Regional Economic Competition and Containerized Freight Shipping: A Study of Regional Accessibility in the United States and Lessons for China

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May 29, 2009

Outline

- Introduction
- Intermodalism
- Intermodalism and the Spatial Economy
- Research Questions
- Accessibility: Concept and Measures
- Methodology and Data Overview
- Domestic Accessibility
- Accessibility to Sea Ports
- Main Conclusions

Introduction

- Transportation and economic/regional development
  - Controversial link
  - Common wisdom is that 'better transportation' brings lower transaction costs, higher productivity
  - At issue: is development localized? and if so, where?
- 1991 U.S. Intermodal Surface Transportation Efficiency Act (ISTEA)
  - Integration of shipping across modes of transportation
  - Goal of fostering economic development
- The focus: intermodalism and regional economic advantages

Intermodalism

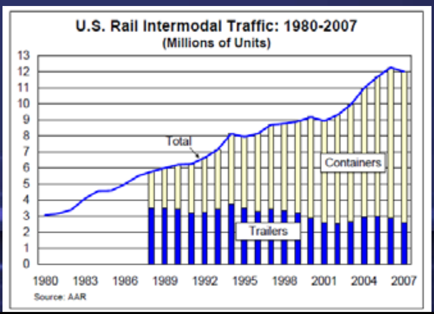
- A definition: 'Intermodal transportation' is the movement of goods (in one and the same loading unit or vehicle), which uses successfully several modes of transportation without handling of the goods themselves in transhipment between the modes (ECMT, 1998)
- Objective of intermodalism is effective connections and coordination among different modes of transportation: interoperability
- Creates interconnectivity of networks framed around remarkable locations:
  - Priority corridors
  - Transfer nodes

Intermodalism (Cont.)

- Advantages:
  - Improves security
  - Faster
  - Less loss and damage
- History:
  - Coal of English canals (19th century)
  - Pallets during WWII
  - The Box
- Creates interconnectivity of networks framed around remarkable locations:
  - Priority corridors
  - Transfer nodes

Intermodalism (Cont.)

- Intermodalism has become prominent in U.S. freight shipping with the steady increase in interstate and international trade, deregulation, new technologies, and the pressure to reduce logistic costs
- Intermodal movements have grown rapidly over the past 20 years; yet, it still represents a very small portion of the total freight market



Intermodalism (Cont.)

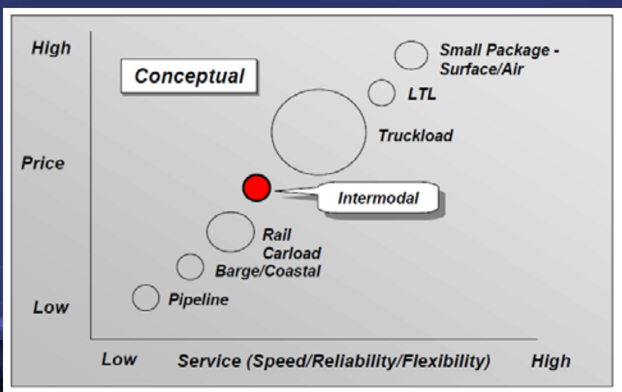
- Intermodalism encompasses extensive network of freight movements through truck-rail, truck-water, and rail-water combinations

Mode	Percent of value	Percent of tons	Percent of ton-miles
All Modes	100.0	100.0	100.0
Singles Modes	88.9	97.0	92.4
Truck	69.5	60.1	34.4
Rail	3.0	10.2	31.1
Water	5.2	8.6	11.0
Air (incl. truck & air)	4.3	0.0	0.3
Pipeline	6.9	18.1	15.6
Multiple Modes	8.9	1.2	5.3
Parcel, postal, or courier	7.8	0.1	4.8
Truck and rail	**0.6**	**0.3**	**1.1**
Other multiple modes	0.2	0.8	3.7
Unknown Modes	2.5	1.9	2.3

Source: Bureau of Transportation Statistics

Intermodalism (Cont.)

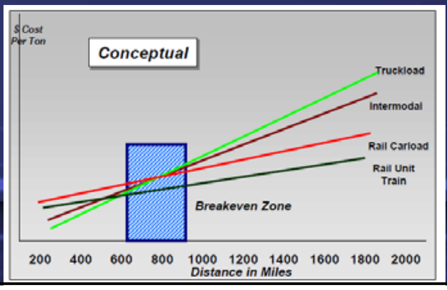
- Truck-rail intermodal
  - Combines the efficiency of rail transportation and the flexibility and convenience of trucking
  - Intermodal fills a price/service gap between rail carload and truckload transportation



(TIOGA Group, 2003)

Intermodalism (Cont.)

