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Trucking Across the Border: The Relative Cost of Cross-border and Domestic Trucking, 2004 to 2009

by William P. Anderson and W. Mark Brown

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^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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by

William P. Anderson* and W. Mark Brown**

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*** Ontario Research Chair in Cross-Border Transportation Policy, University of Windsor**
**** Economic Analysis Division, Statistics Canada**

Authors' names are listed alphabetically.

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Table of Contents

Abstract **5**

Executive summary **6**

1 Introduction **7**

2 The data **9**

2.1 Trucking Commodity Origin and Destination Survey 9

2.2 Estimating *ad valorem* transportation costs 9

2.3 Data description 12

3 Econometric model **18**

3.1 Specification 18

3.2 Estimates 20

4 *Ad valorem* trucking costs **26**

5 Conclusion **32**

6 Appendix **33**

6.1 Estimating the value per tonne by commodity 33

6.2 Jackknife model estimates 34

References **39**

Abstract

Despite the elimination of tariff barriers between Canada and the United States, the volume of trade between the two countries has been less than would be expected if there were no impediments. While considerable work has been done to gauge the degree of integration between the Canadian and U.S. economies through trade, relatively little analysis has parsed out the underlying costs for cross-border trade. The costs of crossing the border can be divided into formal tariff barriers, non-tariff barriers, and the cost of the transport system itself. This paper focuses on the latter by estimating the cost of shipping goods by truck between Canada and the U.S. during the 2004-to-2009 period. The analysis assesses the degree to which costs to ship goods by truck to and from the U.S. exceed those within Canada by measuring the additional costs on a level and an *ad valorem* basis. The latter provides an estimate of the tariff equivalent transportation cost that applies to cross-border trade. These costs are further broken down into fixed and variable (line-haul) costs. Higher fixed costs are consistent with border delays and border compliance costs which are passed on to the consumers of trucking services. Higher line-haul costs may result from difficulties obtaining backhauls for a portion of the trip home. Such difficulties may stem from trade imbalances and regulations that restrict the ability of Canadian-based carriers to transport goods between two points in the United States.

Executive summary

Despite the elimination of tariff barriers between Canada and the United States, the volume of trade between the two countries has been less than would be expected if there were no impediments. While considerable work has assessed the degree of integration between the Canadian and U.S. economies through trade, relatively little analysis has examined the underlying costs of cross-border trade.

The costs of crossing the border can be divided into formal tariff barriers, non-tariff barriers, and the cost of the transport itself. This paper focuses on the later. It investigates the cost of shipping goods by truck (the primary mode by which goods cross the border) between Canada and the U.S. during the 2004-to-2009 period.

Based on data from Statistics Canada's Trucking Commodity Origin and Destination Survey, trucking costs are higher for cross-border than domestic trade, a difference that stems from both higher fixed costs per shipment, especially for exports, and higher line-haul costs that vary with the length of shipment. Higher fixed costs are consistent with border delays and compliance costs which are passed on to the consumers of trucking services. Higher line-haul costs are associated with greater difficulties obtaining backhauls, which, in turn, may be the result of regulations on cabotage rights.

The extra cost associated with cross-border, truck-borne trade amounts to an *ad valorem* tariff equivalent ranging between 0.4% and 0.9%. Compared with equivalent domestic trade, cross-border trade is 18% to 31% more costly. For exports to the U.S., these costs added 0.9% to the delivered price of goods in 2004. This figure fell to 0.4% in 2009, as cross-border line-haul costs converged with domestic levels. Higher fixed costs per shipment accounted for most of the additional cost of transporting goods to the U.S.

The extra costs associated with bringing goods into Canada by truck added about 0.4% to the value of imported goods in 2004. This percentage rose to 0.8% in 2009, as line-haul costs, and to a lesser extent, fixed costs per shipment, rose. Line-haul costs accounted for most of the additional costs of transporting goods into Canada by truck.

In general, over the 2004-to-2009 period, the additional line-haul costs associated with cross-border trade fell for exports but rose for imports. This is consistent with the 'backhaul' portion of the journey switching from the journey home for Canadian-based carriers to the journey to the U.S., as the balance of truck-borne trade shifted from exports to imports.

The costs measured here are only part of the total cost of shipping goods across the border. The institutional costs borne directly by exporting firms for matters like customs administration have been estimated to be as great or greater than the costs passed on to them by freight carriers.

1 Introduction

Despite the elimination of tariff barriers between Canada and the United States, the volume of trade between the two countries has been less than would be expected if tariffs were the sole impediment to trade (Anderson and Yotov, 2010). This suggests that other factors such as differences in regulations, differences in tastes, and possibly transaction costs associated with moving goods across the border are important. According to previous estimates, the volume of trade between the two countries is equivalent to what would be expected if a 21% tariff were imposed (Chaney, 2008). Such large obstacles imply a lack of market access that may affect the productivity of Canadian firms, whose size may be limited by their relatively small domestic market (Baldwin and Gu, 2009 and Baldwin et al., 2012). While considerable work has been done to gauge the degree of integration between the Canadian and U.S. economies via trade, relatively little analysis has been undertaken to parse out the 'border effect'—the underlying costs of the border on trade.[1]

The costs of crossing the border can be divided into formal tariff barriers, non-tariff barriers, and the cost of the transport system itself. This paper focuses on the last factor.[2] It investigates the cost of shipping goods between Canada and the U.S. by truck, which is the primary mode by which goods cross the border. In 2009, goods shipped by truck accounted for 47% of the value of Canada's merchandise exports to the U.S. and 70% of the value of imports from the U.S.[3] Consequently, trucking costs may affect the overall degree of integration between the two markets.

The cost of trucking goods across the border is considerable. Using evidence from a combination of secondary sources and interviews, Taylor et al. (2004) estimate the total cost of crossing the border at about 4% of the value of truck-borne trade in 2001. This is close to the average (trade-weighted) tariff rate before implementation of the Canada-U.S. Free Trade Agreement (Trefler, 2004). The present study extends Taylor et al.'s (2004) analysis by directly measuring the cost of crossing the border, albeit in a manner that does not cover the complete set of costs associated with the border. It also has much in common with Conlon (1981) who measured the *ad valorem* equivalent of transportation costs in the mid-1970s.

