LOGISTICAL RIVALRIES AND IMPACTS OF CANADA'S LOGISTICS SYSTEMS ON U.S. CONTAINER SUPPLY CHAIN

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Introduction

A surge in global commerce has been driven by growth in container trade. North Asia and Europe are major trade partners of the United States in container, and, the Transpacific trade lane is one of the world's highest volume arteries. North American transportation gateways and associated transportation networks for containers play critical roles in international merchandise trade. Global economics is driving the use of larger ships due to their economies of scale. Ports that can handle these large vessels are expected to increase market shares. Container traffic in the United States is highly concentrated and is becoming even more so as larger vessels call on ports that are capable of handling them. As a result of the concentration, there is substantial strain on capacity at most US ports as well as associated transport corridors.

Concurrently, there has been development and expansion of competing ports and routes. The ease of shifting ports by ocean shippers and/or railroads in response to congestion, capacity, draft, and rail service relative to targeted US destinations. Inter-port competition for container shipping is intense. Of particular importance in this study are the near simultaneous expansion and

development of Prince Rupert and the Panama Canal which will reduce congestion and facilitate large-ship draft restrictions and ultimately allow a more diversified import supply chain.

The container port of Prince Rupert was designed to create capacity for 500, 000 TEUs per year in 2007. It will compete with incumbent ports and routes for shipments to the U.S. markets. The Canadian government, railways, and other private interests contributed to initiate efficient Pacific trade gateways and congestion free transportation corridors (Allison Padova 2006). However, risks remain amid increased financial and economic uncertainty.

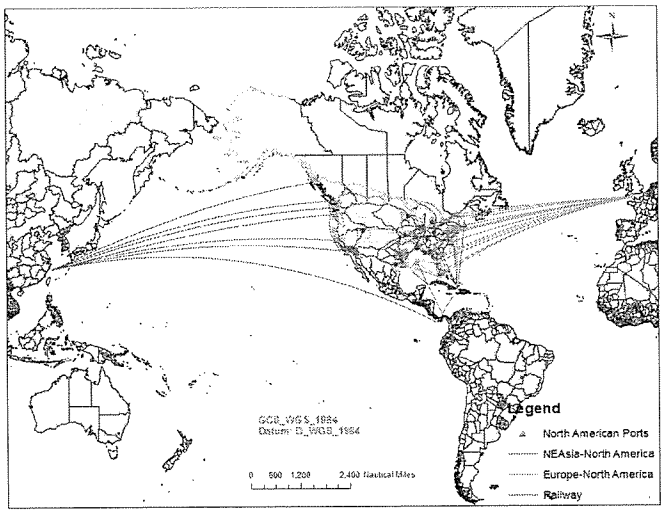
Studies of container shipments have been active area especially during the recent couple of decades with global trade booming. O'Keefe (2003, 1998) conducts study to evaluate competition between Canadian ports and U.S. container ports. Mercator Transport Group (2005) assesses the key competitor ports of San Pedro Bay, including Canadian ports of Vancouver and Prince Rupert. The Tioga Group, Inc. (2008) analyzes trends and issues affecting North American intermodal container movements with primary focus on imports activity. Wilson and Benson (2008) analyze historical movements in world container trade and in U.S. container markets. Leachman (2008) describes an economic optimization model for waterborne containerized imports from Asia to United States. Wilson and Sarmiento (2008) conduct a long term analysis of infrastructure demands and risks with toward a global forecast of container flows.

The purpose of this paper is to estimate the prospective container flows through the Canadian logistic channel for container shipments to U.S. markets. This includes container flow via those water gateways in the East and West Coasts ultimately to US markets defined by Business Economic Areas. We evaluate potential diversion of containers due to emergence of Canadian port of Prince Rupert and assess effects of uncertainty in future demand to container network flows. The results should be interesting to shippers or organizations in container supply chain.

