DRAFT 3

REDUCING GREENHOUSE GAS EMISSIONS FROM TRUCK ACTIVITY IN URBAN AREAS

OVERVIEW OF THE LITERATURE AND AVAILABLE DATA

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Note

This document is an early draft of a review that will be finalized early in 2005. Several sections of the present version are necessarily incomplete, notably the section on freight movement within Sherbrooke and other urban areas.

1. INTRODUCTION

This review is produced as part of the project *Transport and economic development: a case study of the City of Sherbrooke*. The purpose of the project is to figure out how to reduce greenhouse gas (GHG) emissions and other environmental impacts of freight transport in the Sherbrooke region and in the rest of urban Canada while maintaining and even improving the overall efficiency and utility of freight transport.

GHG emissions from trucks and fuel use by trucks are almost precisely correlated. In Canada in 2001, diesel fuel comprised all fuel use by heavy trucks and about one third of fuel use by other freight-carrying trucks; just about all of the remaining truck fuel use was gasoline.[1†] Each litre of diesel fuel that is burned results in the emission of 2.62 kilograms of carbon dioxide (CO_2; the principal GHG). Each litre of gasoline that is burned results in emissions of 2.34 kilograms of CO_2.[2]

The links between other emissions—e.g., nitrogen oxides and particulates—and fuel use are less precise. They depend on several factors including engine characteristics, emissions control devices, and driving conditions and features. Nevertheless, fuel use and other emissions are strongly correlated overall: the more fuel is used the more pollution is produced. Similarly, noise production is related to fuel use, as is vehicle activity and thus congestion.

Accordingly, this project—and this review—focuses on fuel use, more specifically on reducing fuel use and thus environmental impacts through more efficient use of trucks. Using trucks more efficiently means carrying the same loads overall but with fewer trucks or smaller trucks, or both, thereby using less fuel. This method of reducing fuel use should be clearly distinguished from other ways of reducing fuel use that do not involve changing the number or size of trucks on the road. These other ways include driving more slowly or carefully and using more fuel-efficient vehicles. Both are receiving intensive investigation.[3] Less attention has been given to achieving more efficient use of trucks.

How trucks are used and deployed is a matter for the art and science of what is known as ‘logistics and supply chain management’ (LSCM). LSCM has evolved in response to the needs of business to provide better service, including shorter and more predictable delivery times, at the lowest possible cost. The predominant trend has been from ‘push’ logistics to ‘pull’ logistics, which have been described in this way.

> “We are seeing an evolutionary shift from ‘push’ to ‘pull’ logistics systems – from ‘manufacture-to-supply’ or inventory-based logistics to ‘manufacture-to-order’ or replenishment-based logistics. In a push system, suppliers push materials to a manufacturer, who pushes the completed product to a distributor, who supplies the retailer, who fills the customer’s order. Each maintains an inventory of parts and products as a buffer

† Superscript numbers refer to 68 reference and other notes that begin on Page 29.

> against fluctuations in supply and demand. *A pull system relies less on expensive inventory and more on accurate information and timely transportation to match supply and demand.* Point-of-sale data are used to pull products through a system that may involve two or three tiers of suppliers; a manufacturer that has spun off design and marketing functions to other firms; and a third-party-logistics provider who coordinates the movement of parts and products to distributors or directly to customers. *Pull systems are cost-effective, but they place tremendous demands on the transportation system.* Shippers want reliable, timely, and visible door-to-door freight transportation. An accident, congestion, labour disputes, storms – even unanticipated spikes in supply and demand – can unravel these tightly strung systems."[4]

The trend from push to pull logistics appears not to be confined to North America.[5]

On the face of it, the evolution from push to pull logistics involves the substitution of relatively inexpensive transport activity for more expensive warehousing or other inventory storage. Yet, across the U.S. economy, transportation costs appear to have declined since 1979, particularly in the 1980s, while warehousing costs appear to have increased, particularly in the late 1990s, both as a percentage of sales revenue.[6] Thus, either transportation has not been substituting for warehousing or inventory, or other factors have been at play. Such other factors could have included (i) changes in the relative costs of transportation and warehousing, and (ii) a lengthening of supply chains with globalization, which could have necessitated establishment of new warehousing to buffer again interruptions in the flow of goods.

Moreover, total order-cycle times have also remained fairly constant, at least since the early 1990s.[7] Thus, the evolution to pull logistics may have no more than offset systemic trends to longer order-cycle times. Alternatively, pull logistics may not be intrinsically more efficient in this respect than push logistics.

Also receiving some attention in this project is the matter of reducing the number of trucks on the road by moving freight to rail.[8] Sherbrooke is served by two rail freight companies and there may be opportunities for greater use of their services.[9]

Another focus of this project is on what local governments can do not only to help businesses use trucks more efficiently but also more generally to expedite freight movement in the Sherbrooke region. Municipal concerns about transport mostly focus on the movement of people,[10] with insufficient recognition given to the importance of freight movement for the economic viability and development of urban areas.

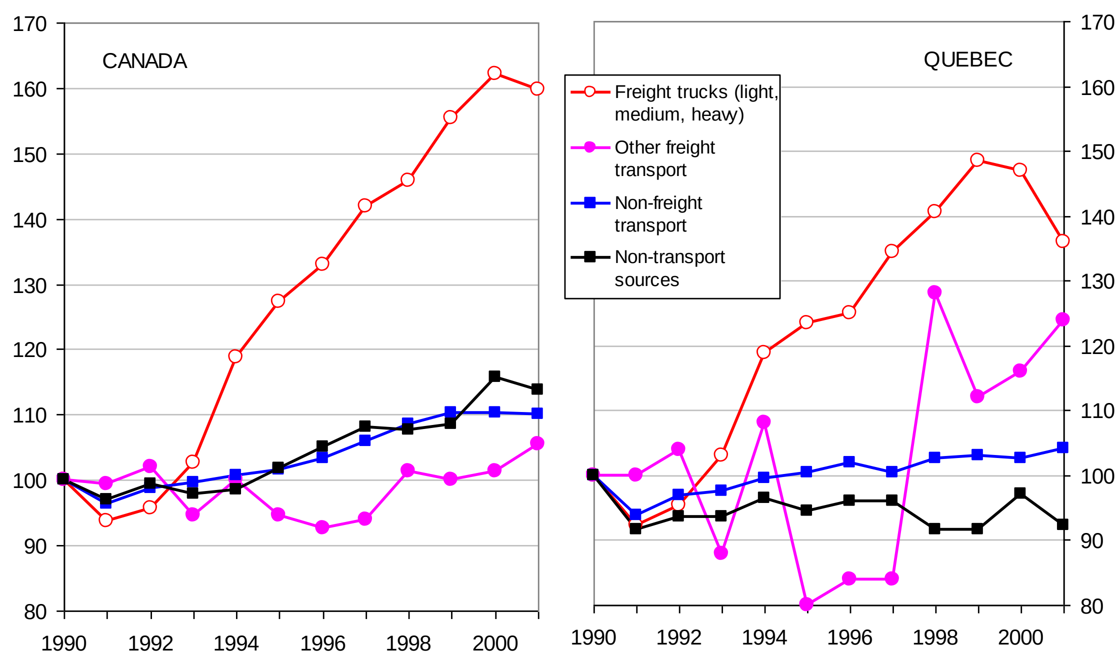
2. TRUCKING AND THE GROWTH IN GHG EMISSIONS

Since 1990—the baseline year for GHG emissions in the Kyoto Protocol[11]—the growth in GHG emissions from trucking has outpaced those from every other source. This is shown in the left-hand panel of Box 1, where it can be seen that across Canada emissions from trucking grew by 60 per cent between 1990 and 2001, the last year for which data are available. Emissions from other freight transport (chiefly rail and marine) grew by 5 per cent. Emissions from other transport (passenger and off-road) grew by 10 per cent, and emissions from non-transport sources (agriculture, industry, commercial/institutional, and residential) taken together grew by 17 per cent.[12]

Put another way, in 1990, trucking was responsible for 7.4 per cent of all GHG emissions in Canada. In 2001, it was responsible for 10.2 per cent of the total. Across the eleven years, trucking contributed 28 per cent of Canada's *growth* in GHG emissions from all sources.

In Quebec, shown in the right-hand panel of Box 1, the relative increase in GHG emissions from trucking was lower: below 40 per cent across the eleven years rather than the Canada-wide 60 per cent. However, trucking's share of the *growth* of emissions was much higher. Indeed, without the increase from trucking, there would have been a decline of about two per cent in GHG emissions from Quebec sources between 1990 and 2001. The

Box 1. Changes in GHG emissions from transport and other sources,
Canada and Quebec,1990-2001 (1990 values = 100)



Source: Natural Resources Canada (see Note 1)

Box 2. GHG emissions in 1990 and growth from 1990-2000, Quebec and the rest of Canada

Source of greenhouse gas emissions	QUEBEC				REST OF CANADA			
	GHG emissions in 1990	Growth 1990-2001	Change from 1990-2001	Change corrected for population growth	GHG emissions in 1990	Growth 1990-2001	Change from 1990-2001	Change corrected for population growth
	Megatonnes		*Per cent change*		*Megatonnes*		*Per cent change*	
Truck activity	6.4	2.3	36%	29%	23.9	15.8	66%	46%
All other activity	53.0	-1.0	-2%	-7%	324.2	48.7	15%	1%

Source: Natural Resources Canada (see Note 1)

increase from trucking meant there was an overall *increase* by about two percent. The difference between Quebec and the rest of Canada is elaborated in Box 2, which shows actual amounts of GHG emissions and also per-capita differences (thereby allowing for Quebec's lower population growth).[13]

If *indirect* contributions are counted, the shares of GHG emissions attributable to trucking are considerably higher than those indicated above. Indirect contributions include those from the extraction, production, and distribution of trucking fuels. Most indirect contributions occur in Alberta and are usually so assigned, resulting in large emission totals for that province. As the share of oil produced from oil sands grows, raising GHG emissions per tonne of oil produced,[14] even more emissions will be assigned to Alberta and to other producing provinces. They might more appropriately be assigned to where the oil is used.[15]

The relatively high rate of growth in GHG emissions from trucking in Quebec and in Canada is part of a worldwide trend. In affluent and poorer countries alike, GHG emissions from and fuel use by trucking tends to grow at a higher rate than those of other transport, which in turn grow at a higher rate than those from most other sectors.[16]

Note that the increases in GHGs from trucking would have been even larger if it were not for achievements in fuel economy, particularly in the case of heavy trucks. These are illustrated in Box 3.[17] (The overall *increase* in energy use per tonne-kilometre of freight moved shown in Box 3, notwithstanding the *reductions* for each freight mode, arises because of changes in the contribution of each mode to the total.)

Some of the potential causes of the increase in trucking activity have been noted in the previous section, namely the evolution from 'push' to more transport-intensive 'pull' logistics and the lengthening of supply chains with globalization.