This paper asks three related questions. First, and most obvious, what is the cost of shipping goods by truck between Canada and the U.S. relative to shipments within Canada? Indirect evidence indicates that the cost of shipping goods across the border may be greater than the cost of shipping the same goods domestically. Numerous studies show that cross-border trade compared with interstate or interprovincial trade is less than would be expected, after accounting for the size and distance between the trading partners.[4] Recent studies suggest that the border about halves trade between Canada and the U.S. (Anderson and van Wincoop, 2003 and Anderson and Yotov, 2010). While these border-effect studies provide a general

1. While a number of recent studies have addressed the "thickening" of the Canada-U.S. border (Sands, 2009; Kergin and Matthiesen, 2008), relatively little research has attempted to identify factors that contribute to the border effect. Taylor et al. (2004) is a notable exception.
2. Non-tariff barriers include those that are policy-driven (for example, regulatory differences that increase the cost of trade) and those related to a broad set of factors that affect transaction costs. These are thought to stem from the presence of common institutions, norms, and tastes within national boundaries (Helliwell, 1998 and 2005). Helliwell (1998, 123) notes, "…as long as national institutions, populations, trust, and tastes differ as much as they do, the industrial organization and other institutional literatures would predict that transaction costs will remain much lower within than among national economies, even in the absence of any border taxes or regulations affecting the movement of goods and services."
3. U.S. Department of Transportation, Research and Innovation Technology Administration, Bureau of Transportation Statistics, North American Transborder Freight Data (2011). http://www.bts.gov/programs/international/transborder/TBDR_QA.html (accessed May 10, 2011).
4. The effect of the border on Canada-U.S. trade has been a subject of research dating back to McCallum's (1995) initial assessment, which led to subsequent work by Helliwell (1998), Brown and Anderson (2002), Anderson and van Wincoop (2003), and Anderson and Yotov (2010), among others.

assessment of the impact of all forms of barriers to trade on economic integration, none attempts to directly measure the cost of shipping goods across the border. By contrast, this study takes an initial step toward parsing the border effect into a set of components.

Second, to the extent that cross-border and domestic shipping costs differ, how much of this difference is due to fixed costs associated with the border, and how much is due to line-haul costs? Post-9/11 security measures may have increased the costs of crossing the border through longer and/or more uncertain wait times. But line-haul costs for cross-border and domestic trade may differ too. Line-haul costs may be lower for cross-border trade because fuel tends to be less expensive in the U.S. They may also vary if trade is unbalanced, leading to higher backhaul costs. If Canada has a trade surplus with the U.S., the odds that a truck carrying Canadian exports to the U.S. will obtain a backhaul load are reduced, so trucks would often return home empty (deadhead) (Taylor et al., 2004). The backhaul problem may be exacerbated by regulations that prohibit Canadian firms from transporting goods between two points in the U.S. (cabotage rights). Canadian truckers are, therefore, unable to 'chain' their trip back to Canada, or to pick up their load in the U.S., potentially increasing the deadhead portion of their journey home.

Finally, what are the *ad valorem* costs associated with trucking goods domestically and across the border? Estimates of *ad valorem* costs are essential to assessing whether trucking costs have a meaningful effect on the volume of trade. For low-weight, high-value commodities (for example, electronic equipment), trucking costs may account for a small fraction of the delivered price of a good. By contrast, for high-weight, low-value commodities (for example, non-metallic minerals), the opposite may hold true.

To answer these questions, several datasets were combined to create a database that measures the cost of domestic and cross-border truck-borne trade, and the value of that trade. The primary source is Statistics Canada’s Trucking Commodity Origin and Destination (TCOD) Survey. It samples waybills of for-hire trucking firms to measure the characteristics of their shipments (for example, revenue, weight, distance shipped and commodity type) for domestic and cross-border shipments, primarily to the U.S. The TCOD Survey provides a means to measure trucking costs; that is, the cost to shippers of moving their goods between origins and destinations. These data are combined with measures of the value of commodities per tonne from the U.S. Bureau of Transportation Statistics’ North American Transborder Freight Data (NATFD) and Commodity Flow Survey (CFS) to generate estimates of *ad valorem* trucking costs. The result is a dataset that offers a way to measure the tariff-equivalent cost of crossing the border associated with this mode of transportation.

The next section ("Data development") describes the methods used to develop a comprehensive measure of trucking costs. This entails a more detailed description of the TCOD Survey dataset and the methods used to amend these data with estimates of the value of goods shipped per tonne, which is required to estimate *ad valorem* trucking costs. This section also contains a descriptive analysis of domestic and cross-border truck-borne trade. Given that the cost of moving goods has both fixed and variable components that may differ for domestic and cross-border trade, the third section ("Econometric model") presents a multivariate analysis that takes into account potential differences between cross-border and domestic shipments to arrive at an estimate of their relative cost. The fourth section ("*Ad valorem* trucking costs") discusses the level and trend of the *ad valorem* cost of domestic and cross-border trade over the study period. Finally, a brief conclusion summarizes the results of the analysis and outlines some caveats in interpreting the data.

2 The data

2.1 Trucking Commodity Origin and Destination Survey

The Trucking Commodity Origin and Destination (TCOD) Survey measures: (1) the output of the for-hire trucking sector and (2) the volume of commodities moved by truck (Gagnon and Trépanier, undated). The survey, first developed in the early 1970s, underwent a major revision in 2004 that substantially increased its coverage and accuracy. The scope was expanded to include the local trucking sector (North American Industry Classification System [NAICS] 48411 and 48422), thereby augmenting the Long-Distance (NAICS 48412 and 48423) and Used Household and Office Goods Moving (NAICS 48421) sectors in the original survey. The new version also included shipments of less than 25 kilometres, which previously had been excluded. In addition, the sample design, data processing and estimation were changed (see Gagnon and Trépanier, undated). Because of the differences in methodology pre- and post-2004, this analysis is restricted to the 2004-to-2009 period. In subsequent work, the dataset will be extended to include pre-2004 survey estimates. This longer time series will provide an estimate of changes to the cost of crossing the border in the post-2001 security environment.

The TCOD Survey is conducted annually, using a four-stage sample design. In the first stage, a stratified sample of trucking firms is randomly selected. For the second stage, the sampling period during the reference year is selected; this may be the first half of the year, the second half of the year, or the entire year. In the third stage, a sample of shipping documents is drawn, with the exception of firms that provide shipping documents electronically, for which all documents are selected. In the fourth stage, and when more than one shipment is reported on the shipping document, a sample of shipments is selected from the document.

The revenue earned by the carrier from each shipment reported by the TCOD Survey is used to assess the relative costs of domestic and cross-border transportation. The question arises as to whether the revenue from a specific shipment is a good proxy for the total cost of transportation. This might not be true if carriers could not pass the full cost of crossing the border onto shippers. However, this would imply that carriers accept lower profit margins for cross-border shipments than for domestic shipments, which seems unlikely. A related question is whether a measured cross-border premium on trucking costs captures the full cost of moving goods across the border. Anderson and Coates (2010) show that a major cost factor in crossing the Canada-U.S. border is the variability in crossing times, which poses a particular problem for goods in supply chains that must be delivered within narrow time windows. There are two ways to hedge against crossing time uncertainty. The first is to build buffer time into shipping schedules, which should be reflected in carriers' revenue. The second is to maintain buffer inventories on the far side of the border. For example, a firm exporting goods from Canada to the U.S. may stockpile inventory in a U.S. warehouse to ensure that deliveries can be made even if goods are delayed at the border. The cost of this strategy would not be reflected in the carrier's revenue. The present analysis, which is based solely on carriers' revenues, may, therefore, underestimate the full cost of cross-border goods movement.

