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Port competition with congestion and accessibility: An interpretive review of recent research *

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Introduction

- Large empirical literature on **port choice** decisions
  - Which factors affect users' choice of ports?

  - Users: shippers (e.g. importers/exporters), forwarders, shipping lines
  - Mainly based on surveys, AHP or discrete choice models (see Martínez Moya & Feo Valero, 2017, for a review)

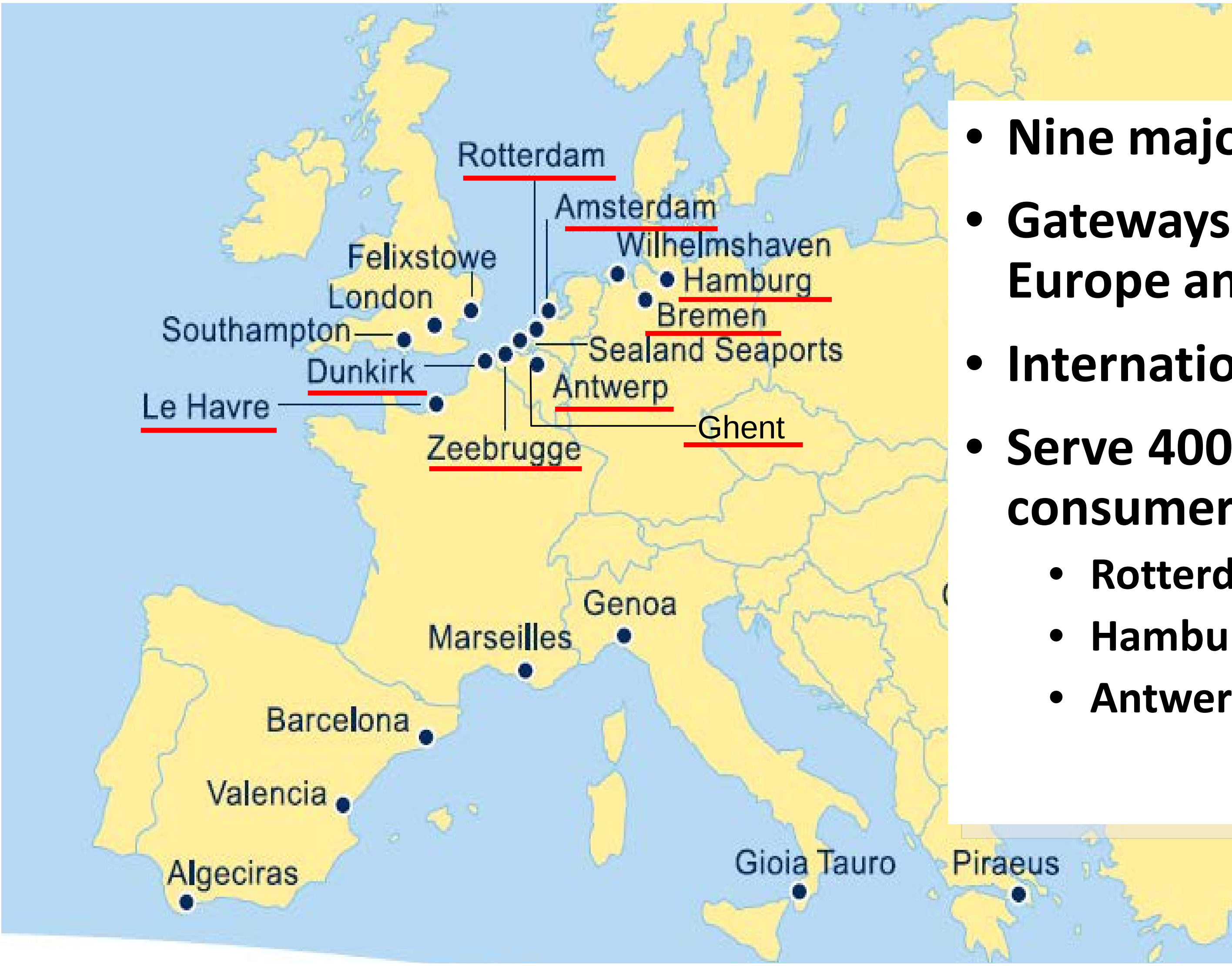
- **Hinterland accessibility** as a key factor for port choice:
  - Geographic **location** (land side): inland distance to/from port, hinterland transit time, availability of expressways, inland transport cost
  - Port **connectivity** (land side): location can be augmented by developing **inter-modal connections** with the hinterland (Martínez Moya & Feo Valero, 2017)

