ADDRESSING THE POTENTIAL FOR INCREASED INTERMODAL FREIGHT MOVEMENTS THROUGH CANADA-US BORDER CROSSINGS

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Introduction

The combination of economic expansion and more stringent security measures has placed increasing pressure on transportation infrastructure at Canada-US border crossings. This is especially true of bridges and other highway infrastructures that serve a mixture of passenger cars and trucks. This paper addresses the substitution of rail/road intermodal freight service for conventional truck freight as a strategy to help alleviate congestion at border crossings.

The paper begins with a review of intermodal service and the current state of its application in Canada. A number of economic principles regarding transport costs and the value of time are introduced to explain why only certain segments of the freight market are likely to switch from direct trucking to intermodal. The application of intermodal service to cross-border freight is discussed, with specific reference to the case of the Windsor-Detroit crossing. This is followed by a discussion of possible rationales for public policy promoting intermodal over direct truck freight service. Finally, the paper ends with some directions for data development and analysis that are needed to provide a realistic assessment of the potential role of intermodal freight in addressing Canada-US border problems.

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How Intermodal Service Works

There are two common formats for rail/road intermodal service: trailer on flat car (TOFC) and container on flat car (COFC). The latter is generally more efficient and has become the dominant format, so I will limit my discussion to it. In a COFC system the shipper loads goods into steel containers consistent with the length and load restrictions of a full sized tractor-trailer truck. Full containers are picked up from the shipper and trucked to an intermodal terminal facility. (This road movement of rail-ready containers is called *drayage*.) At the terminal, containers are sorted by destination and loaded onto special rail cars of regularly scheduled intermodal trains.

There are a variety of types of rail cars for intermodal shipment carrying from two to six containers each. For the busiest and most cost efficient routes, containers are generally *double-stacked*. However many segments of rail networks cannot support double-stacking because of insufficient bridge clearances etc.

For reasons that I will discuss below, the intermodal containers are generally moved over distances not less than about 800 kilometers. Further drayage is generally required to move the container from an intermodal terminal to its final destination.

A large proportion of intermodal freight begins or ends at a port. Where portside rail facilities are available, goods are transferred directly between ships and trains. Most often these containers carry imported goods or goods for export. The rapid growth of intermodal service in North America is in part due to the growth in ocean borne international trade. (Examples of major port-based intermodal services include Burlington Northern Santa Fe's service from Long Beach, California to Chicago and Canadian National's service from the new container port at Prince Rupert, British Columbia to points as distant as Memphis, Tennessee.)

Intermodal Freight in Canada

The combined intermodal shipments of Canadian National (CN) and Canadian Pacific (CPR) roughly doubled from about 16 million tonnes in 1996 to nearly 30 million tonnes in 2005 (Transport

Canada, 2006, Figure A6-4.) This represents a relatively small share of the 257 million tonnes carried by Class I Canadian railroads in 2005 (Table A6-8) . It is important to note, however, that the value per tonne of intermodal goods is generally much higher than that of the bulk goods that comprise the lion's share of rail shipments, which means that intermodal service accounts for a much larger share of goods movements by value than by weight. Also, since intermodal service is more expensive per tonne, it accounts for a substantial proportion of revenues.

Marine exports and imports combined account for about 60% of intermodal tonnes in 2005 (Figure A6-3). The fact that this share has remained fairly steady from 1996 to 2005 implies that growth has occurred not only in port-based intermodal service but also in service with truck drayage at both ends. Moreover, practically all of the growth has occurred in shipments between points within Canada, indicating a small and stagnant role for intermodal service in cross-border freight movement (Figure A6-2).[2]

