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The Control of Carbon Dioxide Emissions from Freight Transportation: A Case Studies Approach

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Introduction

The *Ontario Freight Movement Study: Component Two*, conducted by the Research and Traffic Group for the Ontario Ministry of Transportation, was one of the ten collaborative research studies from which the Ontario Round Table on Environment and Economy and the National Round Table on Environment and the Economy developed their report *A Strategy for Sustainable Transportation in Ontario.* The *Ontario Freight Movement Study: Component Two* uses *industry/company-specific case studies* to assess the prospects–in terms of carbon dioxide (CO_2) emission reduction–of alternatives to present freight distribution, especially (but not exclusively) alternatives involving the use of rail instead of truck.

Fuel consumption, CO_2 emission and (where possible) cost consequences were estimated. Railway fuel consumption was calculated for detailed routing descriptions using a model that computes route and service-specific fuel use based on the cars and locomotives used and the profile of the track. Truck fuel consumption was calculated for the type of vehicle and loadings involved from information provided by operators supplemented by published data. Estimates were adjusted for the conditions of the roads travelled.

Statistical data for Ontario freight transportation were analyzed and the following freight transportation users selected as representative.

Green Forest Lumber Ltd., a Chapleau lumber producer,
H.J. Heinz Company of Canada Limited at Leamington,
General Motors of Canada at Oshawa,
Suncor Inc. (Sunoco) at Sarnia,
Canadian Tire Corporation operating from Brampton, and
Mount Sinai Hospital in Toronto.

Green Forest Lumber

Green Forest is a lumber producer and wholesaler. As the cost of transporting lumber is a substantial portion of its delivered price, and the lumber market is very price competitive, lumber shippers tend to be very cost conscious in their transportation choices. Green Lumber also has to provide delivery that is convenient to its customers.

- For shipments direct to lumber retailers, who would rarely have a rail siding, truck provides convenient delivery. Also few would want a rail carload at one time; the size of a truckload is just about right for most lumber retailers.

- For shipments to Green's own *lumber transfer yards*, rail is generally preferred because of the lower rates usually charged by the railways. At the lumber transfer yard Green can load trucks for local delivery with a selection of lumber to exactly match customer needs.

- The transport equipment used must have a *flat bed* to enable easy loading and unloading of large bundles of packaged lumber with a fork lift truck. Rail cars are larger than trailers and often have bulkheads at either end to hold the load in place. Some also have a beam down the centre of the car to further secure the load.

- Two types of highway trailer are used–48 foot semi-trailers and *B-trains* which are two trailers with a total *deck* length of 65 feet. *B-trains* operate in Ontario and Michigan but not in other states adjacent to Ontario.[1] They have a carrying capacity of 85,000 pounds compared with 47,000 pounds for a semi-trailer.

The selected case focuses on the distribution, to Southern Ontario and Michigan, of lumber produced at Green Forest sawmills located at Chapleau in Northern Ontario:

- through its *lumber transfer yards* in Southern Ontario and the U.S., and

- directly from Chapleau to Ontario building supply retailers.

Over 80% of the lumber from Chapleau is now shipped by rail with much of the remainder trucked to northern Michigan and retail customers in Ontario. Two

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1 While permitted in these other states, gross vehicle weight of 80,000 pounds makes them impractical.

prospective shifts from truck to rail and two possibilities where truck might capture traffic that currently moves by rail were examined. Potential CO_2 savings depend on whether the trucks concerned are already moving cargo to Northern Ontario and would otherwise return south empty.