- Literature on **port competition** focus mainly on the competing ports and their facility investment (or congestion)
  - See Tezuka & Ishii (2016) for a review

- Limited studies on the **role of hinterland accessibility or congestion**, both theoretically and empirically:
  - **What have been done?**
  - **What can be done in the future?**
  - **What are the difficulties?**

  (Will also discuss practical implications and applications if time allows)

Hamburg-Le Havre (HLH) port range

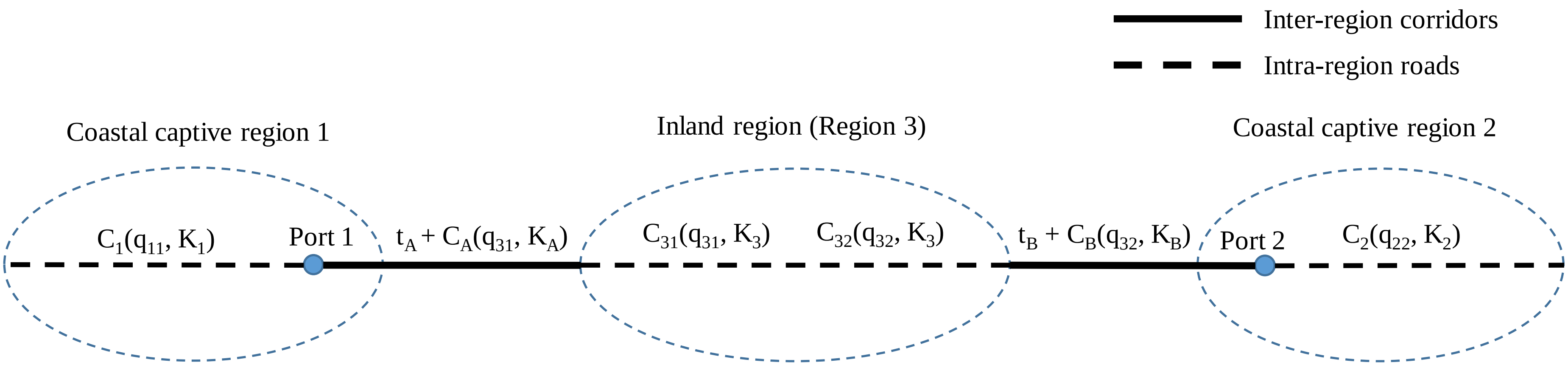


- **Nine major ports**
- **Gateways to north Europe and the Baltic sea**
- **International hub**
- **Serve 400 million consumers**
  - **Rotterdam**
  - **Hamburg**
  - **Antwerp**

A theoretical modelling framework - New

- “Supply chain” perspective: port competition is competition between alternate “transport supply chains” (port + inland)
- Three regions:
  - Regions 1 and 2 have ports and respective captive markets
  - Ports compete for the shippers located in the hinterland (region 3)
  - Regions are linked with **inter-region corridors**
  - Within each region, there are local roads/rails for local distribution of the shipments

- Typical decision variables
  - Regional governments: tolls and capacities for landside transport facilities (e.g. road, rail)
  - Ports: port charges (or, port throughput volumes)



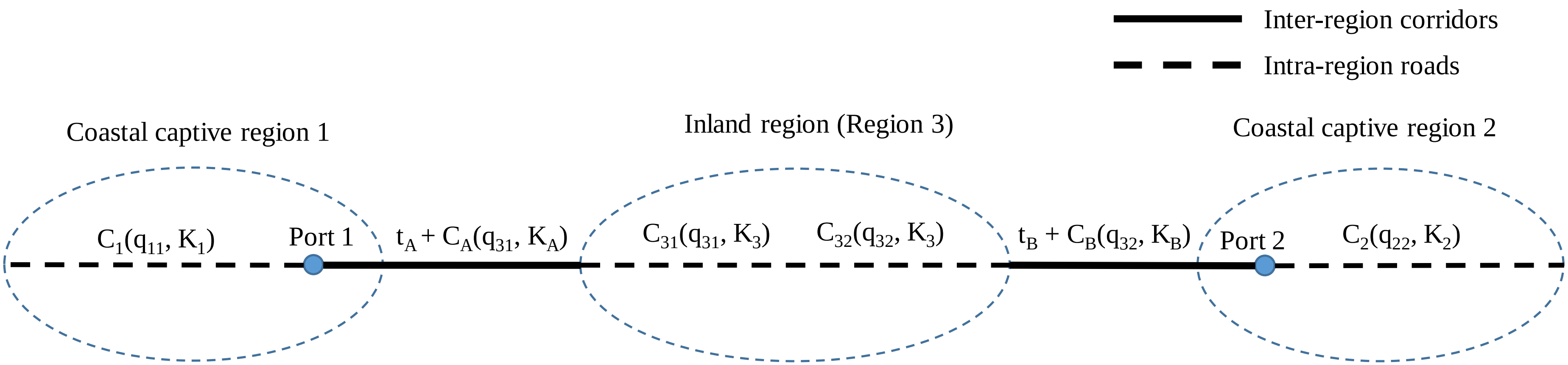
Ports' decision: price (p), quantity (q)