Vehicle activity has two components: trip length and the number of trips. Increases in either one, or both, result in increases in vehicle activity. Data for the U.S.,[18] Europe,[19], and

Box 3. Energy use per tonne-kilometre by freight mode, Canada, 1990 and 2001

	Megajoules per tonne-kilometre		Change 1990-2000
	1990	2001	
Light freight trucks	11.41	10.97	-4%
Medium freight trucks	7.55	6.78	-10%
Heavy freight trucks	2.91	2.22	-24%
Rail freight	0.34	0.24	-29%
Marine freight	0.57	0.54	-5%
Total	1.15	1.18	2%

Source: Natural Resources Canada (see Note 12)

Canada[20] suggest that increases in trip lengths have contributed more to the increase in truck vehicle-kilometres than increases in the annual number of trips.

For Europe, three factors have been said to contribute to the increase in the average length of truck trips:[21]

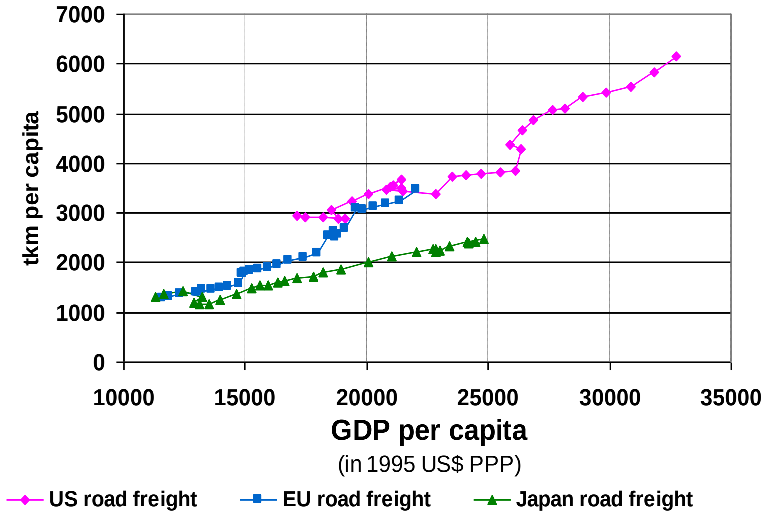
- Wider sourcing of supplies and expansion of market area.
- Centralization of production, warehousing, and terminal capacity, thereby reducing the amount of inventory required to provide a given level of service, but increasing the average distance from the supply point to the consumer
- Development of hub-satellite systems that allow increased vehicle utilization but also serve to increase freight-transport distances.

Load factor is another potential factor in the amount of trucking activity. It is the percentage of a truck's capacity that is used. An empty truck has a load factor of zero per cent; a one-quarter-full truck has a load factor of 25 per cent. Other things being equal, low load factors mean that more truck activity is required to move a given amount of freight.

Comparison of average load factors for all trucks operating in Canada, as indicated by the *National Roadside Studies* conducted in 1995 and 1999, suggest that they declined between the two years from an average of 57 per cent in 1995 to 50 per cent in 1999.[22] By contrast, load factors seem to have increased in the U.S.[23] and perhaps in Europe.[24] Load factors are discussed in more detail in Sections 3 and 4 of the present report.

Finally, mention should be made of a potential underlying cause of the increase in trucking activity: growth in overall economic activity. Box 4 shows how GDP per capita and trucking activity have varied together in the European Union, Japan, and the U.S.[25] There is some question as to whether truck activity causes economic activity, or vice versa, or both.[26]

Box 4. Road freight intensity and GDP per capita, 1970-2000



Source: OECD (see Note 25)

3. LOAD FACTORS AND ENERGY CONSUMPTION

A freight transport system exists to move freight rather than vehicles, yet most of system's energy goes towards moving the vehicles. This is illustrated in Box 5, based on data provided by a truck manufacturer.[27]

A tire company, Bridgestone, has suggested that as a rule of thumb for a truck with semi-trailer each tonne of payload reduces fuel use by one per cent, with the difference between a full and empty truck being 21.1 per cent of the energy used to carry a full load.[28] Bridgestone's analysis thus assumes that almost 79 per cent of the fuel is used to move the vehicle, as opposed to its cargo, perhaps a higher value than that shown in Box 5. Another estimate of how fuel use varies with load factor concluded that a diesel truck tractor with a single trailer together weighing 11 tonnes when empty uses 28.3, 38.1, and 41.4 litres of fuel per 100 kilometres when carrying cargo weighing 0, 19.0, and 25.3 tonnes, respectively.[29] It follows that when the largest weight of cargo was being carried, 68 per cent of the fuel was being used to move the vehicle, also perhaps a higher value than that shown in Box 5.

Thus, the values in Box 5 may be lower-than-average estimates of the fuel used to move trucks as opposed to their cargos. Nevertheless, the 'tractor with semi-trailer' example in Box 5 is used to illustrate how fuel use per unit of payload varies with load factor. The relationship is shown in Box 6.[30] In this example, fuel consumption per unit of payload with a 10-per-cent load factor is about twice the consumption with a 20-per-cent load factor, which in turn is about twice the consumption with a 45-per-cent load factor, which in turn is about twice the fuel consumption when the truck is full.

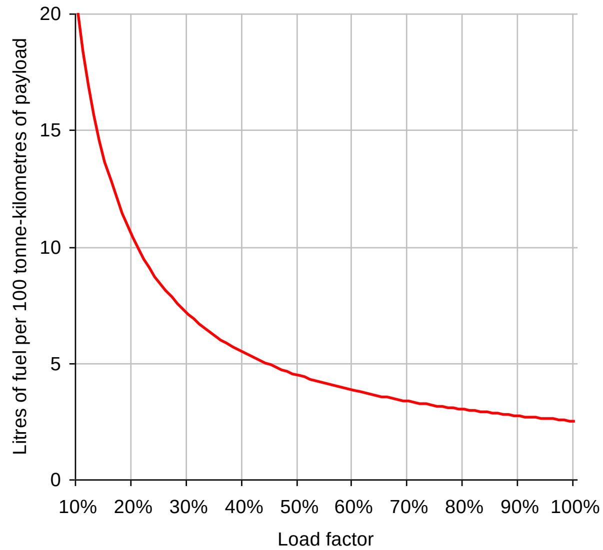
The important aspect of load factor is not so much the estimated energy use per payload tonne-kilometre but the opportunities presented by low load factors to consolidate loads, use fewer trucks, use less fuel, and produce fewer emissions. The key point is not that a one-tenth-full truck uses about eight times as much fuel per tonne of payload as a full

Box 5. Fuel use for empty and full trucks, and the share of fuel used to move the vehicle, as opposed to its cargo, when the truck is full

	Tare weight in tonnes	Payload in tonnes	litres/100 km empty	litres/100 km full load	Share of fuel moving the vehicle (with a full load)
Truck, distribution traffic	5.5	8.5	20-25	25-30	82%
Truck, regional traffic	10	14	25-30	30-40	79%
Tractor and semi-trailer, long-haul traffic	14	26	22-27	30-37	73%
Truck with trailer, long-haul traffic	20	40	28-33	45-55	61%

Source: Volvo Truck Corporation (see Note 27)

Box 6. How fuel use per unit of payload varies with load factor



Source: Volvo Truck Corporation (see Note 27)

truck. It is that ten of the near-empty trucks could—in theory—be replaced by one full truck, thereby saving seven-eighths (88 per cent) of the fuel used. Whether they could be so replaced in practice requires the kind of investigation that is one of the purposes of the present study.

Even quite small increases in load factor can result in significant reductions in fuel use, provided appropriate consolidation can be achieved. For the example in Box 6, increasing the average load factor from 30 to 40 per cent reduces fuel use per payload tonne-kilometre by almost a quarter (from 7.1 to 5.4 litres per 100 tonne-kilometres). Increasing the average load factor from 50 to 60 per cent reduces fuel use by about 15 per cent. Even the latter reduction would be significant in the context of reductions sought in the federal government's *Climate Change Plan for Canada*.[31] The reduction sought in the *Plan* for freight transport appears to be 11.8 per cent of freight transport's 1990 emissions and only 5.7 per cent of its 'business-as-usual' 2010 emissions.

An earlier-cited source noted that "Truck operators always try to weight out their trucks for hauling purposes to the legally allowable weight."[32] The reason is obvious. Haulage costs vary relatively little with load factor and thus net revenue can be increased by carrying more on each trip.

The need to maximize load factors may be less obvious to policy-makers and others concerned to reduce energy use by and greenhouse emissions from trucks. For example, improving load factors received hardly a mention in the work of the Transportation Table of Canada's Climate Change process. It is absent from the list of actions discussed in the Table's *Options Paper*[33] and is not evidently present in the above-noted *Climate Change Plan for Canada*.

One of the more than 20 research papers prepared for the Transportation Table had dealt with the topic.[34] Its authors surveyed the operators of five trucking fleets and concluded that all had attempted to reduce fuel use by matching vehicles to loads for longer trips; and by reducing the need for trips when empty. All had reported success in using "improved dispatch" to reduce fuel use. Specific instances of the effectiveness of measures directed at raising load factors were noted.

Part of the reason why strategists have not focused on load factors may be lack of appreciation of the potential. As noted above, quite small changes in load factor can lead to quite large changes in fuel use, especially when load factors are low. In 1999, load factors for inter-city heavy trucks averaged about 50 per cent in Quebec and the rest of Canada. In the case of Quebec, if the average had instead been raised to 60% (by 2001), it would have fully offset the whole of the increase in GHG emissions from this type of vehicle between 1990 and 2001.[35]

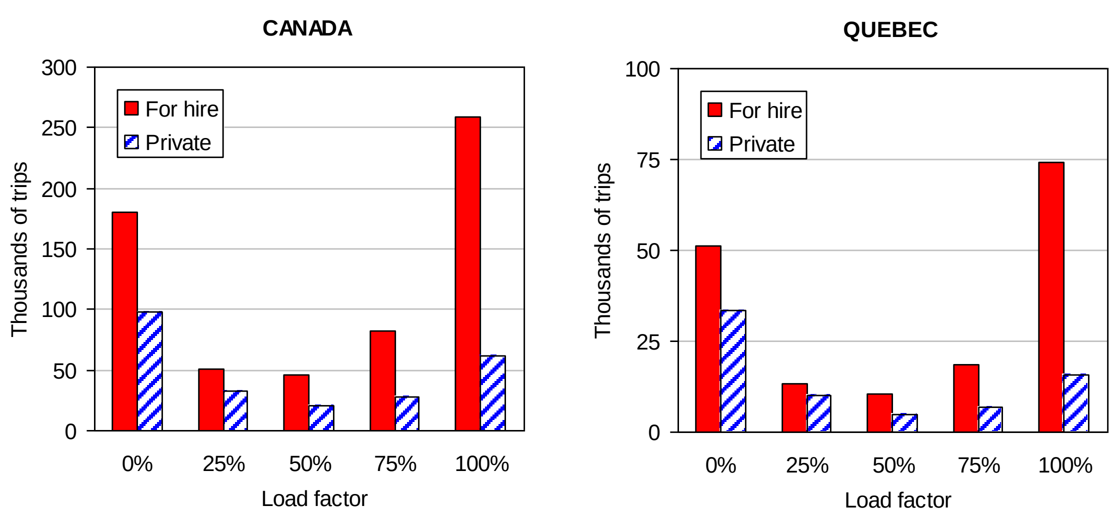
4. Load factors for inter-city truck traffic in Canada and Quebec

In 1991, 1995, and 1999 (but not in 2003), the federal and provincial governments conducted an extensive survey of heavy-duty cargo trucks moving along Canada's main inter-city highways.[36] The 1999 *National Roadside Study* (NRS) sampled truck traffic at 238 sites spread across the 25,200 kilometres of roads in Canada that are the main components of the network used by trucking outside urban areas. There was a seven-day truck count at each site and 65,052 interviews with operators of randomly selected trucks at the sites, supported by truck inspections. Interviews and inspections categorized trucks into empty, one-quarter full, half full, three-quarters full, and full. (The question as to whether 'full' means by 'full by space' or 'full by weight' is addressed below.) Of the sites, 51 were in Quebec, where 16,800 of the interviews were conducted.