Economics 1: The Minimum Competitive Distance

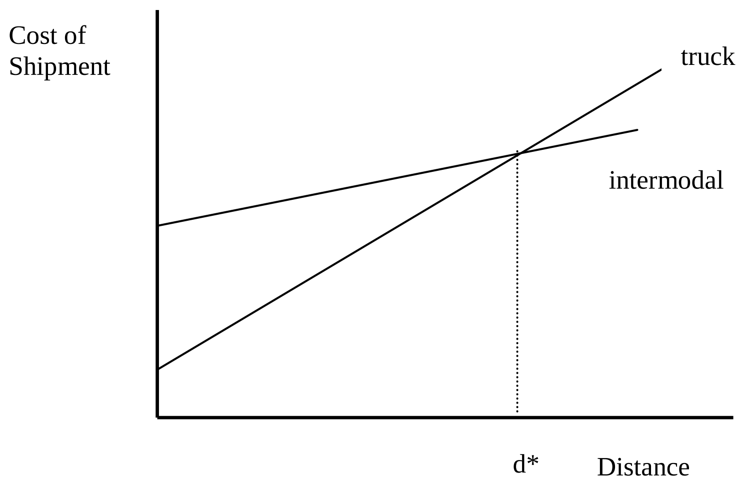
The conventional wisdom states that intermodal service is only cost competitive with truck service for shipments over relatively long distances – generally greater than 800 to 1000km. To understand why this is the case, define the total cost of a shipment as including two components: the *terminal cost*, which is charged on a per-trip basis and the *line-haul cost*, which is charged on a per km basis. Because of drayage and the cost of transferring containers between vehicles, intermodal service has a higher terminal cost than truck service. But because of the greater energy efficiency and lower labor requirements of rail, intermodal has a lower line-haul cost than truck. An elementary results in transport geography is that if there are two modes – one with low terminal costs and high line-haul costs and the other with high terminal costs and low line haul costs – the former will be cheaper over short distances and the latter will be cheaper over long distance. This is illustrated in Figure 1a, where the intercept

[2] This is likely to change with the recent push by CN to serve US locations with intermodal service from Prince Rupert.

for each mode represents the terminal cost and the slope of the cost line is the line-haul rate. In this case d* is the minimum competitive distance, beyond which intermodal service is cheaper than trucking.[3]

In general, the minimum competitive distance increases with the difference between the terminal costs of intermodal and trucking and decreases with the difference between their line-haul rates. This is an

Figure 1a Minimum competitive distance

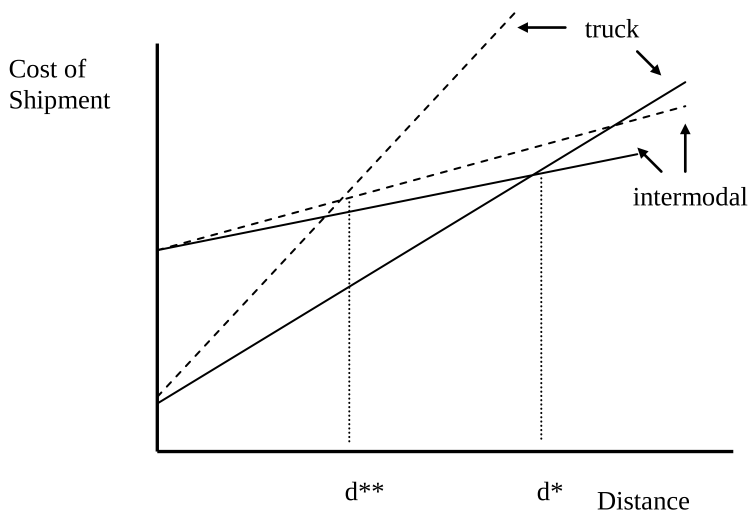


important point because there are a number of trends in the economy that tend to increase the gap in line-haul costs. Rising fuel costs increase the slope of the truck cost function more than that of the intermodal cost function because the former is more energy intensive.

[3] Anderson and Lakshmanan (2005) provide a numerical example based on average US costs for road, rail, drayage and intermodal transfers.

Figure 1b shows how a rise in fuel cost results in a reduction in the minimum competitive distance to d**. A similar case can be made for labor costs – since intermodal is a labor conserving mode it is less sensitive to the current run-up in transportation sector wages. Continued increases in labor and fuel costs should therefore increase the minimum competitive distance of intermodal service.