- Truck-rail intermodal
  - Intermodal rates are typically 15 to 20 percent below motor carrier rates for comparable moves
  - Transit times may be 2 or 3 days longer and more variable, depending on the length of haul
  - Either trailer on flat car (TOFC) or container on flat car (COFC)
  - The intermodal solution is economically viable only if a reduction of the generalized impedance on modal segments compensates for the additional trans-shipment cost
  - Not competitive under 500 miles



(TIOGA Group, 2003)

Intermodalism (Cont.)

- Half the truck-rail intermodal traffic is domestic
- Truck-rail intermodal captures about 15% of U.S. intercity freight traffic at 1000-1500 miles; and much more for high value goods…

Intermodalism and the Space Economy

- The logistical integration of distribution networks through intermodal processes has triggered a transformation in the economic significance of places and spaces at scales ranging from the local to the global perspective (Roson and Soriani, 2000; Priemus and Konings, 2001; Rodrigue 2004)
- Transformation is not limited to points of transfer between modal networks, however
- Because intermodal networks constitute the backcloth on which the physical distribution system operates, erosion to trans-shipment impedances can be expected to generally lead to an improvement of accessibility throughout the area served by the network, although not necessarily with the same intensity at all locations

Intermodalism and the Space Economy (Cont.)

- This process mirrors the contraction of space ensuing improvements to the physical transportation infrastructure of a region or continent (Spiekermann and Wegener, 1994; Vickerman et al., 1999; Bruinsma and Rietveld, 1998)
- The concept of accessibility encapsulates the potential use of infrastructure for shipping commodities, which may contribute to reshaping the space economy (Rietveld and Bruinsma, 1998).

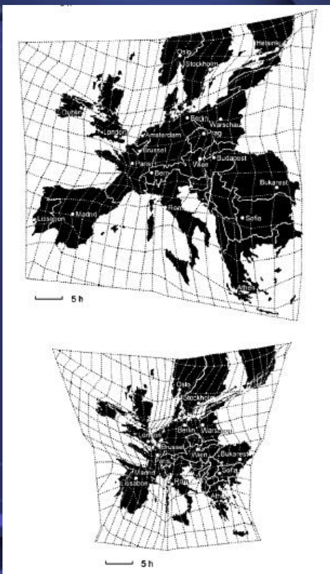


Fig. 3. Time-space maps of Europe (base map) and the European Railway Network in 1993 and 2010

Intermodalism and the Space Economy (Cont.)

- Accessibility impacts of transportation infrastructure
  - Common regional policy evaluation tool in Europe
  - Rail accessibility on the scale of the whole of Europe: Gutiérrez et al. (1996), Vickerman et al. (1999), and Gutiérrez (2001)
  - Highway accessibility on the scale of the whole of Europe: Bruinsma and Rietveld (1993), Gutiérrez and Urbano (1996)
  - At more local scale, Dodgson (1974) on M62 motorway and Linneker and Spence (1991, 1992) on M25; Gutiérrez et al. (1998) applied to Spain’s highway

Intermodalism and the Space Economy (Cont.)

- Before-after studies of accessibility impact have concluded
  - System-wide accessibility improvements exist
  - Their magnitude hinges upon the nature, location, and significance of the infrastructure enhancement
  - Little consistency on the issue of the spatial equity in accessibility
  - Some studies have indicated that resulting accessibility is more equalized across regions (for instance Gutiérrez and Urbano, 1996; Bruinsma and Rietveld, 1994)
  - Others suggest that differences in accessibility may widen rather than shrink between central and peripheral regions (Spence and Linneker, 1994; Vickerman et al., 1999)
  - Others point to the emergence of opposite trends at different geographic scales. For instance, greater inequity in the distribution of accessibility is anticipated on a national scale from the completion of a new high-speed rail line between Madrid, Barcelona, and the French border, yet core-periphery imbalances could be reduced within the European context (Gutiérrez and Urbano, 1996).

Intermodalism and the Space Economy (Cont.)

- Why does accessibility matter?
  - Transportation improvements reduce freight shipping costs
  - A region can take advantage of these conditions to develop its economy
  - However, this is not a sufficient condition

A relative increase in accessibility brought by capital investment in transportation or by the advent of an integrated intermodal transportation system does not necessarily translate into greater competitiveness for a region over others. However, it provides significant impetus that can be leveraged to enhance a region's overall competitive advantage in the national space-economy.