2.2 Estimating *ad valorem* transportation costs

For each shipment, the TCOD Survey reports the revenue generated, weight, and distance shipped. However, the Survey does not report the value of the goods shipped, without which *ad valorem* trucking costs (trucking revenues/value of the shipment) cannot be estimated. To estimate the value of each shipment, a measure is needed of the value per tonne for each commodity, which, in turn, can be multiplied by the tonnage shipped. The value per ton will vary not only by commodity, but also by the distance shipped (Hillberry and Hummels, 2008). Higher-value varieties within commodity classes tend to be shipped longer distances because transportation costs make up smaller shares of their values. In formal terms, the value (*v*) of a shipment (*l*) composed of commodity *k* is given by:

$$v_{lk}^{d} = \left(v/t\right)_{k}^{d} \times t_{lk}^{d}, \qquad (1)$$

where *t* is tonnes and *d* indexes the distance class.

Value per tonne estimates are not available from the TCOD Survey, but they may be derived from two databases provided by the U.S. Bureau of Transportation Statistics (BTS)—the North American Transborder Freight Data (NATFD) and the CFS. The NATFD reports the mode, value and tonnage of commodities exported from Canada to the U.S., by province and state pair. Because these data refer to shipments of Canadian goods, they are used to estimate value per tonne for both Canadian domestic shipments and Canadian exports. However, they cannot be applied to U.S. exports to Canada, since goods produced in the U.S. tend to have a higher value per tonne than do comparable goods produced in Canada. The estimates for U.S. exports are, therefore, based on the Commodity Flow Survey (CFS), which reports similar data for goods shipped within the U.S. Thus, it is assumed that for both Canada and the U.S. the value per tonne is similar for domestic shipments and exports.

Separate values per tonne are estimated for shipments in four distance classes: less than 800 km; 800 km to 1,599 km; 1,600 km to 3,199 km; and 3,200 km or more.[5] However, for commodities with no clear trend in the value per tonne across distances, a single value is applied to all shipments. (Subsection 6.1 in the Appendix provides a detailed description of the calculation of value per tonne.)

The value per tonne by Standard Classification of Transported Goods (SCTG) commodity and trade type is presented in Table 1. Of course, value per tonne differs across commodities. For domestic trade, the value per tonne ranges from $27 for Gravel and crushed stone (SCTG 12) to $53,400 for Pharmaceutical products (SCTG 21), suggesting a very wide variation in *ad valorem* trucking costs.

By design, commodity valuations are also permitted to vary across trade types, in particular, between exports and imports. (Because the same data were used for domestic and export shipments, the differences in their value-to-weight ratios are due solely to differences in shipment distances). Table 1 also presents the percentage deviation in the value per tonne of imports relative to exports. Just over half of the commodities have an absolute deviation of less than 20%, and, as expected, the value per tonne is generally higher for imports than exports. For several commodities, deviations in the valuation of the commodity between exports and imports are large. For instance, the valuation of imports of Tobacco products is about double that of exports. This variability may reflect real differences in the underlying composition of these highly aggregate commodity flows, but it may also stem from errors that can be traced to the concordance between the Harmonized System (HS) and SCTG coding systems, sampling error, and differences in coding routines used by the U.S. BTS and Statistics Canada to classify shipments.

5. These classes were chosen to be consistent with the distance categories used by the CFS and because these broad categories ensure there is reasonably large number of province-state pairs in each.

Table 1
Average commodity value per tonne by trade type, 2004 to 2009

Standard classification of transported goods (2-digit commodities)	Value per tonne			Deviation, import from export
	Domestic	Import	Export	
	dollars			percent
Live animals and live fish	1,888	2,186	1,973	10.8
Cereal grains	234	275	256	7.4
Agricultural products[1]	917	1,842	1,003	83.6
Animal feed and feed ingredients[2]	668	749	660	13.5
Meat, fish, seafood, and preparations	4,615	4,205	4,849	-13.3
Milled grain products and preparations, and bakery products	1,183	2,168	1,962	10.5
Prepared foodstuffs not elsewhere classified and fats and oils	1,062	1,646	1,062	55.0
Alcoholic beverages	1,458	1,626	1,608	1.1
Tobacco products	9,260	43,458	21,690	100.4
Monumental or building stone	709	538	888	-39.4
Natural sands	118	117	133	-12.0
Gravel and crushed stone	27	34	30	13.3
Non-metallic minerals not elsewhere classified	305	306	495	-38.2
Metallic ores	2,619	5,702	6,104	-6.6
Coal	39	92	41	124.4
Crude petroleum	575	650	560	16.1
Gasoline and aviation turbine fuel	621	866	592	46.3
Fuel oils	508	667	489	36.4
Products of petroleum refining not elsewhere classified and coal products	739	1,110	712	55.9
Basic chemicals	1,203	1,883	1,076	75.0
Pharmaceutical products	53,325	51,373	61,011	-15.8
Fertilizers and fertilizer materials	469	379	418	-9.3
Chemical products and preparations not elsewhere classified	3,310	4,019	4,327	-7.1
Plastics and rubber	4,984	4,385	5,758	-23.8
Logs and other wood in the rough	284	387	307	26.1
Wood products	691	895	769	16.4
Pulp, newsprint, paper, and paperboard	915	1,223	1,133	7.9
Paper or paperboard articles	1,958	2,074	2,102	-1.3
Printed products	4,550	3,835	4,553	-15.8
Textiles, leather, and articles	13,423	13,149	12,359	6.4
Non-metallic mineral products	467	1,221	690	77.0
Base metal[3]	1,485	1,606	1,666	-3.6
Articles of base metal	3,452	3,809	3,316	14.9
Machinery	9,649	10,689	11,342	-5.8
Electronic and other electrical equipment[4]	15,958	20,110	18,721	7.4
Vehicles	6,736	8,538	6,664	28.1
Transportation equipment not elsewhere classified	6,913	15,620	32,771	-52.3
Precision instruments and apparatus	42,834	38,351	43,020	-10.9
Furniture, mattresses and mattress supports[5]	5,290	6,896	5,518	25.0
Miscellaneous manufactured products	20,947	6,678	17,394	-61.6
Waste and scrap	1,738	1,321	3,396	-61.1

1. Agricultural products except live animals, cereal grains, and forage products.
2. Animal feed and feed ingredients, cereal straw, and eggs and other products of animal origin not elsewhere classified.
3. Base metal in primary or semi-finished forms and in finished basic shapes.
4. Electronic and other electrical equipment and components, and office equipment.
5. Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs.