Figure 1b Effect of fuel price increase on minimum competitive distance



Another relevant fact is that truck transportation has higher external costs than intermodal (See Forkenbrock, 2001.) Air pollutant emissions, CO_2 emissions, noise pollution and uncompensated infrastructure damage are all higher for truck under most circumstances. The argument could also be made that trucks have greater external congestion costs, but this may vary from one context to another. A recent analysis by Anderson and Lakshmanan (2005) has suggested that increases of 25% in both fuel and labor costs, along with internalization of non-congestion external costs, would result in a reduction of about 33% in the minimum competitive distance.

This framework also helps explain the prevalence of intermodal freight for marine export or import containers. Since import containers are transferred directly from the ship to the train (or from the train to the ship for export containers), drayage is eliminated on one end of the trip. This greatly reduces the gap in terminal costs and also reduces the minimum competitive distance.

Economics 2: The Value of Time and Market Segmentation

The evolution of freight services over the past couple of decades has been toward increased emphasis on speed and timeliness (defined as the ability to deliver goods within narrow time windows.) This is partly due to an increasing proportion of time-sensitive goods in the freight stream, but it is more fundamentally due to the revolution in logistical practice that calls for maintaining leaner inventories via just-in-time systems.

There is an inherent speed penalty for intermodal freight service because it involves one or more transshipments between truck and rail. As with monetary cost, this incremental penalty is smaller for marine shipments because it has only one extra transshipment. Transshipments are often more than simple transfers from a truck to a train. Because containers need to be consolidated into trains with common destinations, a container may have to wait at the terminal until the appropriate train is formed, leading to further speed penalty. To some extent this penalty may be offset by the relative immunity of rail movements to road congestion, but in general intermodal is a slower mode than direct trucking.

Timeliness is more important than speed in lean logistical systems. As long as a shipment arrives within a narrow time window its speed of travel is not important. Therefore as long as intermodal service is very reliable, its speed penalty need not be an obstacle to meeting certain kinds of time sensitive demand. Unfortunately the nature of intermodal systems involves a kind of delivery time risk trucking does not have. In Canada, some of the most heavily used intermodal corridors have trains departing no more frequently than every 24 hours because the cost advantage of intermodal depends on forming large trains. This low frequency of service implies that if a drayage container movement is caught up in traffic for an extra twenty minutes, it may miss its train resulting in a 24-hour delay. Thus, even if the average speed of delivery for intermodal and point-to-point is about even, the standard deviation of delivery time is larger for intermodal.

The difference between COFC intermodal and direct truck in terms of both transport and time cost is well illustrated by comparative freight cost estimates calculated by Statistics Canada (2005), which are summarized in Table 1.

Table 1: Logistics Costs for Direct Truck *vs* Container on Freight Car (COFC) Intermodal for Three Canadian Markets

Toronto – Montreal		
	Direct Truck	COFC
Pick Up/Del. Cost	$0.0	$447.51
Line Haul Cost	$770.25	$775.00
Total Transport Cost	$770.23	$1,222.51
Time Value Cost	$54.07	$333.41
Total Logistics Cost	$824.32	$1555.92
Toronto – Winnipeg		
	Direct Truck	COFC
Pick Up/Del. Cost	$0.0	$482.69
Line Haul Cost	$2,920.10	$2,150.00
Total Transport Cost	$2,920.10	$2,632.69
Time Value Cost	$342.42	$738.91
Total Logistics Cost	$3,262.52	$3,371.60
Toronto – Vancouver		
	Direct Truck	COFC
Pick Up/Del. Cost	$0.00	$589.56
Line Haul Cost	$6,030.72	$2,650.00
Total Transport Cost	$6,030.72	$3,239.56
Time Value Cost	$783.97	$1,405.74
Total Logistics Cost	$6,814.69	$4,645.30
Source: Transport Canada (2005) section 4.6.		