As already noted in Section 2, the results of the 1999 NRS suggest that about half of such trucks on the road were half full or less. Box 7 shows the actual distribution of trips by load factor, showing 'for-hire' trucks and 'private' trucks separately.[37] A considerably higher proportion of the for-hire trucks were full than the private trucks (42 vs. 26 per cent for Canada; 44 vs. 22 per cent for Quebec), a matter returned to below.

Box 8 shows how the full trucks were full.[38] Trucks were more likely to be full by space ('cubed out' is a term often used) than by weight ('weighted out'). Just over a quarter of trucks were full by both space *and* weight. The 1999 NRS documentation is unclear as to whether trucks carrying less than a full load were, for example, half full by space or by weight. Analysis of cargo weights suggests that partial loads may have been even more likely to have been characterized by space than by weight.[39]

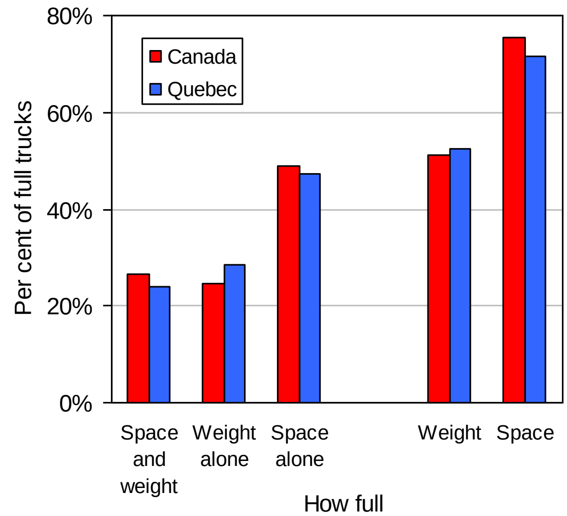
Box 7. Distribution by load factor of inter-city trips by heavy-duty trucks operating in Canada (left panel) and in Quebec (right panel), 1999



Source: *National Roadside Study* 1999 (see Note 36)

Box 9 shows that load factors increased quite steeply with trip distance, especially in the case of for-hire trucks.[40] Put another way, full and nearly full trucks were more likely to be on longer-distance trips, and less full trucks were more likely to be on shorter-distance trips. As well, Box 9 confirms the indication in Box 7 that for-hire trucks were more likely to be well loaded than private trucks.

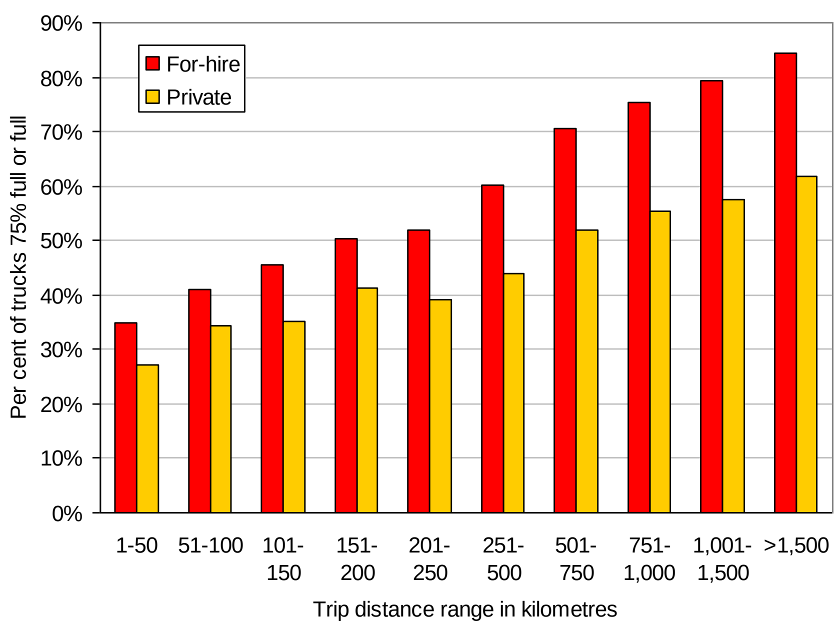
Box 8. How trucks were full by space or weight, or both, Canada 1999



Source: *National Roadside Study* 1999 (see Note 36)

Because less full trucks travelled shorter distances, the expected reduction in energy use and emissions from load-factor improvements could be lower for lower load factors. This is illustrated in Box 10, which shows both the shares of all trips that had load factors of 75 per cent or less and the shares of potential capacity, weighted for distance travelled, for Canada and for Quebec.[41] The weighting for distance travelled reduces the potential for improvement considerably,

Box 9. Loading of trucks at each distance range, for-hire and private trucks, Canada, 1999

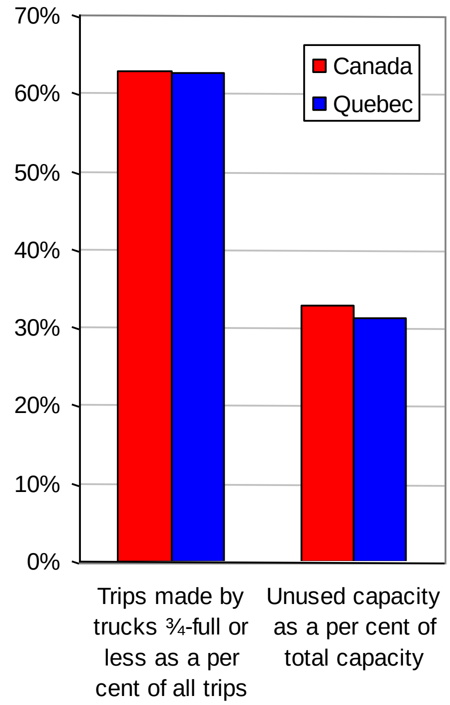


Source: *National Roadside Study* 1999 (see Note 36) from a Canada-wide average of 63 per cent (trips three-quarters full or less) to 33 per cent (unused capacity weighted for distance). Even after the correction for distance travelled, the potential for better loading of inter-city trucks remains considerable.

Many more trucks are on Canadian roads than the inter-city trucks that were the subject of the NRS surveys. A pointer to the scale of this activity is an estimate that in the mid-1990s the *value* of private trucking *exceeded* that of for-hire trucking, even though the 1999 NRS, for example, recorded 2.6 times as many trips by for-hire trucks (see Box 7). The estimate is set out in Box 11, which shows the values of for-hire and private trucking according to the type of trip (urban, intra-provincial, etc.).[42] Private trucking appears to predominate within urban regions.[43]

The 1999 NRS suggests that trucks travelling short distances, especially private trucks, were likely to have low load factors (see Box 9). Thus—to the extent that this finding applies today and to trips within urban areas—the potential for increasing load factors among trips not covered by the NRS survey seems huge.

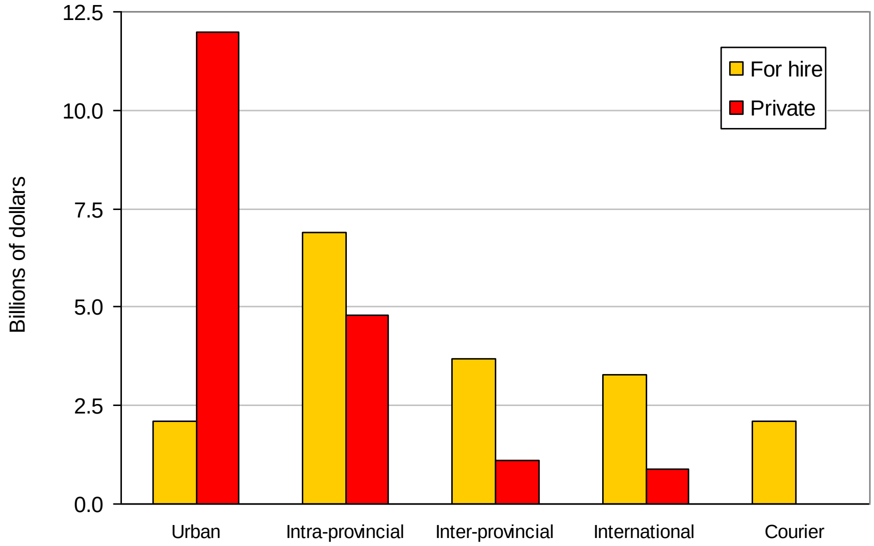
Box 10. Trucks not full as a per cent of all trips and unused capacity as a per cent of all capacity (weighted for trip length), 1999



Source: *National Roadside Study* 1999 (see Note 36)

In conclusion, the available evidence suggests that the potential for reducing energy use and GHG emissions by increasing truck load factors may be large. The more productive opportunities may lie with private trucks travelling shorter distances, in and near urban areas. However, longer-distance trucking should also be addressed. Even though longer-distance trucks are more likely to have high load factors, there may be a sufficient number with low load factors to warrant measures to ensure further consolidation of loads.

Box 11. Value of services provided by for-hire and private trucking by area of operation, Canada, mid-1990s



Source: *Profile of Private Trucking in Canada* 1998 (see Note 36)

5. Freight movement within Sherbrooke and other urban regions

The largest gaps in data on trucking concern movement within urban areas. As noted in Section 4, private trucking appears to predominate in urban areas, and yet Statistics Canada ceased collecting data on private trucking in 1998.[44] The *National Roadside Study* surveys did record private trucks, but mostly the minority that was making making longer-distance, inter-city trips.