Data and Methodology

The supply chain channels include container imports from Northeast Asia through the West Coast to U.S. inland markets, to East Coast of United States, via the Panama Canal, and European imports to U.S. markets through Gulf and East Coast. Figure 1 illustrates the global supply chain in container shipment to United States under consideration. The Transpacific – West Coast and Transatlantic East Coast trade lanes comprise both U.S. and Canadian logistics channels, i.e. the shipper or importers can choose U.S. and Canadian seaports to reach U.S. interior markets.

Figure 1. Global Supply Chain Networks for Container Imports to United States.



The objective is to minimize total cost for global supply chain, subject to infrastructure constraints, demand and demand uncertainty. Logistics capacity strains include constraints at seaports, those associated transportation corridors from water gateways, potential strains at border crossing, and constraints over primary inland

transportation corridors. The problem of an optimal of international water string, seaport, and associated inland rail lines, is formulated based on criteria of minimized total costs. The complete formulation of the model is very detail and length and given in Fan (2008) and Fan et al (2009). To be consistent, a verbal formulation is given to illustrate main concept of model.

Minimize Total Coast:
Operating costs (at-sea and in-port operating costs) of different type of vessels deployed on corresponding international lanes and serviced by different carriers plus the railway shipping rate per TEU on the inland corridor served by major North American railways.

Subject to:
The maximum TEU of a loaded containership and largest container ship type can be accommodated by North American seaports; Ship size and maximum number of container vessels are allowed through Panama Canal; Throughput constraint for import container at North American seaports and at border crossing between Canada and United States; The constraints for container flows over inland railways networks; and Container demand constraints under uncertainty.

North American logistics networks for container imports

There are 28 container ports in the model, including five in Canada. Vancouver and Prince Rupert are major ports of entry for Northeast Asia container imports. Halifax, Montreal, and Toronto are water gateways for container imports from Europe to Canada and U.S. markets. Business Economic Areas (BEAs), the geographic groups of naturally contiguously located counties that are relevant for economic analysis, are used to define the geographical distribution of demand in the United States. Chicago-Gary-Kenosha is the largest interior container demand markets, followed by Memphis, Dallas-Fort Worth, and Kansas City. Detailed procedures regarding demand estimation for import containers is described in Fan (2008).

Rail carriers have advantage over trucks for long haul shipments from seaports to interior BEAs. The major interior BEAs that Canada's system can reach includes Chicago, Memphis, Detroit, St. Louis, and Minneapolis. We use ArcGIS to map the location of container ports, BEAs for container consumption, and use Network Analyst to draw railway networks for container import activity. Figure 2 shows the Canadian network for container import to U.S. markets, as well as the U.S. market size. Prince Rupert is served only by Canadian National Railway (CN).

Canadian new developed port of Prince Rupert provides an interesting option for importers to reach the U.S. markets. Its proximity to Northeast Asia, deep water, and lack of congestion give it potential advantages for imports with container for U.S. inland markets. With channel depth of over 60 feet, Prince Rupert can handle deep draft container ships. Prince Rupert is expected to create capacity for 500,000 TEUs per year after it opened in 2007 and a planned Phase 2 expansion would quadruple capacity to two million TEUs. A second container terminal, now in its design stages, has Prince Rupert on course to handle up to 5 million TEUs by 2020, according to news from port of Prince Rupert[1]

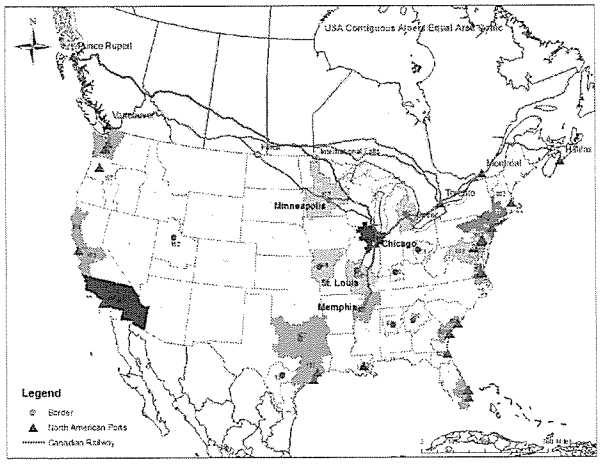
Table 1. Logistics Characteristics of Major Pacific/Gulf Logistics Channels with Origin from Northeast Asia