Regional governments' decision: road tolls (t), capacities (K)

Shippers are located within regions 1, 2 and 3, but not along the inter-region corridors. So cargoes from/destined to region 3 must go through the inter-region corridors

"Generalized cost" for shippers in **captive region i (i=1, 2)**:

$$g_i(p_i, K_i, q_{ii}) = p_i + C_i(q_{ii}, K_i)$$



Generalized cost for shippers in the **inland region 3**:

$$g_{31}(p_1, q_{31}, t_A, K_A, K_3) = p_1 + t_A + C_A(q_{31}, K_A) + C_{31}(q_{31}, K_3) \quad \text{if port 1 is chosen}$$
$$g_{32}(p_2, q_{32}, t_B, K_B, K_3) = p_2 + t_B + C_B(q_{32}, K_B) + C_{32}(q_{32}, K_3) \quad \text{if port 2 is chosen}$$

C_{3i} = inland transport costs if port i is chosen. We assume the local transport system has capacity K_3 while shippers using different ports will use different parts of the local system and hence the congestion cost within region 3 encountered by shippers using port 1 depends on K_3 as well as q_{31}.

C_A (q_{31}, K_A), C_B (q_{32}, K_B): Costs of going through the inter-region corridors, depending on the corridor investment (e.g. rails or inter-modal connections)

In captive region i (i=1, 2): at equilibrium, the marginal shipper will have inverse demand equalize generalized cost:

$$\rho_i(q_{ii}) = g_i(p_i, K_i, q_{ii}) \Rightarrow p_i = \rho_i(q_{ii}) - C_i(q_{ii}, K_i) \Rightarrow q_{11}(p_1, K_1),\ q_{22}(p_2, K_2)$$

In region 3, the inverse demand is $\rho_3(q_{31}+q_{32})$. At equilibrium, there will be:

$$\rho_3(q_{31}+q_{32}) = g_{31}(p_1, q_{31}, t_A, K_A, K_3) \Rightarrow p_1 = \rho_3(q_{31}+q_{32}) - t_A - C_A(q_{31}, K_A) - C_{31}(q_{31}, K_3)$$
$$\rho_3(q_{31}+q_{32}) = g_{32}(p_2, q_{32}, t_B, K_B, K_3) \Rightarrow p_2 = \rho_3(q_{31}+q_{32}) - t_B - C_B(q_{32}, K_B) - C_{32}(q_{32}, K_3)$$

$$\Rightarrow q_{31}(p_1, p_2, t_A, t_B, K_A, K_B, K_3),\ q_{32}(p_1, p_2, t_A, t_B, K_A, K_B, K_3)$$

Downward-sloping demands:

$$\rho_i' < 0 \quad \forall i = 1,2,3$$

Features of the cost functions:

$$\frac{\partial C_i(q_j, K_i)}{\partial q_j} > 0,\ \frac{\partial C_i(q_j, K_i)}{\partial K_i} < 0,\ \frac{\partial^2 C_i(q_j, K_i)}{\partial K_i \partial q_j} < 0 \quad \forall i = 1,2,3, A, B$$

The above features lead to:

$\forall i = 1,2 \text{ and } i \neq j$

1. As a port increases its charge, quantity demanded in its own captive market falls, its inland demand falls, but its rival port's inland demand increases

$$\frac{\partial q_{ii}}{\partial p_i} < 0, \ \frac{\partial q_{3i}}{\partial p_i} < 0, \ \frac{\partial q_{3i}}{\partial p_j} > 0$$

2. Demand of the captive region increases in the captive region's own intra-region road capacity, but it won't be directly affected by the capacity of other corridors/roads

$$\frac{\partial q_{ii}}{\partial K_i} > 0, \frac{\partial q_{ii}}{\partial K_j} = 0$$