Research Questions

- What is the potential impact of freight intermodalism on accessibility nationwide, both domestically and in shipping to seaports?
- How does the potential economic impact of freight intermodalism on accessibility vary across the United States?
- In terms of locational advantages, has intermodalism in ground freight transportation promoted polarization or decentralization?
- Which economic and locational variables have contributed to the improvement in accessibility due to intermodalism?

Accessibility: Concept and Measures

- The concept: How easily any economic opportunity can be reached from a particular location based on a particular transportation system
- The measure: Hansen potential measure

$$A_i = \sum_{j \in L} W_j \, f(c_{ij}; \beta)$$

A_i is the measure of accessibility at location i.

L is the set of all potential destinations.

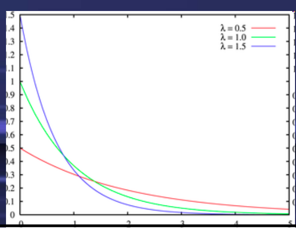
W_j is the indicator of business opportunities at location j.

$f(c_{ij}; \beta)$ is the impedance function of travel cost c_{ij} with coefficient β

Accessibility: Concept and Measures (Cont.)

- For potential OD pairs above 500 miles only
- Domestic measure of business opportunities at potential destination j: $W_j = \frac{P_j}{\sum_i P_i} X + \sum_k \frac{E_{jk}}{\sum_i E_{ik}} Y_k$
- Export measure of business opportunity at potential destination j:
  - Container exports
- Exponential function as network impedance function:

$$f(c_{ij}) = \exp(-\lambda c_{ij})$$

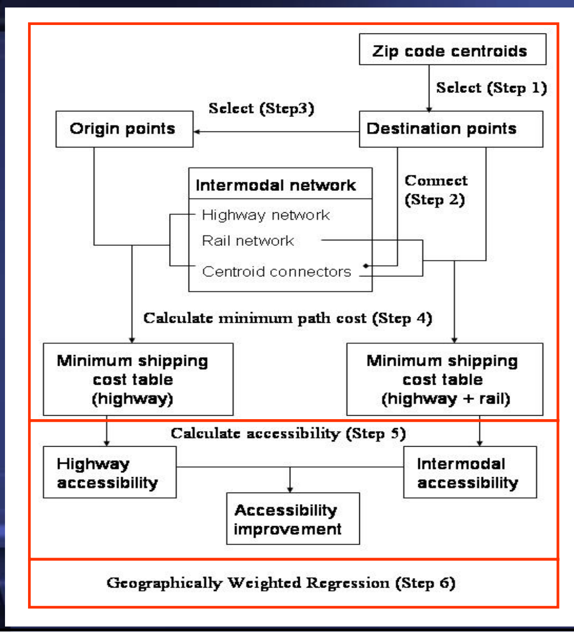


Accessibility: Concept and Measures (Cont.)

- Propose three scenarios to reflect different sensitivities of freight shipping to cost of shipping on the network.
- For the shipping cost of 1000, direct effect of the economic opportunities W_j on freight flow attraction is discounted by:

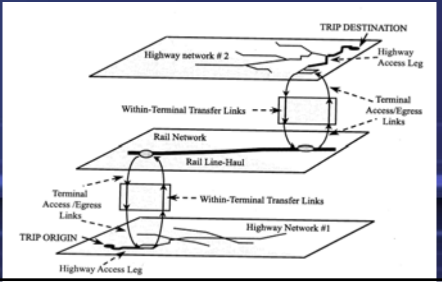
1) High: 95% (Scenario 1; $\lambda = 0.0030$)
2) Medium: 90% (Scenario 2; $\lambda = 0.0023$)
3) Low: 75% (Scenario 3; $\lambda = 0.0014$)

Methodology Overview



Data Overview

- Intermodal network
  - Source: Center for Transportation Analysis, Oak Ridge National Laboratory
  - Independently constructed single-mode networks for highway, rail (water excluded)
  - A set of intermodal terminals and a terminal model to connect them
  - Accompanies 1997 Commodity Flow Survey (CFS) dataset that served to calibrate the link impedances
  - 401 truck-rail terminals
- Structure of Intermodal Network



Source: Southworth and Peterson (2000)

Data Overview (Cont.)