Port	Maximum Vessel Size (TEUs)	Inbound Ocean Cost (US$/TEU)	Outbound Rail Rate (US $/TEU)		
			Chicago	Memphis	St. Louis
P. Rupert	1,2000	150	537	638	573
Vancouver	8,000	178	478	568	.
Seattle	8,000	180	470	564	577
Tacoma	8,000	180	470	564	577
Portland	6,000	216	589	659	598
Oakland	8,000	186	558	543	488
LA/LB	14,000	168	467	491	460
Houston	4,000(8,000)	473(402)	339	286	341

Note: the values in parenthesis at port of Houston indicate vessel size and corresponding inbound costs after Panama Canal expansion.

Table 1 provides a comparison of West and Gulf Coast ports characteristics. The Estimation for ocean shipping costs for containership is based on prototypical model by Wilson and Dahl (2008) and cost estimation for large container vessel extended by Fan (2008). We use results from Fan (2008) to predict rail shipping rates from Prince Rupert to various U.S. inland markets, which is not reported by Waybill Record to days. For other rail routes, we use the shipping rates from public Waybill Record (2006).

Figure 2. Canadian Railways for Container Shipments to U.S. Interior Markets



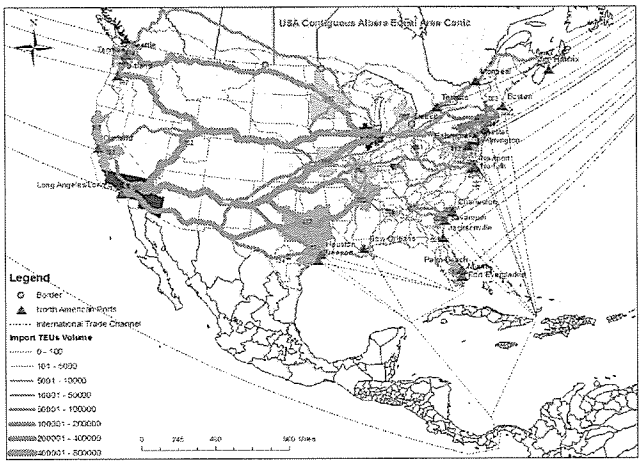
Estimate Results

Traffic flow through North American logistics system

We first validate model under deterministic environment, i.e. all parameters are deterministic. Infrastructure constraints are extracted from current observed flows. To illustrate traffic flows, the estimate for container shipment to U.S. markets (excluding Prince Rupert) in year 2006 is shown in Figure 3. The results are highly reflective of current traffic flows. Container flows are highly concentrated. The

U.S. West Coast ports are the primary gateways for container imports from Northeast Asia. The dominance of ports of Log Angeles/Long Beach is significant. The Ports of New York and Houston are main gateways at East and Gulf Coast. For the inland container movements, the primary railway corridors are from West Coast to BEAs at Chicago-Gary-Kenosha, Memphis, Dallas-Fort Worth, and Kansas City. Los Angeles/ Long Beach to Chicago is by far the most heavily concentrated corridor in United States. The results for imported container traffic over U.S. inland rail networks are consistent with another recent study such as by Cambridge Systematics, Inc. (2007), which shows the primary rail corridors at west region are more congested than those at east regions

Figure 3. Estimate Traffic Flow for Container Imports to United States.



Canadian logistics channels account for a small amount of container shipment to the United States. Table 2 shows the container flows through Canadian existing water gateways and associated transport corridors (excluding port of Prince Rupert). There are about 63,000 TEUs, 45,00TEUs, and 182,000 TEUs through Canadian ports of Vancouver, Halifax, and Montreal destined to U.S. markets,

respectively. The busiest border crossing is at Detroit (MI), which handles around 230,000 TEUs shipped from ports of Halifax, Montreal, and Toronto to United States. The results are highly reflective of actual traffic flow for containers through Canadian system to U.S. markets.