3. A port's demand from inland region won't be directly affected by the captive regions' road capacity. However, it will increase if its inter-region corridor capacity increases, and decrease if its rival's inter-region corridor capacity increases

$$\frac{\partial q_{3i}}{\partial K_{l(l=1,2)}} = 0$$

$$\frac{\partial q_{31}}{\partial K_A} > 0, \ \frac{\partial q_{31}}{\partial K_B} < 0, \ \frac{\partial q_{32}}{\partial K_B} > 0, \ \frac{\partial q_{32}}{\partial K_A} < 0$$

4. Investment in corridors/roads affects shippers' sensitivity to port charges

- Shippers in the captive region become more sensitive to port charge due to its own intra-region road investment

$$\frac{\partial}{\partial K_i}\left(\frac{\partial q_{ii}}{\partial p_i}\right) < 0$$

- A port's demand from inland become more sensitive to its own port charge due to investments in inland roads and in linkages between the captive and inland regions

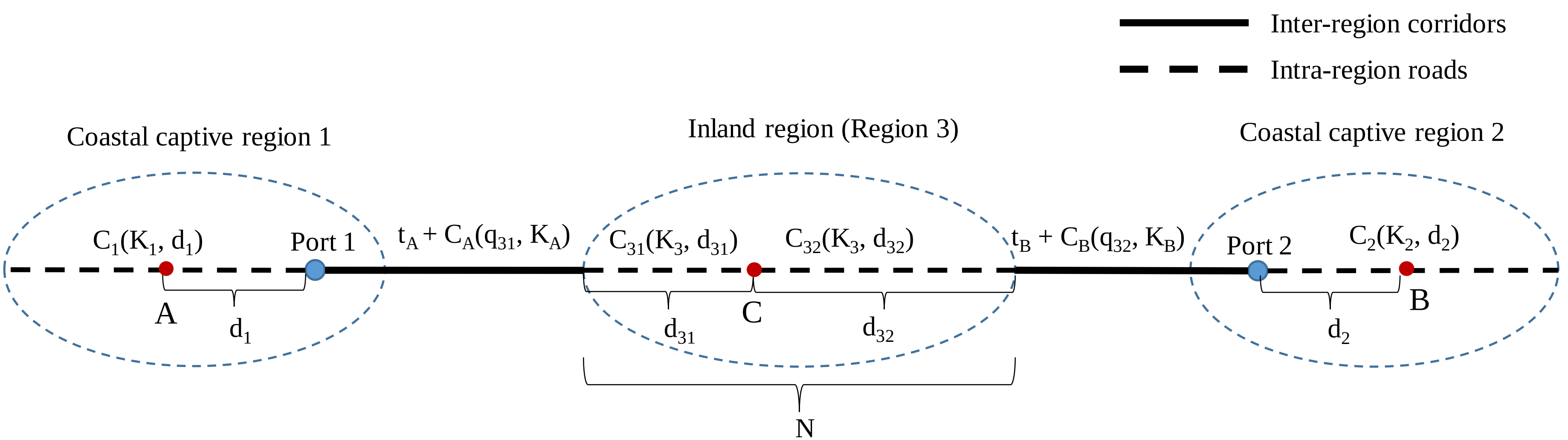
$$\frac{\partial}{\partial K_3}\left(\frac{\partial q_{3i}}{\partial p_i}\right) < 0, \ \frac{\partial}{\partial K_A}\left(\frac{\partial q_{3i}}{\partial p_i}\right) < 0, \ \frac{\partial}{\partial K_B}\left(\frac{\partial q_{3i}}{\partial p_i}\right) < 0$$

- A port's demand from inland becomes more sensitive to its rival's port charge due to investments in inland roads and in linkages between the captive and inland regions

$$\frac{\partial}{\partial K_3}\left(\frac{\partial q_{3i}}{\partial p_j}\right) > 0, \ \frac{\partial}{\partial K_A}\left(\frac{\partial q_{3i}}{\partial p_j}\right) > 0, \ \frac{\partial}{\partial K_B}\left(\frac{\partial q_{3i}}{\partial p_j}\right) > 0$$

Connection with the linear-city model (e.g. **Basso & Zhang, 2007**; Czerny, Hoffer & Mun, 2014; Wan, Basso & Zhang, 2016)