The few available data are puzzling. For example, analysis of the records for 1999 and 2000 from the one automatic vehicle sensor maintained by Transports Quebec within the City of Sherbrooke (on Highway 410, one kilometre north of boulevard Portland) raised the following questions:

- Overall vehicle counts show an increase of almost exactly 50 per cent between 1994 and 2000 in the amount of traffic at this point, from 16,700 to 25,000 vehicles per day. Was there a similar relative increase for truck traffic alone?
- Why are the data for trucks so incomplete (e.g., nothing for July in either year)?
- The records of truck traffic in May of each year suggest that heavy trucks comprised no more than about one per cent of all vehicles. Yet, the City of Sherbrooke's *Transport Action Plan* (1991) suggested that trucking activity on the City's main streets comprised six per cent of all traffic, with heavy trucks comprising about half of this activity (i.e., about three per cent of the total). What is the basis for this discrepancy?
- Comparing the two years for the Sherbrooke station, "camions porteurs" increased by about 35 per cent from 1999 to 2000 while "camions articulés" increased by only three per cent. Why was this?
- For both types of truck, the first half of 2000 saw less traffic overall that in the corresponding months of 1999, while the second half saw much more traffic. Why was this? Such a difference between the first half and the second half of the year is not evident in the data for all vehicles. Thus it may not be a weather effect.

During the course of the project, we hope to be able to address some of these questions, and others about trucking within Sherbrooke, through use of the following sources:

- Analysis of data pertaining to Sherbrooke in the 1999 *National Roadside Study*, to be provided by Transports Quebec.
- Information about cordon counts—possibly specially collected information—to be provided by the City of Sherbrooke.
- Responses to the questionnaire completed by businesses as part of the present project.

Similar uncertainties likely apply to trucking within every other urban region in Canada. Among these regions, only Vancouver,[45] Edmonton,[46] and Calgary[47] appear to have conducted origin-destination surveys of intra-regional freight movement, and these surveys appear to have focused more on truck movements than on how efficiently trucks might be used.

Statistics Canada produces an annual document *Trucking in Canada* that provides information about inter-city movements by for-hire carriers doing a million or more dollars of business each year to and from 24 of Canada's Census Metropolitan Areas (CMAs).[48] Sherbrooke is among the three CMAs not reported on.[49] One table gives details of "originating movements" by CMA; another gives details of "destination movements" by CMA. For each region and for each kind of movement totals are provided for the following: revenues (by the carriers), tonnes (of shipments), tonne-kilometres (performed on shipments), and shipments. Box 12 provides aggregate data on the 24 CMAs reported on for 1991 and 2002.

Box 12 shows that, across the 11 years, these shipments on average became heavier, and moved farther, cost more to send but cost less per unit tonne or tonne-kilometre. In both years, shipments destined for the CMAs weighed much more but travelled a little less far than shipments originating in the CMAs. They cost more to send but cost less per tonne or tonne-kilometre.

Given that on average the same trucks would be used for originating and destination movements, Box 12 suggests that trucks travelling to CMAs may have been more fully loaded (at least by weight) than trucks originating in CMAs.

Sherbrooke did feature in the latest *Urban Transportation Indicators* survey, conducted with respect to 2001 data for the Transportation Association of Canada.[50] This survey provided differing degrees of coverage of Canada's 27 CMAs. Data pertaining to truck use in 2001, gathered from local sources in the course of the survey, are shown in Box 13 for the six of the 27 CMAs that reported such data.

Box 12. Characteristics of shipments by larger for-hire carriers
to and from 24 CMAs, 1991 and 2002

	Shipments (thousands)	Average for shipments			Revenue in dollars per		
		Weight (t)	Distance (km)	TKM	Shipment	Tonne	TKM
Originating movements							
1991	18,884	3.08	433	1,336	186.97	60.62	0.14
2002	20,852	4.40	511	2,251	226.84	51.51	0.10
% change	+10%	+43%	+18%	+69%	+21%	-15%	-28%
Destination movements							
1991	13,314	4.88	417	2,034	225.30	46.20	0.11
2002	14,958	6.40	495	3,168	275.37	43.05	0.09
% change	+12%	+31%	+19%	+56%	+22%	-7%	-22%

Source: Statistics Canada (see Note 48)

Box 13. Truck registration and traffic data for 2001, as gathered during the *UTI Survey* from reporting CMAs

CMA	Heavy duty trucks registered per million residents	Per-capita daily vehicle-kilometres by medium and heavy commercial vehicles on:	
		Freeways	Other major roads
Montréal	6,168	1.49	0.49
Ottawa-Gatineau	5,537	0.47	1.52
Calgary	27,450	0.86	0.28
Quebec City	6,583	0.95	0.40
Winnipeg	14,294	0.09*	0.60
Sherbrooke	4,681	1.12	0.57

*possible error

Source: Transportation Association of Canada (see Note 50)

Box 13 suggests that among reporting urban regions Sherbrooke may be on the low side for heavy truck registrations, on the high side for truck freeway activity, and in the middle for truck use of other major roads.

The 2001 *UTI Survey* also enquired as to the status within the region of several types of transportation and land-use planning initiative. Responses were rates on a six-point scale from “not a priority at present” (scored ‘1’) to “implemented throughout the region” (scored ‘6’). Box 14 shows scores on the section concerning goods movement, in relation to the average scores by other reporting urban regions. (There were 18-21 other reporting regions, according to the type of initiative.)

Box 14 suggests that Sherbrooke reported a relatively low degree of implementation of most types of initiative related to goods movement. However, Sherbrooke’s overall score was not the lowest in this respect: four of the reporting urban regions had a lower overall score. Moreover, for municipalities of its size, Sherbrooke’s score was not unusually low. Nevertheless, the responses suggest that in some areas there is scope for move involvement by the municipality in matters to do with freight movement. Achieving such greater involvement is one of the purposes of the present project.

Also to be noted is that the *ranking* of Sherbrooke’s responses, from high to low, is similar to the ranking of the responses by other responding regions. This suggests that Sherbrooke’s priorities in respect of goods movement are similar to those within other CMAs, although perhaps with differing degrees of emphasis.

Box 14. Responses to the 2001 *UTI Survey*: status of initiatives related to goods movement (higher score means more implementation; see text for further explanation)

Initiative	Response by Sherbrooke	Mean response of other reporting regions
Consideration of goods movement in transportation system planning	1	3.7
Consultation with goods movement industry to identify/resolve issues	1	3.8
Provision of adequate, accessible off-street loading facilities	3	4.4
Designation of appropriate truck routes	6	4.5
Development of intermodal freight terminals and/or freight consolidation terminals	1	3.4

Source: Transportation Association of Canada (see Note 50)

6. CHALLENGES CONCERNING URBAN FREIGHT TRANSPORT AND LESSONS LEARNED

This section provides a brief overview of the general challenges in relation to urban freight transport. It relies heavily on a recent OECD publication *Delivering the Goods: 21st Century Challenges to Urban Goods Transport*.[51] That document begins with the words, "Goods transport in urban areas has a major impact on the economic power, quality of life, accessibility and attractiveness of the local community, but it receives little attention in comparison to passenger movement."[52] It continues by noting several associated problems, and the one-sided nature of perceptions of these problems.

> *Accessibility problems* are both encountered and caused by urban goods transport. Problems encountered by freight vehicles are mainly due to insufficient infrastructure, access restrictions or congestion. This results in freight vehicles causing disruption of traffic and further congestion.
>
> Freight transport contributes considerably to *environmental problems* such as emissions, noise, vibration and physical hindrance. It also causes *safety problems* since freight vehicles, due to their size, manoeuvrability and on-road loading/unloading operations, are a significant cause of accidents. Urban goods transport is a major and rapidly growing sector of oil consumption, which gives rise to problems of *energy consumption* and related emissions concerns.
>
> These problems have led to some increased concerns about the consequences of urban goods transport. Although it is clear that urban goods transport is crucial for maintaining the economic and social functioning of cities, there seems to be a serious lack of awareness of its benefits. Awareness of urban goods transport seems to be rather one-sided, focusing more on its problems than on its importance.

The document continues with a summary of lessons learned from experiences in OECD member countries, as follows.

> While being increasingly concerned about negative impacts of urban goods transport, cities are aware that delivering goods to the city is essential for maintaining their economic and social functions. Therefore, cities are confronted with common and difficult challenges of maintaining their sustainability and liveability while ensuring a goods transport system that sufficiently serves their needs.
>
> In many countries, problems of urban goods transport are dealt with at a local or regional level, resulting in a lack of consistency among local or regional measures. Only a few countries have developed an explicit encompassing national policy focused on urban goods transport.
>
> There is a lack of awareness and knowledge of urban goods transport not only among the general public but also among governments and city planners. This has often led

to transport-related policies and facilities being planned merely from the passenger transport perspective, without adequate consideration of the needs of freight transport.

Few countries have analytical tools and data for evaluating the effectiveness of their policy measures concerning urban goods transport, resulting in their measures causing unexpected side effects.

Policies currently in place tend to focus strongly on short-term problems and solutions. Few attempts seem to have been made to provide forecasts for future developments or to develop long-term policy options. Also, in spite of the fact that urban goods transport is integrated with long distance transport, current measures on urban goods transport often only take account of the urban area and pay little attention to the supply chain as a whole.

Local regulations tend to differ among different municipalities and be changed as circumstances change. This can cause difficulty in enforcing such regulations on drivers who are often not aware of the different and changing restrictions. Such a lack of harmonization and stability also causes problems for the vehicle manufacturing industry in developing vehicles that comply with such regulations.

Since urban goods transport issues are complex and involve many stakeholders, consultation platforms have proved to work well in some countries in bringing such stakeholders together to discuss issues and plan measures.

Publicly owned or publicly driven distribution centres often do not receive support from the private sector and tend to become commercially unsuccessful.

Consolidation of deliveries is emerging as an important tool for solving problems, but little attention is being paid to accommodating or facilitating this through policy measures.

Some countries are attempting to implement innovative policy measures, e.g. selective time-sharing and multiple use of infrastructure, introducing environmental zones and using pricing for diverting freight traffic from residential areas, with some promising results.

The document concludes with the general observation that a key policy objective should be "*sustainable urban goods transport*, which requires the development of an urban goods transport system on a socially, economically and environmentally sound basis. This system should be demand driven, aiming to serve the various needs of urban people, thereby establishing an innovative and effective system, while ensuring efficient use of infrastructure, if possible on a 24-hour basis."

The document's recommendations include the following (with explanatory comments added here).