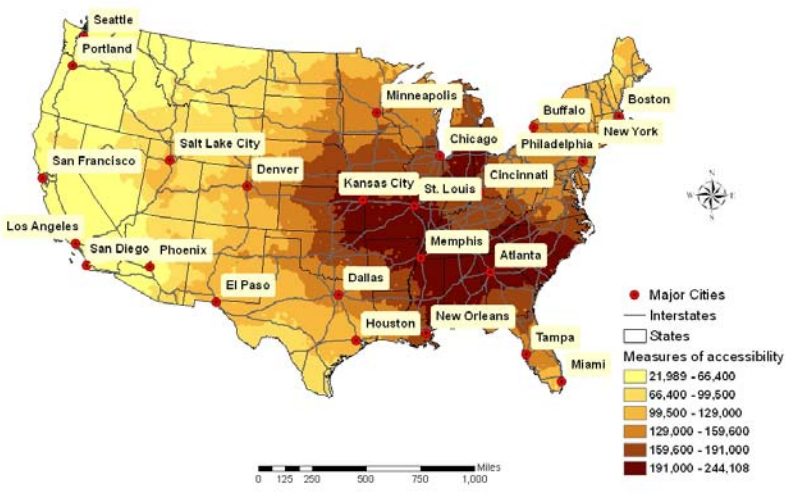
- Five-digit zip code centroids (31,906)
- Population and sectoral employment
- Container traffic (1000 TEUs)
  - Transshipment via Canada
    - Vancouver (2% from US)
    - Montreal (45%)
    - Halifax (30%)

ID	PORT NAME	TOTAL	EXPORT	IMPORT
1	Los Angeles/Long Beach, CA.	7,875	1,745	6,010
2	New York, NY.	2,803	838	1,965
3	Charleston, SC	1,250	529	721
4	Savannah, GA.	1,124	529	595
5	Norfolk, VA.	1,093	460	633
6	Oakland, CA.	1,064	548	517
7	Houston, TX	933	483	450
8	Tacoma, WA.	931	337	594
9	Seattle, WA.	815	329	486
10	Miami, FL.	764	336	428
11	Port Everglades, FL.	423	236	187
12	Baltimore, MD.	307	115	192
13	New Orleans, LA.	237	139	98
14	Portland, OR.	210	147	63
15	Gulfport, MS.	204	94	110
16	Wilmington, DE.	195	29	166
17	Palm Beach, FL.	140	106	34
18	Jacksonville, FL.	113	72	42
19	Philadelphia/Camden, PA	110	16	95
20	Boston, MA.	93	34	58
21	New Port News, VA.	80	32	48
22	Chester, PA.	73	28	44
23	Wilmington, NC.	72	28	44
24	San Diego, CA.	53	9	44
25	Freeport, TX.	50	23	28
26	Richmond, VA	41	20	21
27	Port Bienville	25	23	2
28	Fernandina Beach, FL.	12	8	5
29	Gramercy, LA.	7	1	6
30	Galveston, TX.	6	2	5
31	Tampa, FL.	6	3	2
32	Lake Charles, LA.	4	4	0
33	Portland, ME.	2	1	2
34	Gloucester City, NJ.	1	1	0

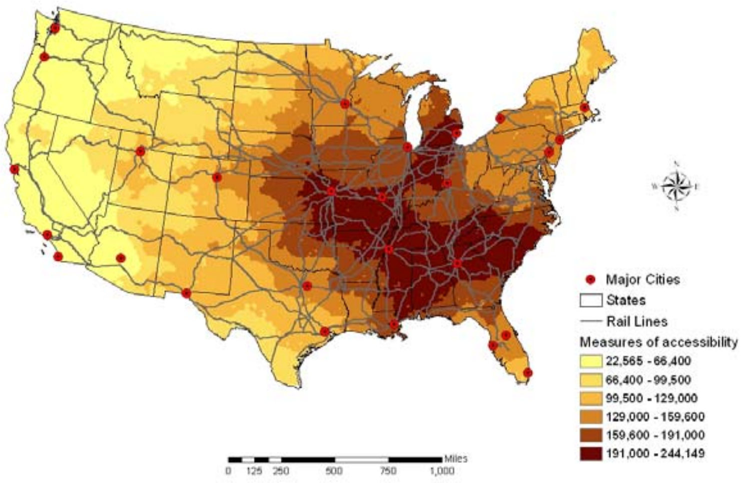
Source: Port Import Export Reporting Service (PIERS)

Domestic shipping

(1-a) Measures of accessibility based on highway networks (Scenario 1)



(1-b) Measures of accessibility based on intermodal networks (Scenario 1)



Accessibility Surfaces

Descriptive statistics of accessibility measures under different scenarios of sensitivity to shipment impedances