- Linear-city model
  - Shippers are uniformly located along the intra-region roads with density equal to 1
  - Let intra-region transport cost per unit of distant be t = 1/K
  - In captive region i, q_{ii} = the distance (d_i) between the port and the marginal shipper. The transport cost of the marginal shipper will be $C_i(K_i, d_i)=d_i/K_i = q_{ii}/K_i = C_i(q_{ii}, K_i)$
  - In inland region 3, q_{3i} = the distance (d_{3i}) between the boundary of inland region and the marginal shipper. The transport cost of the marginal shipper will be $C_{3i}(K_3, d_{3i})=d_{3i}/K_3 = q_{3i}/K_3= C_{3i}(q_{3i}, K_3)$
  - There are N shippers evenly distributed in the inland region



Shippers in captive region i (i=1, 2) will ship the goods as long as the gross utility (V) exceeds the generalized shipping cost. At equilibrium, the marginal shipper located at d_i will have:

$$V = p_i + C_i(K_i, d_i) = p_i + C_i(q_{ii}, K_i)$$

At equilibrium, the marginal shipper in region 3 will have:

$$p_1 + t_A + C_A(q_{31}, K_A) + C_{31}(K_3, d_{31}) = p_2 + t_B + C_B(q_{32}, K_B) + C_{32}(K_3, d_{32})$$
$$\Rightarrow p_1 + t_A + C_A(q_{31}, K_A) + C_{31}(q_{31}, K_3) = p_2 + t_B + C_B(q_{32}, K_B) + C_{32}(q_{32}, K_3)$$

Then: $q_{11} = K_1(V - p_1), \quad q_{22} = K_2(V - p_2)$

$$q_{31} = \frac{\left(\frac{1}{K_B} + \frac{1}{K_3}\right)N + \left(p_2 - p_1\right) + \left(t_B - t_A\right)}{\frac{1}{K_A} + \frac{1}{K_B} + \frac{2}{K_3}}, \quad q_{32} = \frac{\left(\frac{1}{K_A} + \frac{1}{K_3}\right)N + \left(p_1 - p_2\right) + \left(t_A - t_B\right)}{\frac{1}{K_A} + \frac{1}{K_B} + \frac{2}{K_3}}$$

Linear-city model (cont’d)

- These demand functions satisfy all the comparative-statics results above
- So the linear-city model is a **special case** of our general framework
- Furthermore, we can obtain the closed-form solution for the second-stage pricing game (but not for the first-stage investment game)
- The linear-city model can nevertheless facilitate simulation exercises

Markets and hinterland access systems included in analytical papers with duopoly ports

	Captive markets	Inland market (the third region)	Captive regions' road	Inland road	Inter-region corridors	Port congestion
De Borger et al. (2008)	No	Yes	No	No	Yes, with local users not related to ports	Yes
Zhang (2008)	No	Yes	No	No	Yes, so-called local roads	Yes, so-called corridors
Wan & Zhang (2013)	No	Yes	No	No	Yes, with local users not related to ports	No
Czerny et al. (2014)	Yes	Yes, in the form of transshipment	No	Yes, shipping cost	No	No
Wan et al. (2016)	Yes	Yes	Yes	Yes	No	No

Note: Port congestion can be considered as congestion on the cargo-dedicated corridor linking the port to the local transport system, as all port-related traffic has to pass this corridor.

Investment and pricing decisions, and decision-makers on hinterland access facilities and ports

	Captive regions' road	**Inland road**	**Inter-region corridors**	**Port (ownership)**	**Game structure**
De Borger et al. (2008)	NA (Not applicable)	NA	K_A, K_B set by regional governments; exogenous t_A, t_B	Prices set by private ports	Stage 1: governments set corridor capacities Stage 2: ports set prices
Zhang (2008)	NA	NA	Exogenous K_A, K_B, t_A, t_B	Quantities or prices set by private ports	Stage 1: ports set volumes or prices
Wan & Zhang (2013)	NA	NA	Exogenous K_A, K_B, t_A, t_B	Quantities set by private or public ports	Stage 1: ports set volumes
Czerny et al. (2014)	No	Exogenous	NA	Prices set by private or public ports	Stage 1: ports decide privatization or not Stage 2: ports set prices
Wan et al. (2016)	K_1, K_2 set by regional governments	K_3 set by regional governments	NA	Prices set by private or public ports	Stage 1: regional governments choose the form of cooperation Stage 2: governments choose road capacities Stage 3: ports set prices

