
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<tbody>
<tr>
<td>Throughput growth</td>
<td>0.368 (0.295)</td>
<td>0.426 (0.220)</td>
<td>0.449 (0.193)</td>
<td>0.461 (0.180)</td>
<td>0.478 (0.163)</td>
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<tr>
<td>Market share</td>
<td>0.198 (0.584)</td>
<td>0.243 (0.500)</td>
<td>0.301 (0.398)</td>
<td>0.355 (0.314)</td>
<td>0.401 (0.251)</td>
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<tr>
<td>Throughput growth</td>
<td>0.164 (0.650)</td>
<td>0.019 (0.959)</td>
<td>0.062 (0.864)</td>
<td>0.039 (0.914)</td>
<td>-0.131 (0.718)</td>
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<tr>
<td>Market share</td>
<td>0.144 (0.692)</td>
<td>0.016 (0.965)</td>
<td>0.103 (0.777)</td>
<td>0.022 (0.951)</td>
<td>-0.154 (0.671)</td>
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# Seattle

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</thead>
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<tr>
<td>Throughput growth</td>
<td>0.201 (0.577)</td>
<td>0.244 (0.498)</td>
<td>-0.103 (0.778)</td>
<td>0.210 (0.561)</td>
<td>0.242 (0.501)</td>
</tr>
<tr>
<td>Market share</td>
<td>0.165 (0.648)</td>
<td>0.204 (0.571)</td>
<td>-0.126 (0.729)</td>
<td>0.181 (0.616)</td>
<td>0.216 (0.549)</td>
</tr>
</tbody>
</table>
2. Organizational coordination

• For an intermodal chain: port, corridor & road may belong to different, separate organizations

• Each maximizes own interest, which may not be the same as the interest for the entire chain’s
A 1 <-> B 2

Complements

C 3 <-> D 4

Complements
Two (potential) functional integration or alliance chains

1  2

3  4

‘North’ Chain

‘South’ Chain
3. Overlapping & captive hinterlands

• Although the captive hinterlands do not subject to immediate competition, they play an important role in port competition

• How?
  • If both the overlapping and captive markets are considered, important interactions between the two markets & their impact on port competition need to be analyzed
  • This involves an explicit derivation of demand functions
Modal Structure

- Port A (Port of Rotterdam)
- Port B (Port of Antwerp)

Hinterland (e.g. Germany)

Users are distribute along