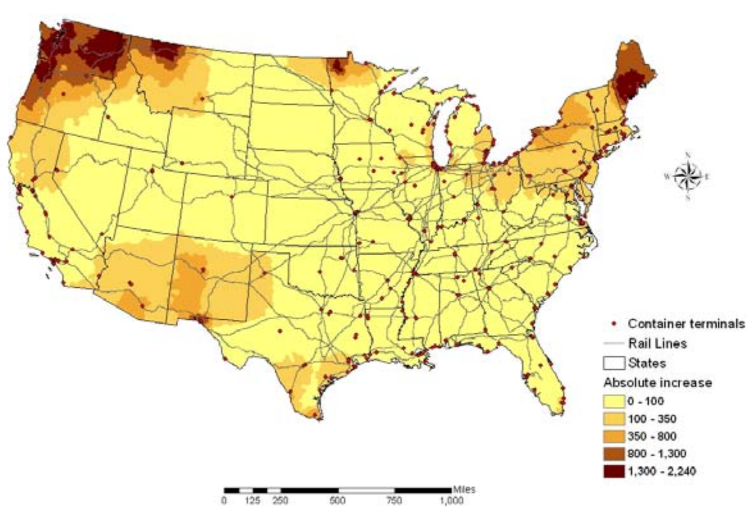
	Scenario	λ Parameter	Min	Mean	Max	Standard Deviation	Coeff. Variation (%)
Highway Network	1 (High)	0.0030	21,411	136,064	244,615	53,113	39.03
	2 (Medium)	0.0023	51,077	248,418	396,763	82,984	33.40
	3 (Low)	0.0014	195,061	584,083	822,588	142,700	24.43
Intermodal Network	1 (High)	0.0030	21,457	136,221	244,657	52,969	38.88
	2 (Medium)	0.0023	51,305	248,955	396,791	82,424	33.11
	3 (Low)	0.0014	200,405	586,507	822,655	139,757	23.83

Accessibility Gains and their Correlates

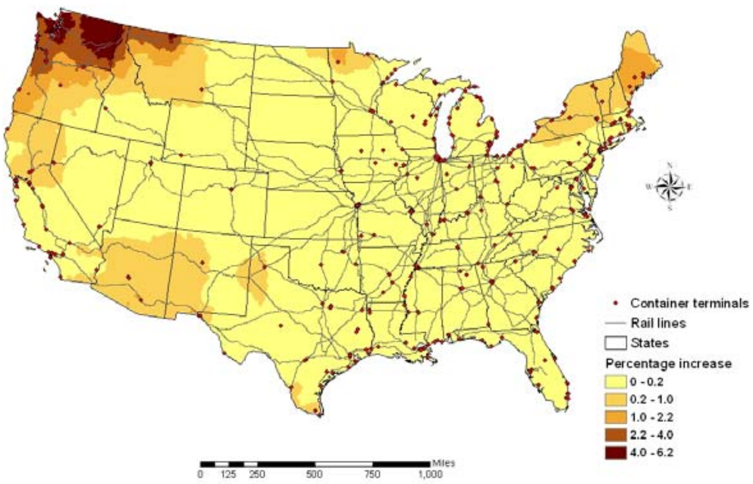
Descriptive statistics of accessibility gain under different scenarios of sensitivity to shipment impedances

	Scenario	λ Parameter	Min	Mean	Max	Standard Deviation	Coeff. Variation (%)
Absolute Gain	1 (High)	0.0030	0.00	157.02	2,240.75	315.06	200.65
	2 (Medium)	0.0023	0.00	537.27	7,457.18	1,096.14	204.02
	3 (Low)	0.0014	0.00	2,423.91	33,639.82	5,105.10	210.61
Percentage Gain (%)	1 (High)	0.0030	0.00	0.25	6.18	0.75	300.00
	2 (Medium)	0.0023	0.00	0.43	8.71	1.21	281.40
	3 (Low)	0.0014	0.00	0.67	12.21	1.76	262.68

(1-c) Absolute gain in accessibility due to intermodalism (Scenario 1)



(1-d) Percentage gain in accessibility due to intermodalism (Scenario 1)



Accessibility Gains and their Correlates (Cont.)