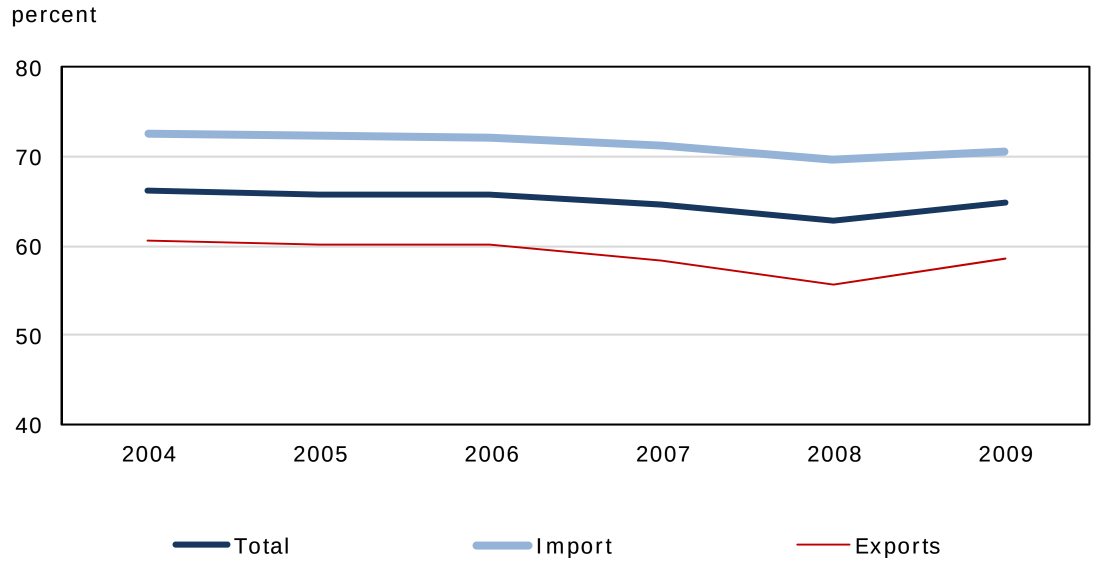
Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

2.3 Data description

The primary purpose of this study is to measure the cost of shipping goods across the border, in level terms and as a percentage of the value of goods shipped. Before presenting these estimates, different aspects of the aggregate data are examined: the overall importance of truck-borne trade, the coverage of this trade by the TCOD Survey, the types of trucking firms that carry this trade, and the nature of the trade itself.

By value, about two-thirds of merchandise trade (excluding commodities shipped by pipeline[6]) between Canada and the U.S. is transported by truck. In 2004, trucking accounted for about 65% of total Canada-U.S. trade (Chart 1). Around 70% of imports and 60% of exports are carried by truck. Over the study period, trucking's modal share, regardless of the type of trade (exports and imports), remained relatively constant.

Chart 1
Canada-U.S. trucking modal share, by value and trade type, excluding commodities shipped by pipeline, 2004 to 2009



Source: Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009.

The scope of the TCOD Survey is limited to for-hire trucking firms based in Canada. Therefore, it excludes foreign-based trucking firms operating in Canada and non-trucking firms with their own fleets (own-account trucking).[7] Nonetheless, for two reasons, trucking costs derived from the TCOD Survey should be representative of the trucking sector as a whole. First, the TCOD Survey accounts for the majority of Canada-U.S. shipped trade by truck. According to the BTS' NATFD, 52.6 million tonnes of freight were exported by truck from Canada to the U.S. in 2008. For the same year, the TCOD Survey reported 47.2 million tonnes of freight shipped by truck to the U.S., which is 90% of the tonnage reported by the NATFD. Second, the trucking sector is highly competitive, with low barriers to entry.[8] Excess profits are likely to be rapidly competed away, equalizing rates across in-scope and out-of-scope firms.

6. Commodities shipped by pipeline are excluded because they are typically not transported by truck (for example, natural gas or crude oil); that is, unlike rail, and, to a lesser extent, vessels, pipelines and trucks are not competing modes.
7. Other NAICS sectors may also provide trucking services as firms turn to bundling logistical services.
8. For instance, Baldwin and Lafrance (2011) find rates of entry into the trucking sector to be above average.

Carriers can be divided into two broad categories: general freight, which typically uses standard tractors and box trailers, and specialized trucks, which transport particular kinds of freight (for example, liquids). This distinction is recognized in the industrial classification of trucking firms, and accordingly, the TCOD Survey classifies motor carriers (referred to from this point forward as carriers) into General Freight Trucking (NAICS 4841) and Specialized Freight Trucking (NAICS 4842). General Freight Trucking carriers are divided into short- and long-distance carriers, and the latter are further subdivided into truck-load and less-than-truck-load carriers. Table 2 provides a detailed breakdown of activity across these industries for domestic and cross-border shipments in 2008.

Most trucking activity takes the form of General Freight Trucking. That is, the majority of trucking revenues, total distance shipped, tonne-kilometres shipped, and total shipments are General Freight. This is particularly true of cross-border trade (Table 2), where about 85% of revenues, 87% of tonnes and 85% of tonne-kilometres are shipped through General Freight Trucking firms. Within Canada, General Freight Trucking is less important, accounting for about 59% of revenues, 39% of tonnage shipped, and 57% of tonne-kilometres.

General Freight Trucking is subdivided into Local and Long-Distance Trucking (NAICS 48411 and 48412), and the latter is subdivided into Truck-Load and Less-than-Truck-Load (NAICS 484121 and 484122). Less-than-Truck-Load carriers specialize in moving goods between terminals where shipments are consolidated and then broken down. Truck-Load carriers specialize in moving single loads between their original and final destination. For domestic and cross-border shipments, Truck-Load firms tend to predominate.