In these estimates, transport costs are separated into two components: pick up and delivery costs (drayage), which are zero for direct trucking and line haul costs. (The drayage costs are analogous to the terminal costs described in the previous section. Other terminal costs are assumed equal for direct truck and COFC and therefore can be left out of the estimates without affecting the relative costs.) Here the distance effect is clear, as transportation costs are lower for direct truck in the Toronto – Montreal market, slightly lower for COFC in the Toronto – Winnipeg market and much lower for COFC in the Toronto – Vancouver market.

These estimates also include a time value cost, estimated by multiplying the average time for delivery by a constant per hour value of time. Here we see that for Toronto – Winnipeg shipments, the transportation cost advantage of COFC is more than offset by its higher time value cost. It is interesting to note that the proportional difference in time values is greatest over short distance: 500% higher for Toronto – Montreal *vs* 80% higher for Toronto – Vancouver. This reinforces the role of distance in determining the relative advantages of direct trucking and intermodal services and suggests that the minimum competitive distance becomes higher if time costs are included.

A couple of points with respect to the time value are important here. The time value shown in Table 1 measures time as opposed to timeliness – it is based on the average delivery time and does not take account of its variance. But the Transport Canada (2005) report includes best and worse case time values, which generally vary by a factor of 2 for COFC. Thus consideration of timeliness tends to work against intermodal service. Also, the estimate of time value is based on a single hourly rate that has two components: the opportunity cost of having money tied up in goods in shipment and the cost of maintaining higher inventory to cover delays in shipment. Both of these elements are increasing in the value of the shipment. The second element may also depend on the type of goods being shipped. For some goods, the receiving facility may be able to tolerate inventory shortfalls for a day or two, but for goods involved in strict just-in-time (JIT) production systems, shortfalls for even an hour or two may not be acceptable so expensive inventory buffers are required to offset potential delays.

Thus, we can think of the freight market as being segmented in three ways:

- Intermodal is less likely to be cost effective for shipments over long distances.
- Intermodal is less likely to be cost effective for shipments of high value goods.
- Intermodal is less likely to be cost effective for shipments involved in JIT supply chains.

Intermodal Service for Cross-Border Shipments

Shifting cross-border freight from direct trucking to road-rail intermodal service has a number of advantages. The higher density of rail freight, as compared with trucking, can relieve some of the physical constraint of moving a huge volume of freight through a small number of choke points. Because rail service is much less labor intensive than trucking, delays associated with clearance of people, as opposed to goods, should be much lower. Rail's lower emissions per ton of freight moved should help mitigate the high concentrations of particulates and other pollutants caused by slow-moving trucks in the vicinities of border crossings.

The potential to shift cross-border freight to intermodal service, however, must be considered in light of two constraining factors: the availability of appropriate rail infrastructure at and leading to border crossings and the economic viability of intermodal for the types of shipments that are crossing the border. As for the first factor, not all crossings have the capacity to move double stack trains. This is especially true for river-based crossings where rail often uses tunnels designed in an earlier era. Furthermore, some rail corridors leading to borders may pass through urban areas where bridges carrying local road traffic over the rail line are too low to permit double stack trains.

Assuming infrastructure problems can be addressed by private and public investment, the question remains whether there will be sufficient demand for intermodal service in cross-border corridors. Based on the criteria defined above, this reduces to the question of whether there are sufficient shipments of relatively long distances, for relatively low value goods or goods that are not part of tight JIT supply chains.

Since Canada and the United States are both spacious countries, it might seem that the minimum competitive distance problem would apply to a relatively small proportion of cross-border trade. However, studies that have examined the spatial pattern of Canada-US trade show that much of it is clustered within cross-border regions, each of which includes just one or two provinces and a few states that are close to the border (See for example, Brown and Anderson, 1999.) This is especially true of the manufactured goods that are shipped in containers, as opposed to bulk commodities, petroleum and natural gas. Also, since Canada and US are both high wage, high productivity economies, neither exports many low valued manufactured goods. Finally, the single largest manufacturing sector for cross-border shipments in both directions is automotives and much of the trade is in components moving though JIT supply chains.