Shipment to Retailers in Southwestern Ontario: Shift from Truck to Rail

Presuming:	change in CO_2 Emission
Fronthaul (trucks must return empty)	54% decrease
Backhaul (trucks would otherwise be moving empty)[2]	37% increase

Shipment to Grand Rapids, Michigan: Shift from Truck to Rail

Presuming:	change in CO_2 Emission
Fronthaul (trucks must return empty)	23% decrease
Backhaul (trucks would otherwise be moving empty)	129% increase

Shipment to Fort Erie Ontario: Shift from Rail to Truck

Presuming:	change in CO_2 Emission
Fronthaul (trucks must return empty)	177% increase

Shipment to Windsor, Ontario: Shift from Rail to Truck

Presuming:	change in CO_2 Emission
Fronthaul (trucks must return empty)	178% increase

As much of the lumber, particularly that destined to Southwestern Ontario, is believed to move in trucks that would otherwise travel empty, important opportunities to reduce CO_2 emission through a shift to rail were not apparent. Further, analysis of the costs for rail versus truck for the portion of the Chapleau lumber that now moves by truck suggests that switching to rail would be costly. As for the longer term prospects, there seems a danger that some of the 80% of the lumber now carried by rail might be captured by the truck mode.

Study of this case revealed some potentially important aspects of the CO_2 emission reduction problem:

- The availability of empty trucks returning from delivering loads can give trucking an advantage over rail. Unfortunately, it may not be practical to take advantage of this circumstance when it is available but use rail whenever it is not.

- Because trucks (and railway equipment) move in complex patterns and truckers accept relatively low rates for a load when they would otherwise move empty, the CO_2 emissions attributable to individual shippers cannot be accurately estimated in isolation from the total network of movements.

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[2] Green Forest reports that, for the most part, lumber is moved to Southern Ontario in trucks that would otherwise be returning empty.

- The ultimate CO_2 emission reduction from a transfer of Ontario freight from truck to rail would significantly exceed the local savings as a larger number of more efficient locomotives are introduced elsewhere on the system.

- Routing rail and truck traffic between Southwestern Ontario and the West through the United States would reduce CO_2 emission.

Heinz

H.J. Heinz produces a limited range of food products at its plant at Leamington Ontario. These products benefit from brand loyalty but must also compete with other similar commodities on supermarket shelves. In shipping its products, a company like Heinz would consider certain attributes most important.

- Heinz requires covered (box car or van) equipment to provide protection for the canned and packaged good(s) shipped. In winter, products must be protected from freezing. Railway box cars or semi-trailers that are insulated and heated are required.

- The cost of transportation is important because margins for food products are generally low. Damage to goods during transit is also a concern.

- Shipments to a Heinz warehouse, say at Calgary, are less time sensitive than those that go directly to the retailer (or wholesaler) since the latter would store smaller quantities. Because of its cost effectiveness and since transit time is less important, the use of rail for shipments to the warehouse would be preferred.

- In shipping to retailers (or wholesalers), truck or rail intermodal services would be preferred because of their better on-time delivery reliability. Also, most semi-trailer sized shipments would involve several stops.

Important movements into and from Heinz's Leamington plant include:

- Semi-trailers by road to customers in the Toronto area, 90% of which return with supplies for the plant;

- Railway carloads and semi-trailers on flat cars, as well as direct truck, to:
  - Heinz's Calgary distribution centre for Alberta and British Columbia,
  - customers in Manitoba and Saskatchewan, and

- customers in the Maritimes;

- Containers for export through the port of Halifax;

- Exports by direct truck to Pennsylvania and Michigan;

- Exports to California, Florida and New Jersey by railway boxcar;

- Imports from Texas, Minnesota and California by semi-trailer on railway flat car and direct truck; and

- Imports from Puerto Rico in semi-trailers moving intermodally by water, rail and road.

Potential operational changes selected for analysis of alternatives were:

- Increased use of rail carload, instead of *trailer on flat car* and direct truck, from Leamington to the Calgary distribution centre,

- Rerouting trucks, travelling from Leamington to Manitoba and Saskatchewan via the Canadian route, through the U.S., and

- Increased use of *trailer on flat car* to the Maritimes.

Predicted emission consequences are:

	change in CO_2 Emission
Canned goods from Leamington to Calgary: Shift from *trailer on flat car* to box car	47% decrease
Canned goods from Leamington to Winnipeg and Regina: Reroute trucks through Chicago	10% increase
Canned goods from Leamington to the Maritimes: Shift from direct truck to *trailer on flat car*	49% decrease

Unfortunately, the declining supply of suitable railway box cars and Heinz's customers' (who do not have railway sidings) preference for semi-trailer loads mitigate against increased all-rail movements. If emission levels are to be restrained, rail intermodal (instead of direct truck) appears to be the only way to do it. In this regard:

- New forms of truck/rail intermodal now emerging may make it possible for a larger proportion of traffic to move intermodally.