Table 2
Characteristics of shipments by trade and carrier type, 2008

	All carriers	General freight			Specialized freight				
		Local	Long distance		Moving	Bulk liquids	Dry bulk	Forest products	Other
			Truck-load	Less-than-truck-load					
All origin-destinations				**percent**					
Revenue	100	12.4	36.5	16.8	1.0	8.6	5.9	2.6	16.2
Tonnes	100	14.1	24.2	5.8	0.2	17.5	19.1	6.9	12.2
Shipments	100	16.9	24.1	27.9	0.6	8.0	6.5	2.3	13.7
Distance shipped	100	9.2	30.9	43.2	0.5	2.2	1.8	0.8	11.5
Tonne-kilometre	100	8.4	47.0	10.5	0.4	6.9	7.2	3.4	16.2
				average					
Revenue per shipment (dollars)	514	377	777	310	815	553	468	588	610
Distance per shipment (kilometre)	583	318	747	902	437	158	159	204	490
Tonnes per shipment (number)	10	8	10	2	3	22	29	30	9
Tonnne-kilometre per shipment (number)	3,685	1,824	7,181	1,384	2,254	3,196	4,069	5,563	4,381
Domestic				**percent**					
Revenue	100	14.8	27.8	16.7	1.2	12.0	7.4	3.5	16.6
Tonnes	100	14.7	18.3	5.7	0.2	20.1	21.1	7.7	12.1
Shipments	100	18.1	20.6	27.4	0.7	9.2	7.2	2.5	14.3
Distance shipped	100	10.1	25.1	46.5	0.5	2.9	1.9	1.0	12.0
Tonne-kilometre	100	9.2	35.6	12.4	0.4	10.7	9.6	4.9	17.3
				average					
Revenue per shipment (dollars)	403	328	543	246	743	527	415	565	468
Distance per shipment (kilometre)	454	252	553	769	356	144	123	175	381
Tonnes per shipment (number)	10	8	9	2	2	22	29	30	8
Tonnne-kilometre per shipment (number)	2,529	1,278	4,371	1,143	1,337	2,946	3,381	4,934	3,057
Cross-border				**percent**					
Revenue	100	7.7	53.9	17.1	0.4	1.7	3.0	0.7	15.5
Tonnes	100	10.2	59.0	6.3	0.3	2.2	7.1	2.0	13.0
Shipments	100	10.0	44.2	30.8	0.2	1.1	2.8	0.8	10.0
Distance shipped	100	7.6	42.3	36.7	0.3	0.7	1.5	0.4	10.4
Tonne-kilometre	100	7.3	63.0	7.8	0.4	1.6	3.8	1.3	14.8
				average					
Revenue per shipment (dollars)	1,150	880	1,402	637	1,931	1,769	1,252	1,036	1,785
Distance per shipment (kilometre)	1,324	1,005	1,266	1,579	1,698	848	691	745	1,384
Tonnes per shipment (number)	10	10	13	2	11	19	24	24	12
Tonnne-kilometre per shipment (number)	10,323	7,477	14,701	2,618	16,500	14,957	14,157	17,491	15,279

Source: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2008.

Specialized Freight Trucking carriers are subdivided into five subcategories: Moving, Bulk Liquids, Dry Bulk, Forest Products, and Other Specialized. Moving, the smallest (Table 2), is excluded from this analysis, because it does not involve new products that can be easily classified. For the remainder of the analysis, the Specialized Freight Trucking firms are consolidated into one category—Specialized.

To simplify the terminology in this report, carriers are classified as Truck-Load (TL), Less-than-Truck-Load (LTL) and Specialized. Local freight carriers are included in the TL category, because their average tonnage per shipment is closer to that of TL carriers. Each classification represents a different trucking technology (TL and LTL versus Specialized) or business model (TL and Specialized versus LTL). Owing to these differences, the various types of carriers may incur differing fixed and/or line-haul costs. For instance, Specialized carriers are likely to have higher fixed costs and line-haul costs, because their capital costs are higher and they are less likely to obtain a backhaul, respectively. On the other hand, LTL carriers may incur higher fixed costs because of delays at the border due to loads with multiple consignments.

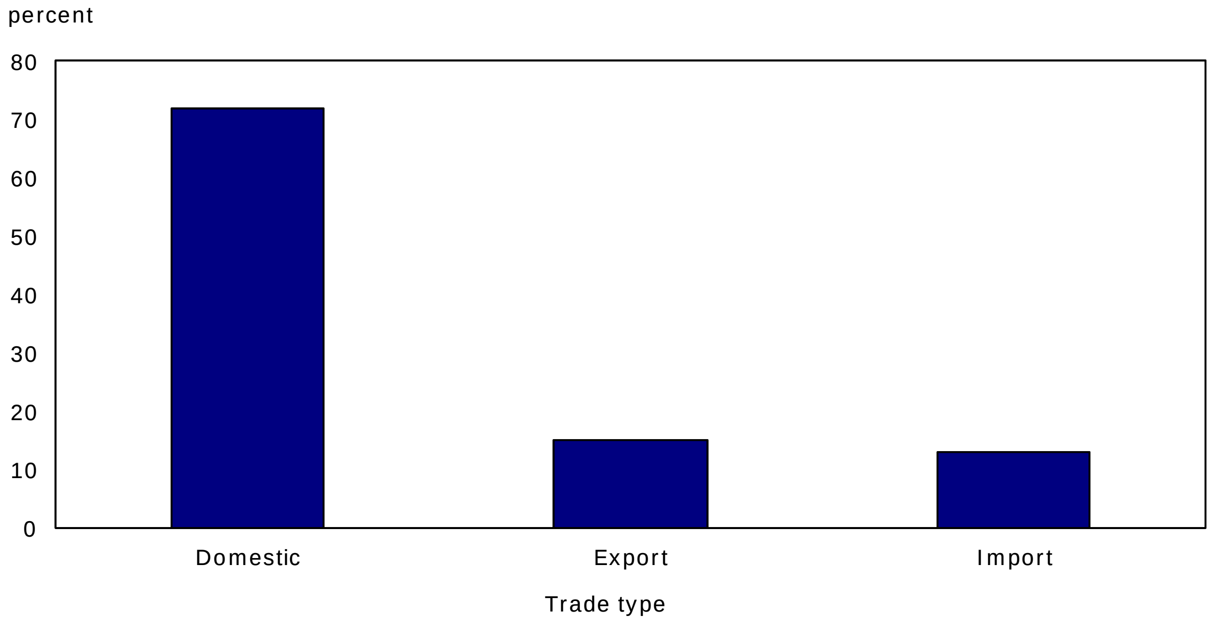
The longest border delays occur when trucks are diverted to secondary yards for further inspection (Taylor et al., 2004). Under Canadian and U.S. customs regulations, trucks with more than five consignments are automatically sent to secondary yards (Taylor et al., 2004). This may happen more frequently for LTL carriers, either because the truck has more than five consignments, or because of an issue with one of the consignments, which results in the whole load undergoing further inspection (Taylor et al., 2004).[9]

In addition to measuring the direct costs associated with trucking, this analysis estimates *ad valorem* costs. This entails estimating the value per tonne by commodity, which can then be used to estimate the value of each shipment. For reasons explained in the Appendix (section 6.1), trade by value includes all commodities defined by the SCTG, except Miscellaneous Transported Products (SCTG 42). From this point forward in the analysis, this goods classification is excluded.

Chart 2 presents the percentage of the value of shipments carried by for-hire trucking firms by trade type, averaged over the 2004-to-2009 period. By value, just over 70% of trade carried by these trucking firms is domestic, with roughly equal portions of the remainder exported and imported.