Regression models of the absolute gain in accessibility (Scenario 2)

Global Regression Results

Number of observations: 6,572
R^2: 0.332
F statistic = 815.521 (prob. < 0.000)

Variables	Description	Coefficients	Std Error	*t*-value	P-value
Intercept		3,334.014	71.581	46.716	<0.001
Acshway	Highway accessibility	-0.00845	0.000	-57.036	<0.001
Ln(Econpot)	Economic attraction	-19.331	6.859	-2.818	0.005
Ln(Raildist)	Distance to the closest rail line	-122.173	11.954	-10.220	<0.001
Termimped	Impedance to closest intermodal terminal	-2.851	0.144	-19.818	<0.001

GWR Results

R^2: 0.911

Variables	Coefficients				
	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Intercept	-763.921	24.971	391.721	1,520.039	14,758.896
Acshway	-0.095	-0.004	-0.001	0.000	0.0132
Ln(Econpot)	-66.108	0.442	2.890	10.088	145.361
Ln(Raildist)	-459.018	-18.039	-3.620	1.757	156.778
Termimped	-16.941	-1.125	-0.308	0.038	8.401

Accessibility Gains and their Correlates (Cont.)

Regression results of the relative gain in accessibility (Scenario 2)

Global Regression Results

Number of observations: 6,572
R^2: 0.333
F statistic = 818.939 (prob. < 0.000)

Variables	Description	Coefficients	Std Error	*t*-value	P-value
Intercept		3.534	0.079	44.631	<0.001
Acshway	Highway accessibility (÷ 1000)	-0.009	0.000	-57.126	<0.001
Ln(Econpot)	Economic attraction	-0.028	0.008	-3.693	<0.001
Ln(Raildist)	Distance to the closest rail line	-0.126	0.013	-9.560	<0.001
Termimped	Impedance to closest intermodal terminal	-0.003	0.000	-18.966	<0.001

GWR Results

R^2: 0.948

Variables	Coefficients				
	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Intercept	-0.294	0.047	0.225	0.857	21.735
Acshway	-0.164	-0.003	-0.0005	-0.0001	0.010
Ln(Econpot)	-0.090	0.000	0.001	0.004	0.121
Ln(Raildist)	-0.418	-0.008	-0.001	0.001	0.084
Termimped	-0.018	0.000	0.000	0.000	0.004

Main Conclusions - domestic

- Freight shipping accessibility measures vary greatly across the country; they are sensitive to the transportation cost decay parameters
- Intermodalism (slightly) enhances accessibility, but according to an uneven spatial pattern
- Accessibility gains exhibit tremendous variance nationwide

Main Conclusions (Cont.)

- With lower friction of distance, overall accessibility gains are larger
- With lower friction of distance, more evenly distributed nationally in relative terms, but less in absolute terms
- Geographic patterns of accessibility do not vary with friction of distance
- Accessibility gains tend to happen more in areas that are small, close to rail lines and terminal, and have poor highway accessibility

Main Conclusions (Cont.)

- Accessibility gap between central and peripheral U.S. regions is slightly reduced by intermodalism: spatial equity remains problematic
- In a multimodal world, locational advantage manifests itself at a finer geographic scale
- From a public policy standpoint:
  - Overall, conditions for economic development are set
  - Regionally, there are small winners and big winners
  - Simple core-periphery model does not hold: some peripheral regions are becoming more accessible with intermodal service, but not enough to make up their handicap over the most accessible locales
  - Vickerman’s tyranny of geography remains potent in many instances

Export shipping

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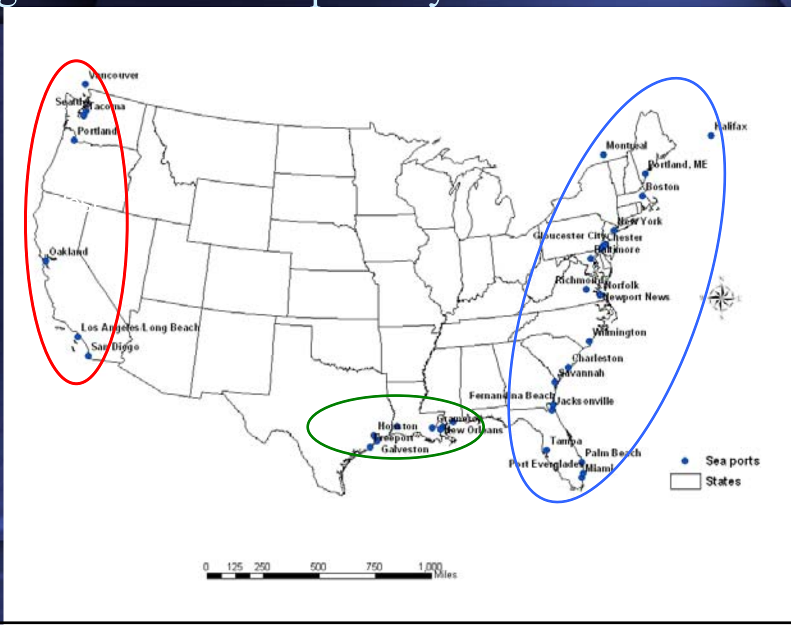
Segmentation of sea ports by coast line