This is not to suggest that the potential for intermodal freight at border crossings is small, so much as to qualify the notion that intermodal can "replace" direct trucking. The research agenda must include an assessment of the volume of cross-border freight for which intermodal service is a feasible alternative to see whether it is large enough to reduce congestion at borders and to justify investment where infrastructure is inadequate.

The Windsor-Detroit Corridor

The border crossing between Windsor, Ontario and Detroit, Michigan is the most important portal for US-Canada trade and the largest land trade crossing (defined by value of goods traded) in the world. The privately owned Ambassador Bridge, which spans the Detroit River, carries 28% of total Canada-US truck movements and 10% of Canada-US car movements. A road tunnel and truck ferry in the same vicinity also carry smaller but still substantial numbers of trucks and cars. (Transport Canada, 2006, Tables A7-13 and 14.) The rail tunnel at Windsor carries about 21% of rail exports and 16% of rail imports as measured by value, but only 6% and 2% respectively as measured by weight (Tables A6-20, 21, 22 and 23). This is because much of the rail shipment through this corridor is of high value automotive and other manufactured goods, rather than the bulk commodities that make up the largest proportion of international rail freight.

Like all US-Canada crossings, the Windsor-Detroit crossing was plunged into crisis after the events of September 11, 2001. The bridge, tunnels and ferry were closed down for several days, resulting in a huge backup of trucks. Long delays followed the reopening of the border due to enhanced security, especially on the US side. While substantial reductions in delays were achieved in 2002-2006 due to improved procedures by border agencies on both sides, a recent report states that the summer of 2007 saw the longest delays since 2001 (US and Canada Chambers of Commerce, 2008.) While these delays are the outcome of security procedures rather than shortfalls in infrastructure capacity, recent planning documents predict that physical infrastructure capacity will become insufficient by the end of the next decade (Border Transportation Partnership, 2004.)

Can an increase in intermodal freight service make a substantial contribution to addressing the challenges that currently face the Windsor-Detroit crossing? As the previous section suggests, the answer depends upon the availability of infrastructure and on the structure of freight demand. On the infrastructure side, the rail tunnel in its current form cannot support double stack trains, which radically reduces the competitiveness of COFC intermodal service. However, the owners of the tunnel currently have a proposal to improve it to support double stack. The impetus for this proposal appears to be the need to accommodate double stack vehicle carriers rather than COFC service. Thus it is likely that necessary infrastructure improvements will occur, even if the potential for COFC service is not large enough to justify those improvements on its own. A recent assessment of cross-border transportation through the Windsor metropolitan area suggested that adequate double stack capacity would make it possible to divert the equivalent of 2000 trucks per day to rail passage[4]. That assessment is based on infrastructure capacity alone, however.

The demand side is more problematic. The flow of freight across the Windsor-Detroit crossing in large part reflects the high level of integration between the US and Canadian automotive industries. Beginning with the US-Canada Auto Pact of 1965, vehicles and components have crossed the border tariff-free. This allowed the big three automakers (and later Japanese automakers) to extend supply chains across the border, rather than to duplicate production in the US and Canada. A large proportion of the truck movements over the Ambassador Bridge are carrying components between automotive plants. Such shipments are relatively short, are of high value and serve JIT supply chains – thus they are not good candidates for transfer to intermodal service.

But the automotive sector does not account for all of the trade through Windsor-Detroit crossing. In order to make an assessment of the proportion of truck freight for which COFC intermodal service is a realistic alternative it would be necessary to conduct an analysis similar to the one whose results are presented in Table 1 for different categories of shipments in different origin-destination markets on opposite sides of the border. This would require the following data resources:

- Origin, destination, industrial sector and value of shipment for an adequate sample of cross border truck movements; and
- Logistical information necessary to estimate time costs for different industrial sectors.