Table 2. Estimated Container Flows through Canada's Ports to U.S. Markets in Year 2006.

Origin	Canadian Port	U.S. BEAs	TEUs	Shadow Price (US$/TEU)
NE-Asia	Vancouver	Chicago	53,000	-85
NE-Asia	Vancouver	Memphis	4,000	-123
NE-Asia	Vancouver	Minneapolis	5,500	-25
Europe	Halifax	Chicago	35,000	-26
Europe	Halifax	St. Louis	6,500	0
Europe	Halifax	Detroit	4,000	-105
Europe	Montreal	Minneapolis	18,000	0
Europe	Montreal	Detroit	70,000	-153
Europe	Montreal	Chicago	95,000	0
Europe	Toronto	Chicago	3,000	-38

Estimated shadow prices for railways constraints are derived. These imply that relaxing traffic volume for containers would improve the total optimal solution. The results would shift potential strain to port of Vancouver. The Port of Vancouver is geographically constrained, and some capacity growth in the future will depend on efficiency enhancements (Allison Padova Economic Division 2006). This also indicates that expansion of transportation corridors at Canadian Pacific logistics channel is expected to diversify containers from U.S. system. Canada's Eastern ports handle a small portion of containers imported from Europe to United States. Since container volume over Transatlantic trade lane is smaller than Transpacific trade lanes, we focus on the potential impacts of Canada's new developed seaport at West Coast.

We perform analysis to assess the container flows for year 2007 within and without the port of Prince Rupert in the model. BEAs areas at Chicago-Gary-Kenosha, St. Louis, MO-IL, Memphis, and

Detroit-Ann Arbor-Flint are considered to be served by port of Prince Rupert (refer to Figure 2). The container demand at U.S. markets in year 2007 is forecasted using time series methods (Fan 2008) and shown in Table 3 (Total Demand TEUs) for BEAs that can be served via Prince Rupert. Otherwise the data and parameters are unchanged. It needs to address that this scenario does not consider the potential congestion over U.S. logistics system.

The estimate shows around 118,000 TEUs via Prince Rupert, in which about 100,000 TEUs diversify from U.S. West Coast and 18,000 TEUs from U.S. East Coast (see Table 3 and Table 4). There are big impacts to U.S. West Coast ports of Oakland and Portland.

Table 3. Predicted Containers Traffic via Canada's Port of Prince Rupert to U.S. Markets for Year 2007.

Origin	Canadian Port	U.S. BEAs	TEUs	Total Demand (TEUs)
Northeast Asia	Prince Rupert	Chicago	65,000	2,415,869
	Prince Rupert	Memphis	39,000	789,574
	Prince Rupert	St. Louis	14,000	138,431
Total			118,000	3,343,874

Table 4. Predicted Container Traffic Changes of U.S. West Coast Ports due to Emerge of Port of Prince Rupert for Year 2007.

U.S. West Coast Ports	Import TEUs Without P. Rupert	Import TEUs With P. Rupert	Percentage Change
Long Beach, CA	3,024,800	3,020,400	-0.2%
Los Angeles, CA	3,933,100	3,933,100	0.00
Oakland, CA	594,335	529,275	-11%
Portland, OR	45,951	38,111	-17%
Seattle, WA	710,957	710,957	0.00
Tacoma, WA	594,646	580,855	-2%

Table 5 shows the dual values of constraints for West Coast logistics channels, which can be served by port of Prince Rupert. The dual value is the amount by which the optimal objective value can be improved (decreased in min problem), if corresponding constraint is

increased to handle each extra TEU, given that current basis remains optimal. The value of shadow price decreases (the value in parenthesis) with presence of Prince Rupert, but negative value persist over most major U.S. logistics channels, implying there are still potential strains on these U.S. inland corridors. The greatest sources of potential cost savings appear to be Los Angeles/Long Beach and Oakland to Memphis and St Louis.