- CO_2 emission from direct truck to western Canada via the Canadian route is only less than emission for the shorter and better U.S. route because Canadian highway load limits are less restrictive. To the extent that Canada's higher load limits improve the competitive position of trucking *vis-a-vis* rail, CO_2 emission is not reduced.

General Motors

General Motors ships large volumes of automobiles and trucks from its Oshawa plant. These are transported to assembly points in Canada and the United States, and sometimes directly to dealers. Important considerations for General Motors would include:

- The carrier's price. Because of the number of vehicles shipped a small price difference can have a large effect on GM's profitability.

- Experience with damage to vehicles in transit. New motor vehicles are valuable and easily damaged. Rail cars are covered with screening to protect the new vehicles from vandalism.

- The small quantities shipped to individual dealers or smaller towns tie GM into truck delivery. More timely delivery is also a factor. Rail is preferred for more distant and larger markets where the economics support larger shipments to special transfer facilities. From there, vehicles are trucked to dealers.

Approximately 80% of new vehicles from the Oshawa plant are shipped by rail. Ontario (except the Thunder Bay area), western Quebec and two U.S. distribution centres are supplied by direct truck. Two possible opportunities to use more rail, including to one of the U.S. destinations (the other does not have nearby facilities to receive by rail), were selected for analysis. The consequences of truck capturing an existing rail shipment were also assessed. Predicted emission consequences are:

	change in CO_2 Emission
Cars and trucks from Oshawa to Montreal area dealers: Shift from truck to rail	54% decrease
Cars and trucks from Oshawa to distribution centre in Dearborn Michigan: Shift from truck to rail	56% decrease
Cars and trucks from Oshawa to Denver Colorado: Shift from rail to truck	121% increase

Unfortunately from the emission perspective, Oshawa to Montreal is a very convenient and economical trucking distance. With truck delivery from Ste Therese to local dealers, rail would be appreciably more expensive. The

Dearborn movement is about the same distance as Montreal; however attributable incremental cost does not include an additional local delivery stage. No doubt rail would still be somewhat more costly.

The practical prospects for GM to reduce the CO_2 emission caused by its transport of vehicles from Oshawa are limited. Within the truck mode, a modest emission saving could be achieved through relaxation of Ontario regulations that preclude *overhanging* to Canadian destinations.

Sunoco

Sunoco operates a refinery at Sarnia and retail petroleum outlets in Ontario and Quebec. It also wholesales fuel to other retailers. Sunoco ships large volumes of low-valued liquid bulk commodities to its retail outlets and the other retailers. Transportation considerations include:

- The products (mostly gasoline) are homogeneous, of low value, easy to store, and shipped in large volumes. For movement to Sunoco's regional depots, transport cost is more important than delivery speed or timeliness.

- Assured supply to maintain the competitiveness of its retail outlets (who do not have access to rail) and retain its wholesale customers indicates final delivery by truck.

- Safe transport that minimizes the risk to the public is important. Petroleum companies prefer pipeline transport wherever possible.

Sunoco's initial distribution is mainly by the pipeline and marine modes to terminals from which tank trucks deliver directly to its retail outlets and to its wholesale customers. There is very little truck movement of petroleum products directly from the refinery and, with the exception of chemicals, very little rail shipment. Marine distribution is to Sault Ste Marie, Montreal and for export.

We expect that Sunoco's product distribution offers significant opportunities for CO_2 emission reduction–perhaps more so than the other cases studied. Unfortunately, as Sunoco provided only very limited information, our assessment of opportunities for CO_2 emission saving was limited to a partial analysis of the substitution of direct rail for marine-pipeline-truck distribution through Montreal and Nepean to outlets in Eastern Ontario. The analysis suggested that emission attributable to the Great Lakes/St Lawrence segment of the move alone exceed what would apply to rail. Were the pipeline energy consumption–which can be substantial–to be added, rail's advantage would increase.