1. Active measures are needed to increase awareness of the importance of urban goods transport and to diffuse knowledge.
2. Evaluation methods and data are prerequisites for effective policy measures.
3. Consolidation is a key to achieving sustainable urban goods transport. (An example of "successful consolidation" provided in the document is reproduced in Box 15 below.[53])
4. Regulations need to be harmonized, standardized, stable, easy to enforce and cost effective.
5. Infrastructure capacity should be used more imaginatively on a 24-hour basis.
6. Cleaner, low noise and more energy-efficient vehicles need to be promoted.
7. Adequate logistic facilities need to be provided. (This refers to adequate on- and off-street loading areas, to promotion of trans-shipment facilities, and to facilitation of e-commerce. See Box 16 on the next page.[54])
8. Efforts need to be made to reduce safety risks of urban goods transport.
9. Reverse logistics needs to be developed. (This refers to management of used materials, including used and reusable packaging, returns, and waste.)
10. Technological and conceptual innovation can support sustainable urban goods transport. (See Box 16.)

The OECD report notes several attempts to reduce the number of trucks moving within urban areas by establishing public- or private-sector distribution centres that consolidate loads, rationalize pick-ups, and optimize loading and routing of the vehicles employed. Overall, the experience is mixed. Such services can be successful in reducing truck activity, energy use, and emissions, but they can also raise costs, deterring use of the services when there are alternatives.

Box 15. Example of successful consolidation

In the central business district of Fukuoka City, Japan, where traffic congestion is a major problem, 29 freight transport operators initiated a co-operative city logistics scheme in 1978. After a public-private partnership process involving national and regional governments, police authorities, local industries and freight transport operators, a city logistics company for co-operative collection and distribution in the area was set up in 1994 under the co-operation of 36 freight transport operators. Along with this scheme, the public sector dealt with traffic problems by installing parking meters to be used exclusively by freight vehicles and by increasing enforcement of parking regulations.

The scheme has resulted in reducing the number of freight vehicles by 65 per cent and reducing freight vehicle kilometres in the area by 87 per cent, thereby reducing environmental impacts accordingly.

Source: OECD (see Note 53)

Box 16. City logistics

City logistics is an integrated approach for urban goods distribution based on the system approach. It promotes innovative schemes that reduce the total cost (including economic, social and environmental) of goods movement within cities. City logistics is based upon the framework of sustainable development and fits within the framework of consultative planning. Both frameworks provide basis for policy evaluations of city logistics initiatives.

City logistics schemes typically involve establishing partnerships between the public and private sectors. There are numerous types of city logistics schemes, including:

- Advanced information systems.
- Co-operative freight transport systems.
- Public logistics terminals.
- Promoting shared use of freight vehicles.
- Underground freight transport systems.
- Area access control.

City logistics encourages collaboration between key stakeholders within a market-based economy. It also promotes the development and application of models for predicting the effects of schemes. Transport network modelling approaches for estimating the demand, level of service and impacts of schemes are required. There have recently been a number of developments in modelling methods that allow the impacts of city logistics schemes to be estimated.

Source: OECD (see Note 54)

An outstanding example of a successful attempt to reduce truck activity in a congested area is the establishment of the Heathrow Airport Retail Distribution Centre, near London UK, managed by Exel, a logistics company. Suppliers' vehicles go to the distribution centre, and only the logistics company's vehicles enter the airport. **The result appears to have been a reduction by 90 per cent in the number of vehicles servicing retail operations within the airport perimeter**. In addition to the reduced congestion and environmental impacts, the following advantages have been noted:

- Major cost savings by suppliers.
- A reduction in the number of less experienced drivers on airport roads.
- More frequent and better scheduled deliveries to terminal buildings, enabling retailers to know more accurately when goods will arrive.[55]

The system was introduced in part to reduce internal traffic and in part to reduce security risks. It illustrates the potential for reductions in truck energy use and GHG emissions. It may also illustrate the essential requirements for the success of such a scheme: a high level of freight transport activity within a relatively small area, complete control over roads in the area, and the prohibition of other means of freight movement in the area.

Another recent discussion of 'City logistics' is in a section with that name in a recent book chapter by Alan McKinnon.[56] He noted the debate in Europe of the last few decades as to whether loads bound for cities should be consolidated,[57] disaggregated[58] or neither, with current trends towards consolidation (which may have always been the priority in North America). He noted too the emergence of "cooperative freight transport systems" or "shared-user transport services" and trials in Copenhagen and Amsterdam where vehicles were granted access to public freight terminals or inner urban areas only if their load factors exceeded 60 and 80 per cent, respectively. In the UK, the national government has encouraged the creation of "quality partnerships for urban distribution"—involving local governments, shippers and carriers, other businesses, residents, and environmental groups—with the mission of developing local solutions to freight problems.

In the U.S., urban freight is one of the 15 planning factors that must be addressed by Metropolitan Planning Organizations (MPOs), planning institutions at the urban regional level required as a condition of receipt of federal funds.[59] A March 2003 survey of all 340 MPOs produced the following responses (based on 136 responding MPOs):[60]

- 78 per cent of MPOs have no staff people dedicated to freight.
- In more than 80 per cent of MPOs, less than five per cent of staff time is spent on freight.
- Only 18 per cent of MPOs had a freight advisory committee, and in only 18 per cent were freight interests represented on the MPO policy board.
- Only 16 per cent of MPOs had a priority list of freight projects.
- In 70 per cent of MPOs, less than two per cent of MPO projects were freight related

One commentary suggested that " … planning for freight transport has received relatively little attention in US urban areas, just as in Europe".[61] It may receive even less attention because of the greater separation of land uses that removes freight problems from residents and thus from public discourse.

Thus, the indications for the U.S. confirm the statement in the OECD report discussed earlier in this section: that freight issues in urban areas may receive too little attention. Such observations may well apply to Canada.[62]

7. RAISING LOAD FACTORS FOR INTER-CITY TRUCK ACTIVITY

The previous section concerned challenges in intra-urban freight transport and options for reducing its impacts, with a focus on increasing load factors

Inter-city trucks often begin and end their journeys within cities and so measures directed at the loading of these vehicles are of interest. It's hard to find assessments of efforts to increase the load factors of trucks operating over longer distances. The apparent popularity of Internet-based load-matching services suggests that there may be considerable interest in raising load factors.[63]

However, the interest may be driven by factors other than fuel savings and reductions in GHG emissions. A recent prospective view of trucking and logistics during 2004 suggested that load factors are increasing but more in response to overall capacity constraints than to particular concerns about fuel use or GHG emissions.[64] Several possible causes for the capacity constraints were indicated (not in order of importance): (i) reduction in effective rail capacity; (ii) growth in economic activity, particularly in the U.S.; (iii) carrier bankruptcies and consolidations during the recent economic recession in the U.S.; (iv) shortages of truck drivers; (v) cross-border security programs; (vi) new U.S. hours-of-service rules for drivers, and forthcoming new Canadian rules; and (vii) higher insurance premiums and uncertainty about fuel costs that have made operators reluctant to add equipment.

Thus, an ongoing trend towards higher load factors could be an almost incidental effect of the prospect of higher fuel costs. According to one source, fuel costs are presently 29 per cent of truck running costs, with wages, maintenance, and tires being other significant costs.[65] Even if as much as 20 per cent of running costs is allowed for depreciation, the resulting 24 per cent is a major part of total truck costs that can make operators sensitive to fuel prices. Moreover, heightened concern about prospects for higher prices of transport fuels is understandable in view of current world oil prices and indications of future constraints.[66]

8. SCOPE FOR MUNICIPAL ACTION TO IMPROVE THE EFFICIENCY OF URBAN FREIGHT TRANSPORT

Box 17 and Box 18 on the next two pages provide the core of a policy analysis of the effects of different measures on truck activity in urban areas, from a UK perspective.[67] Just over half of the measures listed in the two tables are neutral with respect to use of fossil fuel. Of the remainder, all but two were assessed as potentially reducing fossil fuel use. One—'more bus/cycle lanes'—was said to have the potential to increase fuel use because "bus and cycle lanes hindered goods and service vehicle operations".[68] For the other—'urban transhipment centre'—the indication of a potential to increase fuel use may be a misprint because the associated text is this: "it is possible that a transhipment centre could potentially result in improvements in vehicle productivity, and a reduction in labour and fuel requirements in comparison with the current situation in which many freight companies' vehicles are involved in traffic congestion and delays".

Of the 29 measures listed in Box 17 and Box 18 only the one concerning urban transhipment centres, also known as distribution centres, clearly addresses the matter of raising load factors. Thus, it is especially unfortunate that this measure is the one that appears to be associated with a misprint.

The matter of distribution centres was touched on in Section 6, particularly in Box 15 and associated text, during consideration of a recent OECD document. That document reviews several examples of urban distribution centres, all in Europe or Japan. North American examples are hard to find. One description concerns "last mile delivery" in Manhattan: "… many national carriers sub-contract the last leg of the trip to niche carriers with smaller trucks whose drivers know the area and are willing to cope with the local problems (sort of privately run Urban Distribution Centres). National carriers are apparently willing to outsource such services and absorb additional expenses because it saves them time and money.".

Box 17. Relationship between policy measures that could make freight operations easier to perform and vehicle-related activities

	Goods and service vehicles/vehicle activity in urban areas									
Policy measures:	Total vehicle trips in urban area	Total vehicles in urban area	Average trip length	Fossil fuel consumption rate/km	Vehicle size/ weight	Number of vehicles parked on-street at busy times	Time spent parked or unloading on-street	Vehicle using inappropriate routes	Time of operation (inc. or dec.in out of hours work)	Vehicle speed
Relaxing loading/unloading time restrictions	O	↓	O/↑	O	O	↑	O	O	O/↑	O
Relaxing goods vehicle size/weight restrictions	↓	↓	O/↑	O	↑	O/↓	O/↑	O/↑	O	O
Allowing goods/service vehicles into pedestrianised areas at any time	O/↓	↓	O/↑	O	O	↑	O	O	↑	O
Improving on-street loading/parking facilities for goods and service vehicles	O	O	O	O	O	O	O/↓	O	O	O
Allowing goods/service vehicles to use bus lanes	O	O/↓	O	O/↓	O	O/↓	O	O/↓	O	O/↓/↑
Allowing night goods and service vehicle access if not previously permitted	O/↓	O/↓	O	O/↓	O	O/↓	O	O	↑	↑
Car use reduction strategies	O	O	O	O/↓	O	O	O	↓	O	↑
Better enforcement of car parking regulations (but what about cars that are being used for service/commercial activities)	O	O	O	O	O	O	↓	O	O	O
Improved traffic/roadwork information	O	O/↓	O/↑	O/↓	O	O	O	O/↓	O	↑
Road infrastructure/building/bypasses	O/↓	↓	O/↑	O/↓	O	O	O	O/↓	O	↑
Improved road signing	O	O/↓	O/↓	O/↓	O	O	O	↓	O	O/↑
Lorry routes (could be mandatory or advisory)	O	O	O/↑	O/↓	O	O	O	↓	O	O/↑
Improving access to back of premises	O	O	O	O	O	↓	↓	O	O	O
Yellow boxes - traffic management	O	O	O	O	O	O	O	O	O	↑
Traffic calming - traffic management	O	O	O	O	O	O	O	↓	O	↓
Traffic signal sequencing	O	O	O	O	O	O	O	O	O	↑
Moveable width restrictions	O	O	O	O	↑	O	O	O/↑	O	O
Policies to improve public transport	O	O	O	O/↓	O	O	↓	↓	O	↑
Designing goods/service vehicle facilities into building design/planning permission	O	O	O	O	O	↓	O	O	O	O
Encourage relocation of premises to less dense areas	↓	↓	↓	O	O	↓	O	↓	O	O
Park and ride depositories	↑	↑	O	O	↓	O/↑	O	O	↑	O
Urban transhipment centre (see Section 3.2.1)	↑	↑	↓	O/↑	↓	O/↓/↑	O	O	↑	O