Table 5. Dual or Shadow Values of Corresponding Constraints for Selected West Region Logistics Channels with Absence/Presence of Port of Prince Rupert.

Constraint at Port		Constraint on Railway		
Port	Dual Value	Interior BEAs		
		Chicago	Memphis	St. Louis
		Dual Value (US$/TEU)		
Los Angeles/Long Beach	0(0)	-107(-45)	-322(-122)	-128(-88)
Oakland	0(0)	0(0)	-254(-54)	-84(-44)
Portland	0(0)	0(0)	-112(0)	0(0)
Seattle/Tacoma	0(0)	-92(-30)	-238(-37)	0(0)
Prince Rupert	0	0	0	0
Vancouver	0(0)	-85(-27)	-235(-38)	-25(-27)

Note: the value in parenthesis is dual value with Prince Rupert in the model.

Impacts of uncertainty to Canadian logistics system

The number of full containers entering the US is expected to be 7.6% lower this year than last. Mainland China, which accounts for about half of the total, will suffer an anticipated 8% drop in its container exports to the United States this year[2]. The changes reflect much gloomier forecasts for the US economy that is now heading into recession.

To assess impacts of uncertainty to port of Prince Rupert, we analyzed the model with stochastic procedure. Simulated results for year 2006 show that actual demands of major U.S. interior markets fall within about ±15% of forecasting value. Thus, we use same

range around forecasting value to capture uncertainty demand for year 2007. That is that demand parameters are generated randomly within a range of about ±15% around predicted value. The distributions for these uncertain parameters are assumed uniform. Random parameters are drawn independently cross all U.S. markets.

Figure 4. Simulated Container Traffic through Port of Prince Rupert in Year 2007 under Demand Uncertainty.

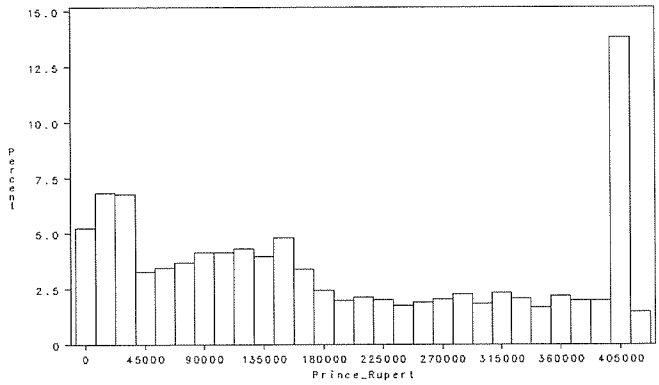


Figure 4 displays the simulated frequency of container (TEUs) flows through Prince Rupert across 5,000 potential scenarios. The results suggest the distribution is not normal, and is near uniformly distributed with bimodal spikes at each end. This is very interesting and can be interpreted from the model and has implications for the industry. Container traffic via Prince Rupert is sensitive to market volatility and the uncertainty of demand at U.S. markets has dramatic impact on Prince Rupert. A major factor causing Prince Rupert to have a spike in volume is the high demand at Chicago. The U.S. ports with costs advantages over Prince Rupert are Los Angeles/Long Beach and Seattle. Any scenario that has infrastructure strains at these seaports or associated transport corridors linking the major interior markets will also contribute traffic diversion to Canada's ports. This implies that if Prince Rupert is efficient and has an associated cost competitive transportation corridor, it will become a rival of U.S. ports.

Fairview Terminal at port of Prince Rupert recently reported handling 181,890 TEUs during the first full year of operation following its opening in the fall of 2007. Throughput jumped from 42,555 TEUs during the first six months of the year to 139,335 TEUs in the second half, thanks to addition of a second COSCO/CKYH Alliance service in July. In the fourth quarter, the terminal operated at more than 60% of capacity, handling 79,106 TEUs[3]. This shows the potential competitive edge of Canada's new port against U.S. system.