This case illustrated potentially important issues.

- Although emission reduction through the substitution of rail for general cargo delivery by truck could prove important, rail's strength is in bulk products transport. Particularly where truck and pipeline routes are circuitous, rail may be able to substitute for them at substantial CO_2 emission reduction advantage.

- The consequences in terms of CO_2 emission, when viewed incrementally in a total system context, may exceed what average per tonne-kilometre figures would indicate.

- Operational changes within modes may offer important emission saving opportunities.

Canadian Tire

Canadian Tire has a large number of retail outlets across the nation to support. It is a major importer, distributor and transporter. Its transportation requirements are focused on the needs of its retailers.

- Control over the entire movement is maintained to ensure timely and adequate supply (service) to each store. This requires frequent and often small shipments.

- The ownership of large numbers of semi-trailers ensures adequate storage wherever needed. It also assists with obtaining loads for the return to Brampton.

- Carriers working for Canadian tire are expected to provide low rates and excellent service with the driver unloading the truck at the store.

- Rail intermodal is used, but not to the extent possible because it does not always meet Canadian Tire's (delivery) requirements.

About 80% of goods sold by Canadian Tire stores come from suppliers in Canada, the U.S. and overseas to Brampton where they are consolidated. Each store in Ontario and Quebec receives daily shipments (if needed) primarily by truck from Brampton. Each truck serves 4 or 5 stores, not always following the same route. Outlets in the Maritimes and the west are served both by direct truck (in the case of the west using U.S. routings) and *trailer on* railway *flat car*. Most imports from Asia are unloaded from containers in Vancouver and reloaded into semi-trailers. Three possibilities for CO_2 emission reduction were analyzed in detail.

	change in CO_2 Emission
Shipments to Quebec stores through Montreal:	
Shift from truck to *trailer on flat car*	47% decrease
Imports through Vancouver to Brampton:	
Shift from *trailer on flat car* via CP Rail to *container on flat car* via CN Rail	25% decrease
Traffic between Vancouver and Brampton:	
Shift from truck to *trailer on flat car*	65% decrease

Issues raised in consideration of this case include:

- Even where a modal shift may not be practical, means to increase truck loading weights will save emissions.
- Meeting the market conditions for organizations like Canadian Tire intermodally would require enhanced service from the rail carriers.
- Containers (on flat car) are more fuel (and CO_2 emission) efficient than trailers (on flat car). Measures to enhance containerization would tend to reduce CO_2 emission.
- CN's transcontinental route is more CO_2 emission efficient than CP's. Thus, measures to shift freight towards alternatives that involve reduced emission would tend to disrupt the competitive balance between the two railways;
- There is an emission advantage when relatively lightly loaded trucks use U.S. routes to/from Western Canada.

Mount Sinai Hospital

The Mount Sinai is a moderate sized hospital in Toronto. It and other hospitals receive a wide variety of supplies in comparatively small quantities on a daily basis. Some of these supplies are of a more urgent nature than others. Urban hospitals like the Mount Sinai face transportation and logistics concerns.

- A regular guaranteed supply of items required on the hospital wards is essential.
- Maintenance of inventory and its management are costly.
- The urban area and the unloading docks at the hospital tend to suffer traffic congestion.

In cooperation with the Toronto Hospital, the Mount Sinai changed the manner in which it receives surgical/medical supplies. Other nearby hospitals may also join. Instead of individual suppliers–mostly courier companies–delivering to the hospital, shipments are consolidated at Livingston Healthcare at Oakville. The Mount Sinai now receives a single daily delivery. Suppliers and the hospital expressed satisfaction with the new system.

Effectively, although clearly sound logistics practice under the circumstances, this consolidation process represents a reversal in the general trend towards *just-in-time* logistics that has been credited with improving flexibility and competitiveness. Reduction in the number of trucks delivering to the hospital and the elimination of congestion at the hospital's loading docks not only facilitated speedier delivery for those shipments still coming to the hospital but it also improved patient and vehicular access to the reception area.