Key: ↑ = Increase in vehicle activity pattern ↓ = Decrease in vehicle activity pattern O = No change in vehicle activity pattern

Source: Transport Studies Group, University of Westminster, UK (see Note 67)

Box 18. Relationship between policy measures that could make freight operations more difficult to perform and vehicle-related activities

Policy measures:	Total vehicle trips in urban area	Total vehicles in urban area	Average trip length	Fossil fuel consumption rate/km	Vehicle size/ weight	Number of vehicles parked on-street at busy times	Time spent parked or unloading on-street	Vehicle using inappropriate routes	Time of operation (inc. or dec.in out of hours work)	Vehicle speed
New/enlarged pedestrianised areas (greater vehicle access time restrictions)	O/↑	↑	O	O	↓	O/↓/↑	O/↑	O	O	O
Lower speed limits in urban areas	O	O/↑	O	O/↓	O	O/↑	O	O/↑	O	↓
More restrictions on vehicle weight/size	↑	↑	O	↓	↓	O/↓/↑	O	O	O/↑	O
More loading/unloading time/parking restrictions	O	↑	O	O	O	O/↓/↑	O	O	↑	O
Alternatively-powered vehicles	O	O	O	↓	O	O	O	O	O	O
More bus/cycles lanes	O	O/↑	O	O/↑	O	O/↑	O	↑	O	O/↓/↑
Urban road user charging	O/↓	O/↓	O/↓	O/↓	O	O	O	↑	O/↑	↑

Key: ↑ = Increase in vehicle activity pattern ↓ = Decrease in vehicle activity pattern O = No change in vehicle activity pattern

Source: Transport Studies Group, University of Westminster, UK (see Note 67)

9. POINTERS TO MATTERS TO BE ADDRESSED IN THE CASE STUDIES

This section will be omitted or entirely re-written for the final version of the review. It is included here to provide a several indications from the foregoing that could usefully be addressed in the case studies, as follows:

1. Opportunities for rail use (Section 1).

2. A long-term trend of an increase in truck traffic (Section 2), with a possible concomitant reduction in the amount of warehousing (Section 1).

3. The question as to whether for trucks operating in Quebec the increase in trip distance is a factor in the increase in trucking activity (see Section 2 and Note 20).

4. For-hire trucks are more likely to be full than private trucks (Box 7 and Box 9).

5. Trucks are more likely to be full by space than by weight (Box 8).

6. Trucks on longer trips are more likely to be full, especially for-hire trucks (Box 9).

7. For-hire trucking predominates between urban regions; private trucking predominates within urban regions (Box 11).

8. Trucks travelling to urban regions are more fully loaded than trucks travelling from urban regions (Box 12).

9. The City of Sherbrooke could consult more with the goods movement industry to identify and resolve issues including (i) provision of adequate, accessible off-street loading facilities, and (ii) development of intermodal or freight consolidation terminals (Box 14).

10. The applicability to Canadian urban regions generally and Sherbrooke specifically of the recommendations in the OECD document *Delivering the Goods*, as summarized on Page 21 (Section 6).

END NOTES

1 The fuel use data are from the Natural Resource Canada's Comprehensive Energy Use Database, available at the URL below. Overall, 67% of fuel used by freight trucks in Canada in 2001 was diesel fuel, up from 65% in 1990, and 31% was gasoline. The shares for Quebec are almost identical: 68% and 31%.
1. http://oee.rncan.gc.ca/neud/dpa/comprehensive_tables/index.cfm?Text=N&PrintView=N. Accessed April 12, 2004.

2 The indicated emissions factors are from Page 202 of *CO_2 Emissions from Transport*. European Conference of Ministers of Transport, Paris, France, 1997. According to this source, diesel-using vehicles typically use almost 20% less fuel than equivalent gasoline-using vehicles. Thus, even though 12% more CO_2 results from burning a litre of diesel fuel, overall GHG emissions from diesel-fuelled vehicles are lower.

3 An example of work on reducing fuel use by trucks is the FleetSmart program of Natural Resources Canada, described at the URL below.
1. http://oee.nrcan.gc.ca/fleetsmart/about/about.cfm?PrintView=N&Text=N. Accessed April 12, 2004.

4 The quote on push and pull logistics systems is from testimony of Lance R. Grenzeback, Cambridge Systematics, Inc. on 'Emerging Freight Issues' before the Subcommittee on Highways and Transit, Committee on Transportation and Infrastructure, U.S. House of Representatives, March 21, 2001, available at the URL below.
1. http://www.house.gov/transportation/highway/03-21-01/grenzeback.html. Accessed April 12, 2004.

5 For a useful discussion of push and pull logistics in Europe, see *Freight Logistics and Transport Systems in Europe*, European Council of Applied Sciences and Engineering, Paris, France, March 2001, at the URL below.
1. http://www.euro-case.org/Activities/Freight_FinalReport.pdf. Accessed April 12, 2004.

6 Information about trends in the components of logistics costs comes from Slide 24 of *Logistics Cost and Service 2003* (Establish Inc./Herbert W. Davis and Company, Fort Lee, N.J., 2003) at the URL below.
1. http://www.establishinc.com/pdfs/clm2003.pdf. Accessed April 12, 2004.

7 Information about order cycle times comes from Slide 32 of the source detailed in Note 6.

8 According to Natural Resources Canada, at the source detailed in Note 1, in 2001 rail in Canada expended 78.7 petajoules of energy to perform 325.7 billion tonne-kilometres of freight movement; heavy trucks expended 342.1 petajoules to perform 154.3 tonne-kilometres. Thus, the rates of energy use by heavy trucks and rail were respectively 2.22 and 0.24 megajoules per tonne-kilometre; i.e., the latter used just a little more than one tenth of the energy used by the former. It follows that movement of freight by rail can be advantageous from the perspective of energy use—and thus GHG emissions—if it can be achieved without substantially lengthening the route taken or incurring additional energy use in other ways.

9 Rail freight service to and from Sherbrooke is provide by Quebec Central Railway, which has rail links to CN Rail and to Montreal, Maine and Atlantic Railway. (See the URL below.)
1. http://www.rinbad.demon.co.uk/ca_qcr.htm. Accessed April 12, 2004.

10 An example is a key source of information about transport within Canada's urban areas: the Urban Transportation Indicators surveys conducted by the Transportation Association of Canada in respect of the years 1991, 1996, and 2001. Almost none of the survey questions and resulting indicators have concerned freight transport.

11 The Kyoto Protocol is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC) adopted at the Third Conference of the Parties to the UNFCCC, held in Kyoto, Japan, in December 1997. The Protocol concerns reductions in emissions of six greenhouse gases (GHGs), i.e., gases whose concentration in the earth's atmosphere influences the mean temperature of the earth's surface by

affecting the rate of energy loss of the earth (see the first URL below). The Protocol is binding on the 38 countries listed in Annex 1 to the UNFCCC, i.e., most of the industrialized countries, including those with economies in transition (former Soviet Union and eastern European countries). The Protocol comes into effect when two criteria are met: (i) it has been ratified by 55 Parties to the UNFCC, and (ii) it has been ratified by Annex 1 countries responsible for 55% of the total 1990 GHGs emitted by Annex 1 countries (see the second URL below). The first criterion has been met. Regarding the second criterion, 29 Annex 1 countries have ratified the Protocol, representing 44% of 1990 Annex 1 GHG emissions (see the third URL below). Significant non-ratifiers of the Protocol are the U.S., responsible for 33% of the 1990 Annex 1 total, and Russia, responsible for 17% of the total. Russia has not yet refused to ratify the Protocol. Canada, responsible for 3% of the total, ratified the Protocol on December 17, 2002. When the Protocol comes into effect, Canada's obligation will be to reduce its GHG emissions so that the average during the five years 2008 to 2012 is 6% below the 1990 level. As well, "demonstrable progress" must be made by the ratifying Annex 1 countries by 2005 (see the second URL below).
1. http://unfccc.int/resource/iuckit/fact02.html. Accessed April 12, 2004.
2. http://unfccc.int/resource/iuckit/fact21.html. Accessed April 12, 2004.
3. http://www.unfccc.int/resource/kpstats.pdf. Accessed April 12, 2004.

[12] The data in Box 1 are from the source detailed in Note 1. 'Trucks' include small, medium, and large trucks used for carrying freight. 'All other activity' includes other transport activity and activity in the agricultural, commercial and institutional, industrial, and residential sectors. Of the increase in GHG emissions from trucks across Canada, 47% was from heavy trucks; the corresponding share for Quebec was 26%. The increases for small, medium, and heavy trucks for Canada were 79%, 57%, and 53%, respectively; for Quebec they were 92%, 46%, and 15%, respectively.

[13] The GHG emissions data in Box 2 are from the source detailed in Note 1. Population data are from Statistics Canada's CANSIM II Table 510001, Series V466668 (Canada) and Series V468243 (Quebec).

[14] It's hard to find good comparisons of the energy costs of production of transport fuels from conventional oil—i.e., oil that can be readily extracted from readily accessible locations—and from oil sands. A reasonable value for the former may be one tenth of the energy in the usable fuel. This corresponds to an estimate of energy use in the production of petroleum in the U.S. (Cleveland CJ, Kaufman RK, Stern DI, Aggregation and the role of energy in the economy. *Ecological Economics*, 32, 301-317, 2000). A reasonable value for the energy cost of production from oil sands may be one third of the usable fuel. This estimate is based on an article by John Busby in the January 2004 issue of the *Newsletter* of the Association for the Study of Peak Oil and Gas, available at the first URL below. Thus, about three times as much energy may be required to produce a litre of gasoline from oil sands as from conventional oil. An industry comparison of GHG emissions from the two processes suggested that the ratio may be about 2.1:1 (see Figure 8.5 of *Oil Sands Technology Roadmap*, Alberta Chamber of Resources, January 2004, available at the second URL below).
1. http://www.asponews.org/docs/Newsletter37.pdf. Accessed April 12, 2004.
2. http://www.acr-alberta.com/Projects/Oil_Sands_Technology_Roadmap/OSTR_report.pdf. Accessed April 12, 2004.