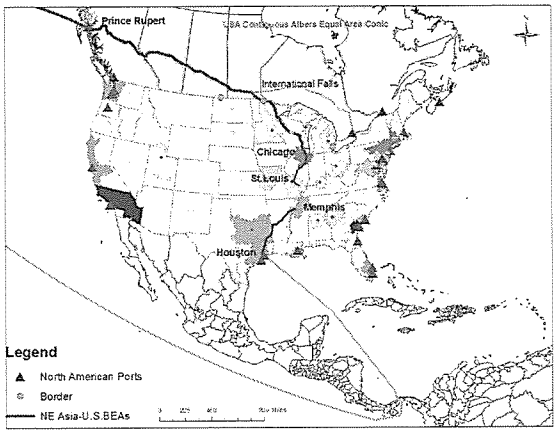
Prince Rupert vs Panama Canal

The Panama Canal route is an all-water option for transpacific containers to the Gulf and East Coast of United States. The port of Houston appears to have a substantial potential for container shipments to U.S. interior markets, such as at Memphis and Dallas-Fort Worth. The model results indicate a shadow price of-135 at Houston for port handling capacity which suggests a bottleneck for shipment through the Gulf Coast. The Houston port authority completed a five-and-a-half-year plan to deepen the channel from 40 to 45 feet and expansion of Bayport complex is conceived to create an opportunity to nearly triple the port's overall container handling capacity[4].

There exists a potential inter-port competition among U.S. West Coast, Gulf Coast, and Canada's port of Prince Rupert. To evaluate inter-port competition, we assume that capacity of port of Houston and associated corridor has been expanded to compete with Canadian port of Prince Rupert. The estimates show Houston will dominate shipments of containers, which previously are shipped via Canada's Prince Rupert to Memphis. Prince Rupert still has cost advantages over Houston to ship containers from Northeast Asia to Chicago (see Figure 5). The Panama Canal's current maximum containership size is 4,400 TEU and there are pressures for use of larger ships due to economies of scale. The expansion of Canal is ongoing and will allow large vessel (12,000 TEUs) to reach U.S. Gulf and East Coast. Houston would be a competitive port after Canal expansion that

enables large container vessel deployed over Pacific-Panama Canal trade lane.

Figure 5. Inter-port Competition between Port of Prince Rupert and Houston.



Conclusions

We estimated prospective flow through the Canadian logistic channel for container shipments to United States with specific focus on Prince Rupert. The Transpacific West Coast trade lane is dominating logistics channel for U.S. container demand markets. The estimates show that Prince Rupert provides a competitive alternative for containers imported from Northeast Asia to major U.S. interior markets, such as Chicago, Memphis, and St. Louis. Los Angeles/ Long Beach still dominate shipments for U.S. interior container markets. However, the negative shadow price reveals there are potential strains over these transport corridors. Canada's east system service a small portion of container with origin from Europe to United States.

The uncertainty of demand at U.S. markets has dramatic impact on port of Prince Rupert. This implies that the congestion in U.S. system can be relieved by shipments through Prince Rupert. Prince Rupert is expected to increase its market share and become more resistant to volatility of markets.

Expansion of Panama Canal will enable ports at Gulf and East Coast to handle large container vessel deployed on Transpacific-Panama-Gulf/East trade lane. Our results suggest more intense inter-port competition. Houston will be an optional competitor against Canada's port of Prince Rupert.

Other interesting options can be included in the model, such as expanding Mexican container ports, which can be new competitor against U.S. and Canadian water gateways. Routing via the Suez Canal can also be alternative to ship container from Northeast Asia to U.S. East Coast. Halifax will have the same potential at East Coast as Prince Rupert. In summary, there are many factors affecting global supply chain. Industries or transportation sector can succeed when they adapt to changing circumstances and circumstances are always changing.

Endnotes

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