9. Also, LTL trucks cannot take advantage of Free and Secure Trade (FAST), a U.S.-Canada program that allows shipments in supply chains that have been certified as low-risk to receive faster clearance and fewer referrals to secondary inspections. Because LTL loads involve multiple shippers, it is seldom possible to certify them as low-risk.

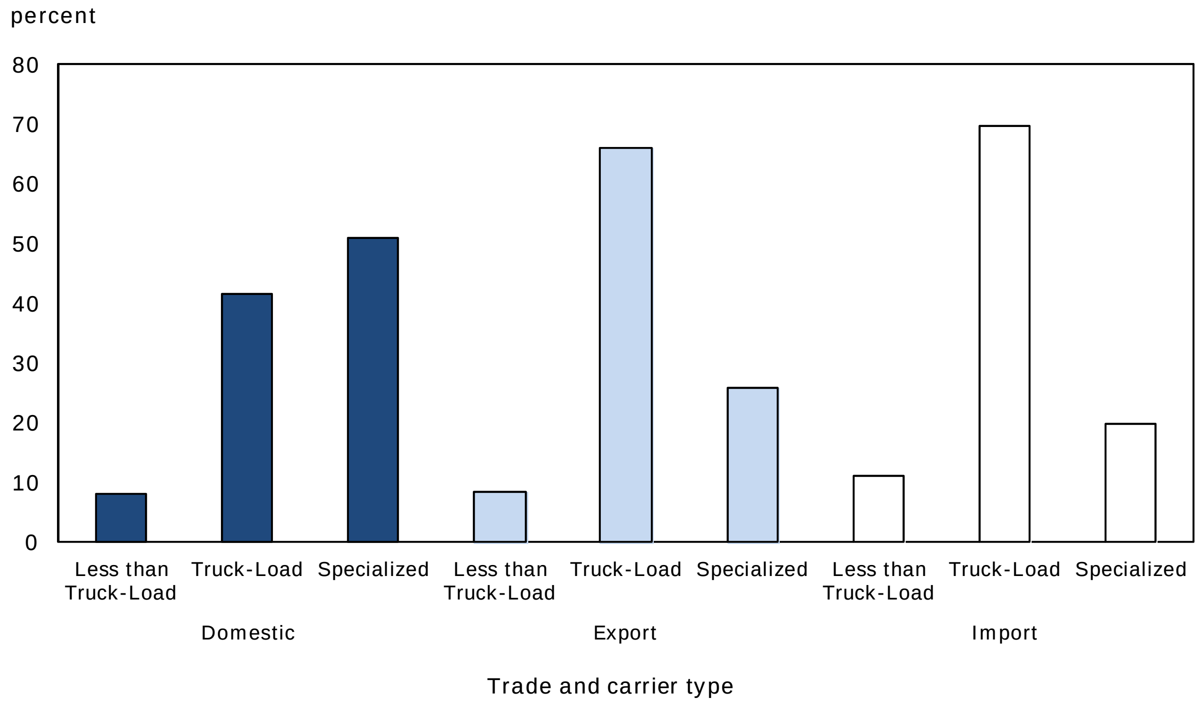
Chart 2
Distribution of average 2004-to-2009 value of shipments, by trade type



Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

TL carriers dominate export and import trade, accounting for about two-thirds of the value of trade, whereas Specialized carriers transport the majority of domestic goods (Chart 3). LTL carriers account for about 10% of the value of goods shipped, regardless of trade type. While all three types of carriers are included in the following econometric analysis, the dominance of cross-border trade by TL carriers suggests that their cost structure matters the most for cross-border trade.

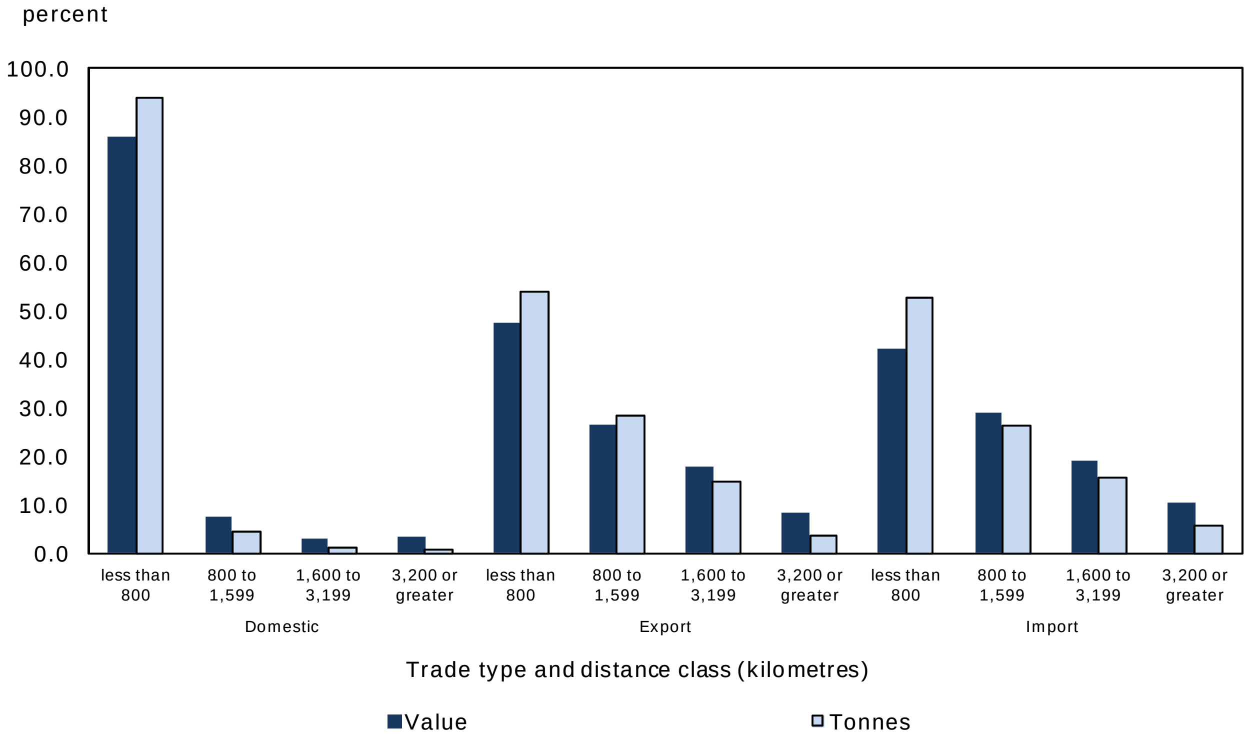
Chart 3
Distribution of average value of shipments, by trade and carrier type



Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

Reflecting the close relationship between trucking costs and distance, and the tendency for the cost competitiveness of the rail mode relative to trucking to increase with distance, the largest share of shipments by both value and tonnage tends to take place within 800 km (Chart 4). This is particularly true of domestic trade, where 86% of shipments by value are within 800 km; only 3.5% of shipments by value, and fewer than 1% of shipments by tonnage, travel more than 3,200 km (Chart 4). Cross-border trade is far less oriented toward these relatively short distances, with 52% of the value of exports and 58% of the value of imports shipped more than 800 km. This variation by distance shipped across trade classes necessitates a multivariate approach to comparing trucking costs that takes distance into account. It also complicates the comparison of *ad valorem* trucking costs for domestic and cross-border trade, because the longer distances associated with cross-border trade may result in higher *ad valorem* costs.