[15] Little oil from Alberta's oil sands is actually used in Quebec, which relies heavily on imported oil. However, Canada is a net exporter of oil, chiefly from Alberta, and its proceeds benefit all Canadians. According to the *BP Statistical Review of World Energy*, June 2003, available at the URL below, Canada in 2002 produced 135.6 million tonnes of oil and exported 71% of this total, almost all to the U.S. Of Canada's consumption of 89.7 million tonnes, about 57% was imported, about half from Europe and the remainder from a variety of sources.
1. http://www.bp.com/downloadlisting.do?categoryId=2010519&contentId=2015066. Accessed April 12, 2004.

[16] According to a forthcoming report by the Organization for Economic Cooperation and Development, world-wide annual carbon dioxide emissions from cars are set to rise from about 1.5 billion tonnes in 1990 to about 2.8 billion tonnes in 2030. Over the same period, annual CO_2 emissions from heavy trucks are

projected to rise from about 0.9 billion to 3.0 billion tonnes. 70% of the increase in car CO_2 emissions and 90% of the increase in heavy truck CO_2 emissions would come from non-OECD countries. (See *Clean Transport, Reducing Motor Vehicle Emissions Through 2030: MOVE II Project*, Unpublished report ENV/EPOC/WPNEP/T(2003)5, OECD, Paris, November 2003.)

[17] Box 3 is based on data from the source detailed in Note 1.

[18] The U.S. data in Tables 1-32 and 1-45 of *National Transportation Statistics*, U.S. Department of Transportation, 2003, available at the URL below, suggest that between 1990 and 2001 average truck trip length increased by 24% and the number of truck trips increased by 16% (combination trucks only).
1. http://www.bts.gov/publications/national_transportation_statistics/. Accessed April 12, 2004.

[19] According to one source, "Increasing haul lengths have been the main cause of road freight growth, … responsible for approximately two thirds of the increase in road tonne-kilometres." (McKinnon A, Logistics and the Environment. In Hensher D and Button K, *Handbook of Transport and the Environment*, Elsevier, Amsterdam, 2003. Much of material in this chapter is also in McKinnon A, Influencing Company Logistics Management. In *Managing the Fundamental Drivers of Transport Demand*, European Conference of Ministers of Transport, Paris, 2003, pp. 60-74. A Web version of the latter item is available at the URL below.)
1. http://www1.oecd.org/cem/topics/env/Brussels02.htm. Accessed April 12, 2004.

[20] According to the results of the 1995 and 1999 *National Roadside Studies*, detailed in Note 36 below, average trip distances by heavy trucks appeared to have increased by 28% between 1995 and 1999. (Note that for trucks operating in Quebec the increase was only 1.7%.) According to the source detailed in Note 1, the number of trips made annually by heavy trucks remained essentially unchanged.

[21] The three factors contributing to the increase in the length of truck trips in Europe are from the source detailed in Note 19.

[22] Information about the two *National Roadside Studies* is in Note 36 below. The 1995 load factor is based on the simple average of all records for 1995 and likewise for 1999 (i.e., without special filters in the latter case). Average load factors for trucks operating in Quebec were similar to Canadian values: 56% in 1995 and 49% in 1999. These estimates and comparisons on load factors may not be valid.

[23] For U.S. trends in load factors, see Boyer KD, Burks SV, *Drivers and Ballerinas: Productivity and Cost Trends in the Trucking Industry, 1997-1997*, available at the URL below.
1. http://www.nutc.northwestern.edu/public/TCLectureSeries/Boyer%20Burks%20110603%20text.pdf. Accessed April 12, 2004.

[24] According to the European Environment Agency, truck load factors in Europe, expressed as tonne-kilometres per vehicle-kilometre, may on average have increased between 1990 and 1997. (*Indicator Fact Sheet, TERM 2002*, available at the URL below). However, this may not be a good indicator as it may represent more an increase in truck size rather than an increase in load factor. Moreover, the text with the chart that shows an increase suggests that overall this measure may have declined rather than increased.
1. http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/technology/load/TERM_2002_30_EU_Load_factors_for_freight_transport.pdf. Accessed April 12, 2004.

[25] Box 4 is a colour version of Figure 8 of Caïd N, *Reviewing the links between transport and economic growth*, Report ENV/EPOC/WPNEP/T(2003)4 prepared for the meeting of the Working Group on Transport, Organization for Economic Cooperation and Development, Paris, France, December 2003.

[26] For discussions of the causal relationships between freight transport and economic activity, see *Transport and Economic Development*, European Conference of Ministers of Transport, Paris France (ISBN 9282112985), October 2002.

[27] The information in Box 5 is from Table 4 of the document *Emissions from Volvo's trucks (standard diesel fuel)* produced by the Volvo Truck Corporation in November 2003, available at the URL below. The last column was calculated using the mid-points of the ranges in the previous two columns.
1. http://www.volvo.com/NR/rdonlyres/EF65E6D8-BF98-4BBF-B539-18C925B53844/0/Emis_eng_20640_03017.pdf. Accessed April 12, 2004.

[28] For Bridgestone's assessment of the relationship between gross vehicle weight and fuel use, see the URL below.
1. http://www.trucktires.com/us_eng/technical/bftechnical/fuel_economy_f.asp. Accessed April 12, 2004.

[29] This example is from Figure 31 (Page 73) of Muster T, *Fuel Savings Potential and Costs Considerations for US Class 8 Heavy Duty Trucks through Resistance Reductions and improved Propulsion Technologies until 2020*, Energy Laboratory, Massachusetts Institute of Technology (Report MIT EL 00-001), May 2000, available at the first URL below. (See Page 89 of this source for the numbers plotted in the chart in its Figure 31.)
1. http://lfee.mit.edu/publications/PDF/el00-001.pdf. Accessed April 12, 2004.

[30] The y-axis in Box 6 refers to the amount of fuel required to move 100 tonnes of payload through one kilometre, or 10 tonnes through 10 kilometres, and so on.

[31] The November 2002 *Climate Change Plan for Canada*, available at the URL below, sets out the federal government's strategy for meeting its potential commitment under the Kyoto Protocol, as set out in Note 11. According to Page 21 of the *Plan*, freight transport is to contribute about 5.3 megatonnes of a total reduction from transport of about 21 megatonnes ('actions under way' and 'proposed next steps' only). The percentage reductions in the final sentence of this paragraph represent this 5.3 megatonnes as a proportion of the 1990 total for freight (45 megatonnes) or of an estimated 2010 'business-as-usual' total (93 megatonnes). The 2010 estimate is based on extrapolation of changes from 1990-2000, taking into account the estimate of the 2010 transport total (206 megatonnes) given in Table 2 of the *Plan*. The *Plan* notes that other, unspecified reductions may be contemplated for freight transport within the total of 60 megatonnes of required reductions that are not provided for in the *Plan*.
1. http://www.climatechange.gc.ca/plan_for_canada/plan/pdf/full_version.pdf. Accessed April 12, 2004.

[32] See Pages 25 and 13 of the document by Muster detailed in Note 29.

[33] The November 1999 *Options Paper* produced by the Transportation Table of Canada's Climate Change Process is available at the URL below. Truck tracking (which could contribute to raising load factors) is discussed as a possible action, but rated as a "less promising measure".
1. http://www.tc.gc.ca/programs/environment/climatechange/subgroups1/Options_Paper/English/default.htm. Accessed April 12, 2004.

[34] The paper prepared for the Transportation Table's Trucking Sub-Group that dealt with improving load factors was prepared by L-P Tardif & Associates Inc. and entitled *Environmental Awareness and Outreach Measures to Reduce GHG Emission*s (August 1999). It is available at the URL below.
1. http://www.tc.gc.ca/programs/environment/climatechange/subgroups1/truck/study1/final_report/final_report.htm. Accessed April 12, 2004.

[35] See the text associated with Box 6 and also Note 12.

[36] Only the results of the 1999 *National Roadside Study* (NRS) are publicly available, from the Canadian Council for Motor Transport Administrators (CCMTA) at the first URL below. Although the documentation for the 1999 NRS speaks to the possibility of analysis by data collection site, such analysis is not possible using the version available from CCMTA. This is pursuant to an agreement between the federal and provincial governments whereby the complete database of the 1999 NRS is not available to the public. The available database does allow analysis on a provincial and Canada-wide basis in respect of a large

number of characteristics of trucks, operators, cargo, and trips.

The much less extensive 1995 NRS seems no longer to be ordinarily available. It does not appear to have been designed to allow analysis at the level of the data collection site. Three comparisons of the 1995 and 1999 NRS are made here: Note 20 concerns an apparent increase in trip distance; Note 22 and associated text concern an apparent reduction in average load factor; Note 37 concerns a difference concerning 'private' trucks engaging in 'for-hire' business. These differences between the results from the two NRS surveys appear to have been the exception rather than the rule. Several other analyses, not reported here, suggest that for the most part, the characteristics of truck activity were similar across the two years.

The detailed results of the 1991 NRS seem unavailable. The most extensive mention of this *Study* is in the 1998 document *Profile of Private Trucking in Canada*, available at the second URL below.

The 1999 NRS concerned only cargo-type trucks with a gross weight of more than 4.5 tonnes, including tractors, tractor-trailer combinations, and straight trucks with six or more axles, and travelling for at least part of their journey on the 24,134 kilometres of Canada's National Highway System or on 1,061 kilometres of other roads considered to be of significance to inter-city truck traffic. Trip data concerned all travelled roads and ferries, including those outside Canada.

1. http://www.ccmta.ca/english/publicationandreports/publicationandreports.html. Accessed April 12, 2004.
2. http://strategis.ic.gc.ca/epic/internet/ints-sdc.nsf/vwGeneratedInterE/fd01101e.html. Accessed March 1, 2004.

[37] 'For-hire' trucks are operated by companies in the business of carrying freight for other companies. 'Private' trucks are owned by the businesses that ship the freight. In the present analyses, trucks normally classified as 'private' that are carrying other businesses' freight are counted as 'for-hire' trucks.

One clear difference between the results of the 1995 and 1999 National Roadside Studies was the increase in the number of private trucks found operating on a for-hire basis (for Canada, from 4.2% to 12.9% of private trucks). The share of private trucks on the road (including those operating on a for-hire basis) increased slightly between 1995 and 1999, from 31.4% to 32.6%. Thus, the growth in the share of for-hire trucking over the four years did not comprise growth in the for-hire trucking industry so much as growth to the extent to which other businesses with trucks to spare operated in a for-hire mode.