Impacts of hinterland accessibility on ports' decision variables

		Decision variable: price		Decision variable: quantity	
		Private	**Public**	**Private**	**Public**
Increase inter-region corridor capacity (K_A) – excl. captive markets (De Borger et al., 2008; Zhang, 2008; Wan & Zhang, 2013)	Own (port 1)	+ (most likely)		+	+
	Rival (port 2)	-		-	-
Reduce inter-region corridor toll (t_A) - excl. captive markets and local commuters (Wan & Zhang, 2013)	Own (port 1)			+	0
	Rival (port 2)			-	0
Reduce inter-region corridor toll (t_A) - excl. captive markets but incl. local commuters paying the same toll as trucks (Wan & Zhang, 2013)	Own (port 1)			+ (large commuter value of time) - (otherwise)	-
	Rival (port 2)			- (large commuter value of time) + (otherwise)	+
Increase captive intra-region road capacity (K_1) (Wan et al., 2016)	Own (port 1)	+ (if captive markets are large) - (otherwise)	-		
	Rival (port 2)	+ (if captive markets are large) - (otherwise)	-		
Increase inland intra-region road capacity (K_3) (Wan et al., 2016)	Own (port 1)	-	- (most likely) + (only if K1 >> K2)		
	Rival (port 2)	-	- (most likely) + (only if K2 >> K1)		

Implications when ports competing in prices

- As $\partial\pi_2/\partial p_1>0$ (or $\partial W_2/\partial p_1>0$) and prices are strategic complements
  - When there are no captive markets: improving accessibility in inter-region corridor makes a port "soft"
    - → Region 1 should overinvest in K_A (or substantially cut t_A)
  - Improving accessibility in intra-region roads of the captive region makes a port soft only when captive market is large and ports are private
    - → Region 1 should overinvest in K_1 only when ports are private and captive markets are large;
    - → Region 1 should underinvest in K_1 otherwise
  - Improving accessibility in intra-region roads of the inland region tends to make a port "tough"
    - → Region 1 should induce inland to underinvest in K_3

Implications when ports competing in quantities

- When there are no captive markets
- As $\partial\pi_2/\partial q_1<0$ (or $\partial W_2/\partial q_1<0$) and quantities are strategic substitutes
  - When ports are private, improving accessibility in inter-region corridor makes a port tough (unless commuters' value of time is small)

    → Region 1 should overinvest in K_A (or substantially cut t_A)
  - When ports are public:
    - Improving accessibility by adding capacity makes the port tough → Region 1 should overinvest in K_A
    - Improving accessibility by cutting corridor toll makes the port soft → Region 1 should not cut t_A

Other issues studied in the literature

- Optimal port pricing and investment policies (De Borger et al., 2008; Wan and Zhang, 2013)
- Port privatization (Czerny et al., 2014)
  - When captive market is small, privatization tends to happen and leads to higher port region's welfare
  - When captive market is large, lowering in third-region accessibility will make privatization produce higher regional welfare, but regional governments will keep ports public unless the third-region accessibility is extremely low (a case of "prisoners' dilemma")
  - Asymmetric country sizes: the smaller country has a greater incentive to privatize its port operation

Ports being complements in port charges

- Matsushima and Takauchi (2014)
  - Trade between two countries must use both trading partners' ports, and goods go through (by sea or land) between the two ports → transport cost
  - Domestic demand for goods made domestically increases in both port charges and transport cost
  - Foreign demand for domestically made goods (i.e. port traffic volume) decreases in both port charges and transport cost
  - Port charges are strategic substitutes
  - Lower transport cost shifts both reaction functions outward → equilibrium port charges increase, and such an impact is stronger for private ports than public ports

→ When transport cost is very low, port privatization is more likely to happen and private ports tend to charge more than public ports; When transport cost is very high, the opposite holds.

Other issues studied in the literature (cont'd)

- **Inter-regional coordination** among local governments when investing in hinterland accessibilities (Wan et al., 2016)
  - When ports are public, the worst coalition (coalition between two captive port regions) is stable when captive markets are large; the non-cooperative case is stable when captive markets are small
  - When ports are private, the coalition between one captive region and the inland is stable if captive markets are small; non-cooperative case is stable when captive markets are large

Ports being complements in port congestion costs ("knock on" effect)

- Jiang et al. (2017)
  - Ships call two ports in sequence and in a circle
  - Each cargo (shipment) only pays the port charge of its destination port
  - Each port serves its own market and hence <u>ports do not compete for shippers</u>
  - However, the delay due to congestion in the first port will be carried over and added to the delay of cargoes to be handled in the second port – the "knock on" effect
  - Such congestion externality makes the ports look like "competing":
    - An increase in one port's charge reduces its traffic and congestion, leading to less knock-on effect and hence an increase in the other port's traffic