Chart 4
Distribution of the average value and tonnage of shipments, by trade type and distance class, 2004 to 2009



Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

3 Econometric model

3.1 Specification

On a per shipment basis, trucking costs include a fixed component and a variable (line-haul) component. The fixed component covers the cost of facilities, insurance, terminal (loading and unloading), and costs associated with crossing the border. The variable component pertains to costs that vary with distance, such as driver costs, fuel, and vehicle depreciation and maintenance. While a variety of factors such as congestion in specific corridors and the probability of obtaining a backhaul affect the pricing of specific shipments, it is reasonable to assume that most of the variance in revenue per shipment may be explained in terms of a simple pricing rule that accounts for both the fixed costs incurred by firms on a per shipment basis (α) and variable (line-haul) costs per kilometre shipped (β): $r_{ijl} = c_{ijl} = \alpha + \beta d_{ij}$, where *r* is revenue (price charged) per shipment, *c* is cost, *d* is distance and *i*, *j*, and *l* index the origin, destination and shipment, respectively. It is assumed that all economic profits are competed away, and therefore, for the average shipment, revenues and costs are equalized. Firms likely set their price per kilometre on the basis of a full-load (or average load). This would imply the following revenue function:

$$r_{ijl} = \alpha + \frac{\beta}{t^*} d_{ij} t^*, \tag{2}$$

where t^* is the unknown tonnage (for example, full load) used for pricing purposes. Therefore, the implicit line-haul cost per tonne-kilometre using this pricing rule is β / t^*. This implies that for a load with a tonnage less than t^*, the rate per tonne-kilometre would have to be scaled upward to ensure that the pricing rule, on a per kilometre basis,[10] is maintained:

$$r_{ijl} = \alpha + \left[\frac{\beta}{t^*} + \phi \left(t^* - t_l \right) \right] d_{ij} t_l, \tag{3}$$

where $\phi \left(t^* - t_l \right)$ is the scaling factor that is a linear approximation of the relationship between price per tonne-kilometre and the pricing rule per kilometre. (The exact correction is β / t, which renders the equation non-linear in parameters.) Multiplying the terms in square brackets through by $d_{ij} t_l$ results in:

$$r_{ijl} = \alpha + \left(\frac{\beta}{t^*} + \phi t^* \right) d_{ij} t_l - \phi d_{ij} t_l^{\,2}. \tag{4}$$

Equation 4 can be estimated using the following simple quadratic form:

$$r_{ijl} = \alpha + \delta d_{ij} t_l + \sigma d_{ij} t_l^2, \tag{5}$$

where $\delta = \beta / t^* + \phi t^*$ and $\sigma = -\phi$ and the expectations are that δ will be positive and σ negative.

Equation 5 is augmented by including an additional distance term to account for instances when there is no backhaul (deadheading). In these cases, the revenue per shipment will be a function of both tonne-kilometres, which reflects the fronthaul, and the simple distance, which reflects the empty backhaul. Therefore, the expectation about the addition to the fronthaul price that results from not obtaining a backhaul is simply the rate γ charged per kilometre for running empty multiplied by the distance and the probability (P) of not obtaining a backhaul:

$$\gamma d_{ij} P = \nu d_{ij}. \tag{6}$$

Finally, a squared distance term is added to equation 5 to account for any non-linear effect of distance on revenues. This non-linearity may be present if the probability of not obtaining a backhaul decreases with distance. That is, for short trips, the additional surcharge levied for the deadhead portion of the trip is a relatively small portion of the cost to shippers, because fixed costs make up a large portion of the charge. As distances increase, the surcharge makes up a growing portion of the cost to shippers, reducing demand for trips without a pre-arranged backhaul. Adding an error term to equation 5 results in the equation:

10. A heavier load uses more fuel per kilometre, so the line-haul cost for a light load would be slightly less. In its estimated form, however, the model is sufficiently flexible to take this into account.

$$r_{ijl} = \alpha + \delta d_{ij} t_l + \sigma d_{ij} t_l^2 + \nu d_{ij} + \varphi d_{ij}^2 + \varepsilon_{ijl}; \text{ or}$$
$$= \underbrace{\alpha}_{\text{fixed cost}} + \underbrace{\left(\delta t_l + \sigma t_l^2 + \nu + \varphi d_{ij}\right) d_{ij}}_{\text{linehaul cost}} + \varepsilon_{ijl}. \quad (7)$$

Equation 7, therefore, includes both a fixed cost component and a variable, or line-haul, cost component. The marginal effect of distance depends on number of tonnes shipped and, because of the squared term, distance itself.

3.2 Estimates

To permit the effect of distance and tonnage on carrier revenues to vary across carriers types—Truck-Load (TL), Less-than-Truck-Load (LTL) and Specialized—separate models are estimated for each (Table 2). The sample is restricted to shipments less than 5,000 km and less than 23 tonnes for TL and LTL carriers. For Specialized carriers, for which heavier loads are more common (median 26 tonnes), the sample is restricted to loads less than the 95 percentile (about 52 tonnes or less). Shipments further than 5,000 km are excluded, because they are likely to be idiosyncratic (for example, to northern Canada). Despite this restriction, almost all major city pairs are included. For instance the distance between Halifax and Los Angeles, one of the longest city-pair combinations, is about 4,700 km. For TL and LTL carriers, loads are restricted to less than 23 tonnes, which approximates the maximum tonnage permitted on most North American highways. Greater tonnages likely require special permits that would increase the cost of the shipment independent of other factors. When the model was tested for the sensitivity of results to higher tonnages for these two classes of carriers, no qualitative effect on the estimates emerged.

To facilitate the analysis, the cross-sections from 2004 to 2009 are pooled. Of course, over the period, both the fixed and variable costs associated with each shipment may have increased. To account for this, the model presented in Equation 7 is augmented by including a time trend (*y*) and its interaction with tonne-kilometres (*t* x *d* x *y*) (see Equation 8). The interaction of the time trend with distance alone was also tested (*d* x *y*), but the effect was statistically insignificant.