Box 7—and the other analyses here based on the 1999 NRS—represents only trips for which cargo capacity, trip origin, and trip destination were all known. For Canada, these trips totalled 85% of the actual 65,052 trips covered by the 1999 NRS, thus representing about 85% of all qualifying trips.

[38] Box 8 is based on the 1999 NRS, as detailed in Notes 36 and 37.

[39] For Canada, average cargo weights for full, ¾-full, ½-full, and ¼-full trucks were respectively 18.6, 14.4, 7.0, and 3.1 tonnes. Thus, a ½-full truck on average carried less than half the cargo carried by a full truck, suggesting that they were even more likely to be ½-full by space than full trucks were full by space.

[40] Box 9 is based on the 1999 NRS, as detailed in Notes 36 and 37.

[41] Box 10 is based on the 1999 NRS, as detailed in Notes 36 and 37. Potential capacity was estimated by assuming that each truck carried the average cargo weight of full trucks for the respective jurisdiction. Weighting for trip distance was achieved by estimating actual and potential total payload tonne-kilometres and calculating the difference between the two as a per cent of potential total tonne-kilometres.

[42] Box 11 is based on Exhibit 3.1 of *Profile of Private Trucking in Canada*, 1998, detailed in Note 36. The statement that private trucks predominate for distances shorter than about 200 kilometres is based on Exhibit 3.2 of that document. Statistics Canada stopped collecting data on private trucking in 1998, so little is known about what likely continues to be both a key aspect of freight transport and an important component of the Canadian economy. A recent report produced by Transport Canada suggests that in 2000 private trucking was still economically more important than for-hire trucking, i.e., $21.8 billion vs. $20.8 billion (Nix F, *Trucking Activity in Canada: A Profile*, Transport Canada, March 2003, available at the URL below) but this estimate seems to have been no more than a scaling up of the mid-1990s value set out in Box 11.

1. http://www.tc.gc.ca/pol/EN/Report/TruckActivity/Truck%20Activity%20in%20Canada.pdf. Accessed April 12, 2004.

43 The document by Fred Nix detailed in Note 42 offers an indication of the scale of freight movement within urban areas by noting that perhaps two billion tonnes of freight moves annually within urban areas, perhaps four times the inter-city truck movement in terms of tonnes lifted. If this is the case, inter-city movement would still constitute more transport *activity* (i.e., tonne-kilometres) because inter-city truck journeys are likely more than four times longer on average than truck journeys within urban regions.
An earlier source suggested that perhaps 14% of truck tonne-kilometres occur in urban areas, using 44% of fuel used by trucks on the road and thus responsible for a similar share of GHG emissions (Delcan Corporation, *Assessment of Freight Forecasts and Greenhouse Gas Emissions*, prepared for the Freight Sub-Table of the Transportation Table of the National Climate Change process, June 1999, available at the first URL below). The authors of this report noted that "there is very little statistical basis for estimating the percentage of tonne-kilometres served in urban areas" (p. 32).
If freight movement as a whole is being considered, what is often the final link in the chain, the shopping trip, could also be noted. According the box on Page 6-18 of *Mobility 2001:World Mobility at the End of the 20th Century and its Sustainability* (World Business Council on Sustainable Development WBCSD, Geneva , Switzerland, available at the second URL below), "the amount of fuel used by consumers in going to the store to pick up the groceries is five times as great as the fuel consumed by trucks and trains to get the groceries to the store". In the analysed example, breakfast cereal, a reasonably allocated share of shopping trips accounted for 83% of the field-to-table transport energy use.
1. http://www.tc.gc.ca/programs/environment/climatechange/subgroups1/freight/study1/Final_Report/Final_report.htm. Accessed April 12, 2004.
2. http://www.wbcsd.org/DocRoot/uu8taBpoTDXkvBiJHuaU/english_full_report.pdf. Accessed April 12, 2004.

44 For further discussion of private trucking, see Note 42 and Box 11, and associated text.

45 For the 1999 *Lower Mainland Truck Freight Study* contact the Strategic Planning Department of TransLink through the URL below.
1. http://www.translink.bc.ca. Accessed April 12, 2004.

46 For information about the 2001 *Edmonton Commodity Flow Study*, see the URL below.
1. http://www.trans.gov.ab.ca/Content/docType52/Production/edmonton commodity flow.htm. Accessed April 12, 2004.

47 There is reference to the 2001 *Calgary Commodity Flow Survey* in the document at the URL below (Hunt JD, et al, *Modelling Retail and Service Delivery Commercial Movement Choice Behaviour in Calgary*, presented at the 10th International Conference on Travel Behaviour Research, Lucerne, 10-15 August 2003).
1. http://www.ivt.baum.ethz.ch/allgemein/pdf/hunt.pdf. Accessed April 7, 2004.

48 The 2002 edition of *Trucking in Canada* (released April 2, 2004) is available for a fee at the URL below. Box 12 is based on this edition and the 1991 edition, which may be available on enquiry from Statistics Canada.
1. http://www.statcan.ca/english/IPS/Data/53-222-XIB.htm. Accessed April 12, 2004.

49 The other two CMAs not reported on in *Trucking in Canada* (see Note 48) are Abbotsford and Kingston. Sherbrooke, which is more populous than Abbotsford and Kingston, is also more populous than three CMAs that are reported on: Trois-Rivières, Saint John, and Thunder Bay. (The urban regions reported on are likely those that were CMAs at the time of an earlier Census.)

50 The report on the 2001 *UTI Survey* will become available during 2004 from the Transportation Association of Canada, information about which is available at the URL below. Note that the information from the

2001 Survey presented in Box 13 and Box 14 has been provided prematurely and is subject to verification.
1. http://www.tac-atc.ca. Accessed April 12, 2004.

[51] The 160-page document *Delivering the Goods: 21st Century Challenges to Urban Goods Transport* (Paris, France: Organization for Economic Cooperation and Development, 2003, ISBN 9264102809) is available for a fee in print and online from OECD Publications at the URL below.
1. http://oecdpublications.gfi-nb.com/cgi-bin/oecdbookshop.storefront. Accessed April 12, 2004.

[52] A possible indication of the relative lack of attention to goods movement within Canadian urban regions is the *UTI Survey* noted in the previous section (see Note 50, Box 13, Box 14, and associated text). Of the 71 types of transportation and land-use initiatives enquired about, 53 concerned the movement of people, five concerned the movement of goods (see Box 14), and 13 were applicable to either type of movement.

[53] Box 15 is reproduced from Box 4.4 of the OECD document detailed in Note 51.

[54] Box 16 is reproduced from Box 4.6 of the OECD document detailed in Note 51.

[55] See *Heathrow Airport Retail Consolidation Centre*. Good Practice Case Study 402, Action Energy, UK Government, May 2002, at the URL below.
1. http://www.transportenergy.org.uk/vpo/downloads/letter/GPCS402.pdf. Accessed April 12, 2004.

[56] For McKinnon's chapter, see the source detailed in Note 19.

[57] According to the document detailed in Note 51, " … research by the French Environment Agency in 1997 found that round-trip deliveries using heavier and larger trucks in the urban environment can consume less energy than a bundle of direct deliveries. As more trips are required to deliver loads with smaller vehicles, this makes less efficient use of the urban infrastructure. The research found that 12 delivery vans of 500 kilograms each, making parallel deliveries to 12 shops ten kilometres away from a distribution centre, was more energy-consuming and produced more emissions and noise than one six-tonne truck making a round-trip delivery to these 12 shops from the same distribution centre." (p. 33)

[58] Load disaggregation into smaller vehicles for in-city delivery can result in reduced noise, vibration, and accident severity.

[59] For detailed information about MPOs see the Web site of the Association of MPOs at the URL below.
1. http://www.ampo.org/who/about_mpos.html. Accessed April 12, 2004.

[60] The report on the AMPO survey is at the URL below.
1. http://www.ampo.org/survey/FreightSummary.pdf. Accessed April 12, 2004.

[61] The quote and subsequent comment are from the summary report on an international visit in connection with the European Union's BESTUFS project, available at the URL below.
1. http://www.bestufs.net. Accessed April 12, 2004.

[62] See Note 52 for a possible indication of the lack of regard for urban freight issues in Canada.

[63] A visit to the first URL below gives an indication of the extent of Internet-based load-matching activity. One operator (Transcore), not listed at this URL, manages about 300,000 matches a day for some 50,000 users (Stastny P, Trucking. *Canadian Transportation Logistics*, 106(11), pp. 46-, Nov./Dec. 2003.). The authors of a paper prepared for the Trucking Sub-Group of the Transportation Table of the National Climate Change Process suggested that Internet-based load-matching may be of limited effectiveness because it does "nothing more than what was done in years gone by with people sitting at a telephone with card indexes … however, doing it faster, cheaper and more thoroughly". Their conclusion was that enhanced load

matching would produce no more than a 0.3-per-cent reduction in truck GHG emissions by 2010. (Taylor GWR, Nix F, Delaquis M, *The Potential for GHG Reductions from Improved Use of Existing and New Truck Technology in the Trucking Industry,* June 1999, available at the second URL below.)
1. http://dmoz.org/Business/Transportation_and_Logistics/Trucking/Truck_Transport/Freight_Matching_Services/. Accessed April 12, 2004.
2. http://www.tc.gc.ca/programs/environment/climatechange/subgroups1/truck/study2/final_report/FINAL_TRUCK_TECH.doc. Accessed April 12, 2004.

64 See the article by Paul Stastny detailed in Note 63.

65 For the estimate of truck running costs, see the presentation by Fred Nix to the Forest Engineering Research Institute of Canada, Grand Prairie, Alberta, November 2003, at the URL below.
1. http://www.feric.ca/en/wd/home/events/transportationseminars/AB_Presentations/Fred_Nix_AB.pdf. Accessed April 12, 2004.

66 Notwithstanding the September 2002 projection by Natural Resources Canada the world price of crude oil per barrel will remain more or less constant at US$22.57 (in 2002US$) at least until 2025 (see Page 108 of the document at the first URL below), the price has not been below this level since early 2002 and is currently at US$37.14 (April 8, 2004). For a compelling discussion of the prospects for transport fuel prices, see *Oil-based technology and economy prospects for the future*, The Society of Danish Engineers, Copenhagen, Denmark, December 2003, available at the second URL below.
1. http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2004).pdf. Accessed April 12, 2004.
2. http://www.tekno.dk/pdf/projekter/p03_Oil-based_Technology_and_Economy_preliminary_edition.pdf. Accessed April 12, 2004.

67 Box 17 and Box 18 are respectively Tables 4 and 5 of Allen J et al, *A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows. Report 3: Making urban goods and service operations more sustainable: policy measures and company initiatives*. Transport Studies Group, University of Westminster, London UK, March 2000, available at the URL below.
1. http://www.wmin.ac.uk/transport/download/urbandistfinal3.pdf. Accessed April 12, 2004.

68 The quote is from Page 75 of the document detailed in Note 67.