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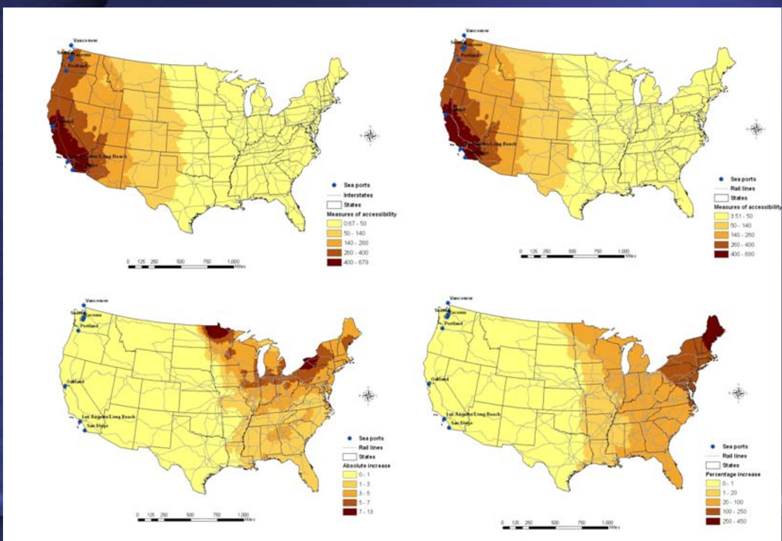
Descriptive statistics of accessibility measures (West Coast)

Scenario	Accessibility	Count	Minimum	Mean	Maximum	Std. Dev.	Coeff. Var.
1 (β = 0.0030)	Highway accessibility	6572	0.05	35.66	460.87	67.46	1.89
	Intermodal accessibility	6572	0.44	36.08	460.87	67.27	1.86
	Absolute gain	6572	0.00	0.42	5.04	0.56	1.33
	Relative gain (%)	6572	0.00	46.68	888.23	111.06	2.38
2 (β = 0.0023)	Highway accessibility	6572	0.67	78.61	680.98	117.03	1.48
	Intermodal accessibility	6572	3.50	80.34	680.99	116.06	1.44
	Absolute gain	6572	0.00	1.73	13.27	2.07	1.19
	Relative gain (%)	6572	0.00	29.60	450.13	61.10	2.06
3 (β = 0.0014)	Highway accessibility	6572	18.72	266.60	1,174.41	242.25	0.91
	Intermodal accessibility	6572	49.32	276.60	1,174.44	235.02	0.84
	Absolute gain	6572	0.00	10.00	56.54	12.06	1.20
	Relative gain (%)	6572	0.00	14.88	171.57	26.22	1.76

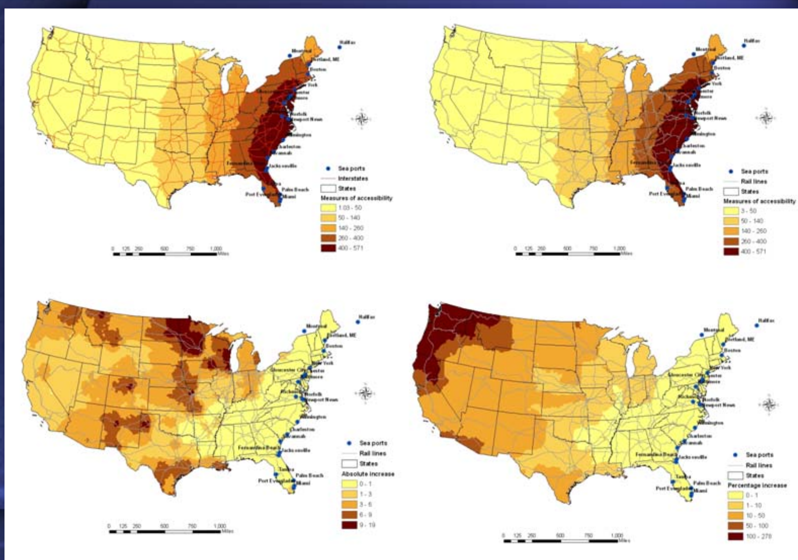
West Coast ports (Scenario 2; ß = 0.0023)