Thirteen of the 58 suppliers identified to us were interviewed by telephone and the movements for a sample of three were traced in some detail.

- A Montreal supplier that ships by Purolator,
- A Mississauga supplier that ships by Purolator, and
- A Pickering supplier that uses its own trucks.

In all of the cases examined, the supplies travelled further. However, because larger aggregate shipments were involved, it was concluded that CO_2 emission was, in all probability, reduced.

Discussion

Shippers consider a complex combination of cost and service factors in their choice of modes and carriers. While the factors are generic, the multiplicity of choices available and the weighting of them vary from shipper to shipper. Canadian Tire, for example, is most concerned with the timely delivery of goods to their stores, especially for special items advertised in their flyers. General Motors is concerned with timely receipt of parts at its final assembly plant so that its continuous production of vehicles is not disrupted, and will pay a premium for this service. For the shipment of finished vehicles, however, time is not as important a consideration as the freight rate GM has to pay and the condition of the new vehicles when they arrive. Shippers who need quick accurately timed shipments prefer trucking over rail while price conscious shippers or shippers with heavy loading commodities tend to prefer rail.

CO_2 Emission Reduction Prospects and Indicated Further Study

As the *real* (inflation adjusted) price of fuel fell, our industrial system developed in a pattern that depends on economical truck transportation. Now, recognizing the potential consequences of global warming, Canada is committed to reduce emissions. Transition to a system that uses less fuel will be difficult. Under various circumstances, rail is considerably more fuel efficient than truck; however, many Ontario industrial plants are located far from rail. Communities have developed around truck-dependent industry. The automobile manufacturers contract for parts production to manufacturers dispersed geographically on the premise of economical *just-in-time* truck delivery. These are not readily reversible processes.

Had the full cost of fuel consumption been recognized as the industrial infrastructure developed, the picture would be very different. Rail would be used more. Air freight would be used less. Trucks and trains would travel more slowly. Engines would be more efficient. Vehicles would be lighter. Industry would have located such that a great deal less freight transportation was used. We would be a more concentrated society. Now, however, we must face transition to a state of lower CO_2 emission, and determine how it can occur.

While it has been possible for us to determine that individual shippers could adjust their distribution modes to save CO_2 emission, the new distribution pattern that would result is more elusive. The case studies provide an examination of the potential for CO_2 reduction for what we believe to be a representative group of Ontario freight shippers. The question now is what these results might imply for CO_2 emission for freight movement in Ontario as a whole. It is not, as we might have hoped, simply a question of extrapolation. Hopefully the results from the case studies can now be extended and used to estimate the effectiveness of an emission restraining strategy–for example a *carbon* tax. Some implications of and barriers to adopting less fuel intensive alternatives to Ontario's present transportation and logistics systems, that may not have been discussed under the individual cases, include:

- Often, movements involve multi-carrier routings. Originating carriers tend to dictate circuitous routes which maximize their share of revenue.

- Any significant shift to rail will be limited by the availability of locomotives and railway cars, including specialized equipment.

- Within rail, boxcars are being supplanted by more energy-intensive *trailer-on-flatcar* technology.

- The cost of loading and unloading, and the need to use truck to deliver to customers, are barriers to increased use of rail. Future technology may alter this; however, for the present, these costs proscribe rail capturing traffic that consists of small volumes with dispersed origins or destinations.

- Ontario's high-quality highways have facilitated dispersed industrial development. It is not surprising that truck transport dominates the freight sector, and that this dominance is embedded in Ontario's industrial structure.

Regarding areas requiring further study, the case analysis approach taken in the present study seems the only practical way of continuing to address at least the modal alternatives and logistics aspects of CO_2 emission reduction for the freight sector. Here, we believe that the data developed for the six cases documented in this report should constitute a useful start. There is, of course, also the important *technology* dimension to emission reduction that must be integrated into the analysis. And, considerations of technology must go well beyond transportation vehicles and their energy efficiency. The fundamental approach to logistics would be involved.