While neither of the these categories of information are currently available from secondary sources, they might be economically collected with cooperation from, in the first case, border agencies

[4] This estimate is from a presentation by Sam Schwartz Engineering PLLC to the City of Windsor, January 2005. Given that there are about 10,000 truck movements across the Ambassador Bridge on a typical weekday, a shift of 20 would be necessary to meet the 2000 containers per day estimate.

from both countries and, in the second case, logistical managers from a cross section of firms.

Policy

Federal and provincial governments might promote a shift from road to intermodal freight *via* two types of mechanisms. The first is the subsidization or complete funding of infrastructure – particularly changes to tunnels and bridges to permit double stacking. The second is to use subsidies or other incentives to encourage shippers who would otherwise choose direct trucking to switch to intermodal.

What is the rationale for such policy? For one thing, promoting intermodal freight may be a cheaper alternative to expanding the capacity of road infrastructure. This is especially likely where improvements to tunnels, rail bridges and road bridges that pass over rail corridors are necessary to "unlock" the cost advantage of double stacking. A more universal reason for policies promoting intermodal freight is that it is lower than direct trucking in a number of external cost categories. As I have already noted, emissions of pollutants and greenhouse gases are lower for intermodal service, so a subsidy may be a relatively economical way to achieve pollutant and carbon reductions.

External congestion costs are a powerful, albeit context specific, rationale for policies promoting intermodal freight. Returning to the case of the Windsor-Detroit crossing, shippers of JIT commodity deliveries who are unlikely to use intermodal service will still benefit from it indirectly if it attracts enough freight to reduce congestion on the bridge. But they will not be required to pay anything for the resulting benefit. Thus as a good with a positive external benefit, intermodal service will tend to be under-consumed in the absence of public sector intervention.

Conclusion: Research Directions

A realistic assessment of the potential role of intermodal freight service in reducing delays and environmental problems at Canada-US border crossing will require a substantial research effort to develop necessary data and analytical tools. As I have already noted, the type of data that are currently available on cross-border shipments does not include sufficient detail to estimate the proportion of the market for which intermodal service is a viable alternative. Data needs include surveys of cross border shippers to provide origin-destination detail and surveys of logistics managers to provide information on the value of time and timeliness. Such surveys need to include data for firms in a variety of industrial sectors.

Given such data, it will be possible to develop freight demand models that can forecast trends in intermodal and direct truck service. Furthermore, conditional forecasting methods can be used to address policy questions such as the following:

- What volume of freight transfer from direct trucking to intermodal service can be anticipated as the result of an infrastructure improvement? (Answering this question is necessary for cost-benefit analysis.)
- What level of price subsidy for intermodal (or taxation for trucking) is necessary to achieve a target shift from trucking to intermodal service?
- What benefits in terms of congestion, pollution or carbon reduction can be expected as the outcome of any particular type of policy to promote intermodal? (Or alternatively, is the promotion of intermodal a relatively cost effective strategy for reducing congestion, pollution or carbon?)

References

Anderson, William P. And T. R. Lakshmanan (2005) Demand for Intermodal Freight Services: Current and Potential, presented at the North American Regional Science Meetings, Las Vegas, NV, November. (Copy available from the authors: bander@bu.edu).

Brown, W. Mark and William P. Anderson, 1999."The Influence of Industrial and Spatial Structure on Canada- U.S. Regional Trade" *Growth and Change*, 30(1):23-47.

Canada-US-Ontario-Michigan Border Transportation Partnership (2004) *Planning Need and Feasibility Study Report.*

Forkenbrock, David J. (2001) Comparison of external cost of rail and truck freight transportation, *Transportation Research Part A:* 321-337.

Transport Canada (2006) *Transportation in Canada 2006*

Transport Canada (2005) *Operating Costs of Trucks in 2005*

U.S. Chamber of Commerce and Canadian Chamber of Commerce (2008) *Finding the Balance: Reducing Border Costs While Strengthening Security.*