- Jiang et al. (2017) (cont'd)
  - However, when the knock-on effect is strong, such "competition" might be harmful to social welfare by charging too low and invest too little → Common ownership of the ports might be desirable
    - Two independent profit-maximizing ports may set port charges below the social optimum
    - Independent operation leads to substantially less capacity investment compared with social optimum and joint profit maximization; the latter two have the same capacity investment rule

Missing pieces in analytical models

- Port congestion + captive markets
  - Similarly, a rail/road link between the port and the rest of the transport system and the link is shared by both captive and inland cargos, e.g. the bridge linking Yangshan Port to Shanghai
  - Capacity change on this link affect both the captive and inland cargos as the case of port → who should make such an investment? Port? Local government?
- Inter-region corridors + captive markets

Missing pieces in analytical models (cont'd)

- Local commuter traffic within inland region 3
- A comprehensive comparison
  - Price vs. quantity competitions
  - Private vs. public ports
- Asymmetric (mixed) port ownership; asymmetric captive market sizes
- Shipping lines' behavior: e.g. Wu et al. (2017) "Do larger ships visit fewer regions/ports? An empirical analysis on global liners serving China"

Relevant empirical questions to validate assumptions in theoretical models

- Who set port/terminal charges and capacities in a port and their objective functions? (Tezuka & Ishii, 2016)
  - Are they constrained by certain contracts or regulations?
  - Different facilities are owned/operated by different players, while owners/operators may not be the final decision makers
  - Do public (government-owned) ports maximize social welfare or which part of the social welfare?

Relevant empirical questions to validate assumptions in theoretical models (cont'd)

- Relationship between ports: substitutes or complements, or both?
- Port strategies: price vs. quantity
- Impacts of various accessibility improvements on port charges and throughput volumes

Existing empirical studies

- Limited empirical studies testing the relationship between port charge (or quantity) and landside accessibility
- Econometric models mainly investigate the impact on port throughput (or market share) but not port charge
- Multinomial logistic or binary logit models
  - Inland to port distance, transport cost, or transport time as one of the variables that determine the net utility of shipping via a port vs. other alternative ports
  - Estimate ports' market-share change if any of the determining factors changes

Other econometric models

- Impact on port throughput (Wan et al., 2013)
  - A panel of 11 US container ports; annual data from 1982 to 2009
  - Linear regression in log-log form
  - Dependent variable (DV) = container throughput;
  - Hinterland accessibility-related independent variable (IV) = Own or rival's urban road congestion (i.e. delay per peak traveler), own or rival's road capacity (i.e. total lane-miles)

Other econometric models (cont'd)

- Impact on port productivity (Turner et al, 2004; Wan et al., 2014)
  - Panel data, USA or Canadian container ports
  - Two-stage: DEA + Tobit regression
  - Regression DV = DEA scores;
  - Regression hinterland accessibility IV = Number of railroads, availability of on-dock rail, own and rival's urban road congestion, feasibility of double-stack railcars, share of terminal area with immediate access to on-dock rail

Other econometric models (cont'd)

- Impact of hinterland accessibility on gateway port attractiveness (Yang et al., 2016)
  - Panel data: 31 provincial regions in China which may use Shanghai port as the gateway port, from 1994 to 2012
  - Linear regression and logistic regression
  - DV = attractiveness of Shanghai in being the gateway of a region (share of a region's trade which uses Shanghai as the gateway)
  - Hinterland accessibility IV = Freight rail (and road) distance from the region to Shanghai, region's highway density, Yangtze River Basin dummy (=1 if the region is accessible by Yangtze River directly, i.e. via inland waterway)

Simulation/case-study/numerical examples (with hinterland accessibility being modeled)