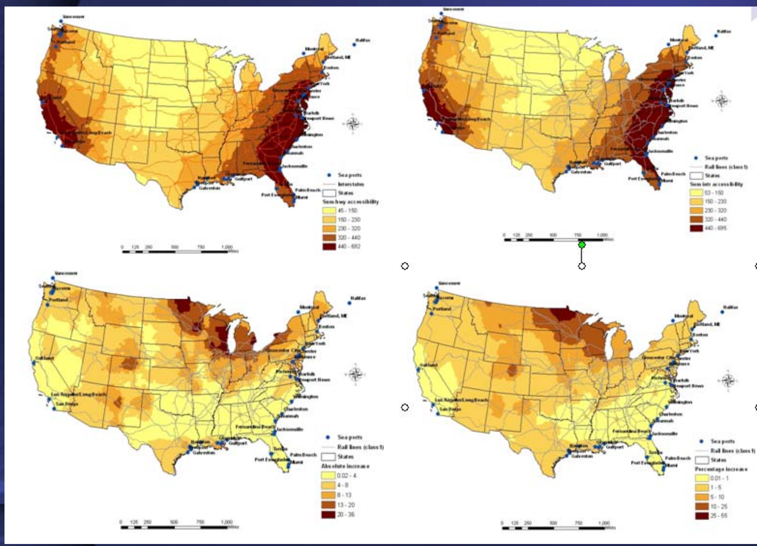
Descriptive statistics of accessibility measures (East Coast)

Scenario	Accessibility	Count	Minimum	Mean	Maximum	Std. Dev.	Coeff. Var.
1 (β = 0.0030)	Highway accessibility	6572	0.08	66.39	351.64	86.32	1.30
	Intermodal accessibility	6572	0.40	67.48	351.64	85.82	1.27
	Absolute gain	6572	0.00	1.09	6.51	1.07	0.98
	Relative gain (%)	6572	0.00	34.73	478.53	73.56	2.12
2 (β = 0.0023)	Highway accessibility	6572	1.00	139.70	573.62	150.57	1.07
	Intermodal accessibility	6572	3.26	143.06	573.62	148.82	1.04
	Absolute gain	6572	0.00	3.36	18.84	2.98	0.88
	Relative gain (%)	6572	0.00	23.58	278.60	45.44	1.92
3 (β = 0.0014)	Highway accessibility	6572	24.60	416.56	1,128.17	306.38	0.73
	Intermodal accessibility	6572	49.88	430.58	1,128.17	297.00	0.68
	Absolute gain	6572	0.00	14.01	64.60	12.74	0.91
	Relative gain (%)	6572	0.00	12.61	122.58	21.55	1.71

East Coast ports (Scenario 2; ß = 0.0023)



All ports
(Scenario 2; ß = 0.0023)



Main Conclusions - export

- Freight shipping accessibility measures vary greatly across the country; they are sensitive to the transportation cost decay parameters
- Intermodalism enhances accessibility, sometimes quite significantly, but according to an uneven spatial pattern
- Accessibility gains exhibit tremendous variance nationwide
- Accessibility gains tend to happen more in areas that are small, close to rail lines and terminal, and have poor highway accessibility

Main Conclusions (Cont.)

- Accessibility gap between central and peripheral U.S. regions is slightly reduced by intermodalism and differentially with respect to the three sets of ports: spatial equity remains problematic
- In a multimodal world, locational advantage manifests itself at a finer geographic scale
- From a public policy standpoint:
  - Overall, conditions for economic development are set
  - Regionally, there are small winners and big winners
  - Simple core-periphery model does not hold
  - Vickerman's tyranny of geography remains potent in many instances

Lessons for China

- 2002 Plan for railroad containerization: 15 priority (inland) load centers

(Loo and Liu, 2005)

Lessons for China (Cont.)

- Intermodalism enhances accessibility, and in turn economic development
- Localized effects
- Intermodal is competitive for short drayage distances only
- Rail network needs to be efficient (double stacking), reliable
- Local roads to inland load centers need to be free of congestion, reliable
- Inland load centers will contribute to a more balance economic development pattern in the country
- Benefits could outstrip those noted in the US where highway access is much less favorable
- Coastal provinces will maintain their locational advantages
- Spatial equity will not be the outcome of the process

Thank you!

Any questions?

For more information:

Lim, H., and J.-C. Thill. "Intermodal Freight Transportation and Regional Accessibility in the United States," Environment and Planning A, 40, 2008, 2006-2025.

Thill, J.-C., and H. Lim. "Intermodal Containerized Shipping in Foreign Trade and Regional Accessibility Advantages," Journal of Transport Geography, 2009, in press.