	Inclusion of hinterland accessibility	Ports studied	Application of game theory	Issue
Luo & Grigalunas (2003)	Yes, in the form of fees paid to truck or rail and time spent on truck/rail modes	14 US coastal container ports	No	Use a shortest path algorithm to simulate/estimate the distribution of container cargos among US container ports and each port's serving area
Saeed & Larsen (2010)	Yes, in the form of inland rail and truck transport costs	Port of Karachi	Yes, Bertrand competition	Coalition among terminal operators within the same port and competition between coalition members and non-members
Zongdag et al. (2010)	Yes, in the form of hinterland transport cost and time	Antwerp, Rotterdam, Bremen, and Hamburg	No	Introduce a port competition simulation model which uses multinomial logit model to assign trade flow between each OD market to individual transportation chains based on the generalized transport cost of each chain (incl. sea transport cost and time, port handling cost and time, as well as hinterland transport cost and time). The model can be applied to study how changes in hinterland transport costs would affect the market share of each port
Lee & Farahmand (2013)	Yes, marine-rail intermodal transport	Container ports on the west coast of North America (2 in Canada, 6 in USA and 2 in Mexico)	No	Use discrete-event simulation to model marine-rail intermodal transportation that imports cargo from China and South Korea to selected destinations in the US. Study how disruptions occurred at ports would divert traffic to other ports. Shorter rail travel distance and double-stack rail might increase the possibility of diversion

Issues yet studied empirically

1. Impact of hinterland accessibility on ports' pricing
2. Distinguish impacts of different types of hinterland accessibility improvement projects
   - Types of projects can be distinguished based on which port is benefited by the project
   - Types of projects can be defined based on the type of landside facility being improved: captive intra-region, rival's captive intra-region, inter-region, rival's inter-region, common inland's intra-region, etc.

Issues yet studied empirically (cont'd)

3. Investigate influential factors for the level of coordination in accessibility improvement projects

- These projects can be, but not limited to, physical expansion on roads and rail networks, deepening of inland waterways, technology advancement and managerial innovations which increase operational efficiency or reduce user cost of transport facilities, programs which lift various barriers or inconvenience in intermodal cargo flows, etc.

A possible model specification for issue 2

$$Y_i = \alpha_0 + (\alpha_1 D_{1i} + \alpha_2 D_{2i} + \alpha_3 D_{3i}) \cdot M_i + \alpha_4 T_i + \varepsilon_i$$

- Y_i = the % throughput change for port i based on the throughput difference between the year after the project completion and the year right before that
- Dummy variables
  - D_{1i} = 1 if the project improves accessibility to the port itself
  - D_{2i} = 1 if the project improves accessibility to the rival port
  - D_{3i} = 1 if the project improves accessibility to both ports
- M_i = the monetary amount of project investment
- T_i = growth in international trade value of the inland and the local markets where the port serves

A possible model for issue 3

- Standard logistic regression
- Dependent variable: the type of coordination
  - There are four types: no coordination, coordination between one port and the hinterland, coordination between two major competing ports, and coordination among the hinterland and two competing ports.
- The independent variables:
  - the project type
  - the ownership structure of the competing ports
  - relative market size measured by the ratio of local and inland size of population or trade-related business
  - the amount of investment

Difficulty in carrying out empirical studies

- Some difficulty may be overcome for a small scaled study or a case-study type simulation which involve in a few (2 or 3) ports with limited time periods (one or two years). But for econometric models, we need a large sample of port cities (with maybe time series for many periods)
- Lack of large scale, detailed and standardized data, esp. landside (incl. local and hinterland) transport development information
  - When the facility is developed? Who own/operate it at what investment cost? Cost of using it?
  - Such information is very fragmented and difficult to trace and standardize as infrastructure develops across time
  - It is relatively easy to find ownership/development information about port facility (i.e. terminals), but not landside transportation

Difficulty in carrying out empirical studies (cont'd)

- Complex and varying landside transport systems encountered by different ports/terminals. Which transport facility should be considered? Which should be considered as local system or inter-region system?
  - Rail, local roads, highways, inland waterway
  - Cargo dedicated or sharing with other traffic, on-dock/off-dock
  - Need sufficient geographic knowledge about each port and its major markets and knowledge about local transport system to understand which routes are used by port-related traffic
  - Difficult to identify which landside transport development is related to the port and ports usually do not announce such information, as it is usually considered as part of urban/city planning

Difficulty in carrying out empirical studies (cont'd)

- Identify location of captive and inland markets
- Distinguish gateway vs. transshipment cargo traffic volume
- Measure accessibility:
  - Time (delay), capacity, expenses (various fees/charges), service level/frequency
  - Accessibility is not just about the infrastructure but also affected by the related **service providers**, e.g. availability of freight forwarder, NVOCC, 3rd-party LSP, and truck drivers
  - Not just about how to measure, but also difficult to obtain all the data-

Difficulty in carrying out empirical studies (cont'd)

- Identify cooperative arrangements among governments or ports in developing facilities
- Identify which ports/terminals are compete in which markets and identify rival ports
- Measure (calculate) port charges

THANK YOU