The time trend (and its interaction with tonne-kilometres) is further interacted with a vector of trade type binary variables, $\mathbf{p_u}$, that indicate whether the shipment is domestic (*d*), for export (*x*) or for import (*m*), where $\mathbf{u} \in d, x, m$. This functional form allows for differing coefficients across trade types.

Finally, to account for variability in revenues across commodities, the model includes a vector of commodity fixed effects at the 5-digit level of the Standard Classification of Transported Goods, $\boldsymbol{\lambda}_\mathbf{k}$, where *k* indexes commodities.[11] Revenues may vary across commodities for many reasons. For instance, to ship higher-value commodities, carriers will tend to charge more for a higher level of service in terms of speed and reliability. Hence, in its final estimated form, the revenue equation is:

$$r_{ijl} = \alpha + p_m + p_x + \mathbf{p}'_\mathbf{u}\left[\left(\delta t_l y + \sigma t_l^2 + \nu + \varphi d_{ij}\right) d_{ij} + y\right] + \boldsymbol{\lambda}_\mathbf{k} + \varepsilon_{ijl}. \quad (8)$$

11. Because of the very large number of commodity-based binary variables, their estimated parameters are not shown in Table 3.

As a final econometric note, the p-values are based on robust standard errors corrected for the correlation of errors across shipments transported by the same firm. The model was also tested using jackknife estimation that better takes into account the design of the Trucking Commodity Origin and Destination Survey (Appendix, Section 6.2). These estimates suggest that the p-values in Table 3 are reliable.

Before the variation in carrier revenues between domestic and cross-border shipments is discussed in detail, the broader patterns in the results should be established. First, regardless of the trade or carrier type, substantial fixed costs are always associated with shipments. Second, holding distance constant, it costs more per tonne shipped. However, this marginal effect decreases with the tonnage, which is consistent with at least a portion of firms setting prices on a per-kilometre basis. Costs generally increase with distance, but the influence of distance is strongest for cross-border shipments and for Specialized carriers—trips for which backhauls are expected to be more difficult to obtain. The effect of distance is typically non-linear, with its marginal effect decreasing with distance.

Table 3
Model estimates of revenue per shipment by carrier type and trade type

	Truck-load		Less-than-truck-load		Specialized	
	coefficient	**p-value**	**coefficient**	**p-value**	**coefficient**	**p-value**
Domestic						
Year	12	0.019	12	0.000	9	0.020
Distance	0.030	0.460	0.011	0.088	0.314	0.000
Distance x tonnes	0.12	0.000	0.10	0.000	0.07	0.000
Distance x tonnes x tonnes	-0.0038	0.000	-0.0031	0.000	-0.0014	0.000
Distance x tonnes x year	0.0016	0.001	0.0011	0.294	0.0012	0.120
Distance x distance	-0.00001	0.136			-0.0001	0.000
Intercept	158	0.000	96	0.000	235	0.000
Export						
Year	9	0.408	17	0.006	48	0.010
Distance	0.33	0.000	0.027	0.161	0.457	0.000
Distance x tonnes	0.14	0.000	0.19	0.000	0.08	0.000
Distance x tonnes x tonnes	-0.0046	0.000	-0.0076	0.000	-0.0016	0.000
Distance x tonnes x year	-0.000875	0.060	0.0005	0.596	-0.0020	0.266
Distance x distance	-0.0001	0.000			-0.0001	0.000
Export binary	140	0.014	203	0.000	78	0.213
Import						
Year	25	0.000	-2	0.882	28	0.180
Distance	0.13	0.005	0.030	0.048	0.572	0.000
Distance x tonnes	0.15	0.000	0.16	0.000	0.07	0.000
Distance x tonnes x tonnes	-0.0057	0.000	-0.0067	0.002	-0.0017	0.000
Distance x tonnes x year	0.0032	0.000	0.0033	0.024	0.0027	0.000
Distance x distance	-0.00002	0.029			-0.0001	0.002
Import binary	-21	0.208	211	0.000	-147	0.114

	Truck-load	Less-than-truck-load	Specialized
Diagnostic stastistics			
Number of observations	337,079	16,976,224	2,610,467
F-statistics	471.8	171	160
R-squared	0.62	0.40	0.47

Notes: P-values are based on robust standard errors corrected for within-group (trucking firm) correlation. All models are estimated with commodity fixed effects using commodities classified under the Standard Classification of Transported Goods at the 5-digit level. Data cells are left blank when variables are not included in a model.

Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

The key question posed in the introduction was whether fixed and line-haul costs differed significantly between domestic and cross-border trade. Chart 5 presents the fixed cost for TL carriers across trade types.[12] Because TL carriers account for the majority of cross-border trade, the discussion focuses on these carriers. Later, the results for LTL and specialized carriers presented in Table 3 will be considered.

Fixed costs for exports exceeded fixed costs for domestic trade throughout the 2004-to-2009 period, but they increased more slowly. In 2004, fixed costs for exports were about 180% of those for domestic trade, but by 2009, the figure had fallen to 150%. For imports, the fixed cost per shipment at the beginning of the period was statistically indistinguishable from domestic costs. However, because import fixed costs increased more rapidly, by the end of the period, their level was significantly higher. This may reflect the additional security measures undertaken by the U.S. government, which were followed by similar measures by the Canadian government.

Chart 5

Fixed costs, by trade type for truck-load carriers, 2004 and 2009

Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

It is difficult to determine what factor or factors underlie these trends in fixed costs for cross-border trade. Because average border delays have declined at most crossings, the fixed effects for exports and imports might be expected to converge with those of domestic shipments. But shorter delays do not necessarily mean that the cost of crossing the border has decreased. In fact, a number of programs instituted to help ease border congestion impose significant costs on shippers and carriers. For example, a manifest must be submitted electronically by each truck an hour before it arrives at the border. This allows border agencies to expedite clearance by conducting risk assessments in advance, but it places an additional cost burden on carriers. Similarly, shorter delays may be attributed, in part, to 'trusted trader' programs such as the U.S. Customs-Trade Partnership Against Terrorism (C-TPAT) and the Canadian Partnership in

12. The fixed cost is calculated as the sum of the intercept, the binary adjustments for imports and exports and the year parameter times the year variable (1 for 2004 and 6 for 2009.)

Protection (PIP). In exchange for more rapid clearance at the border, participants agree to invest in facilities, equipment and staff devoted to improved supply chain security. Rational firms will participate in such programs only if they can recover the cost of compliance through increased revenues.

The results in Table 3 are helpful in presenting the components that make up line-haul costs, but because of the large number of interaction terms, they are less helpful in determining if line-haul costs differ between domestic and cross-border trade. To do this, Chart 6 presents line-haul costs per kilometre for shipments travelling 100 km, 800 km, 1600 km and 3200 km in 2004 and 2009. These estimates are for a 10-tonne load, which is close to the average for domestic and cross-border trade for TL carriers (Table 2).

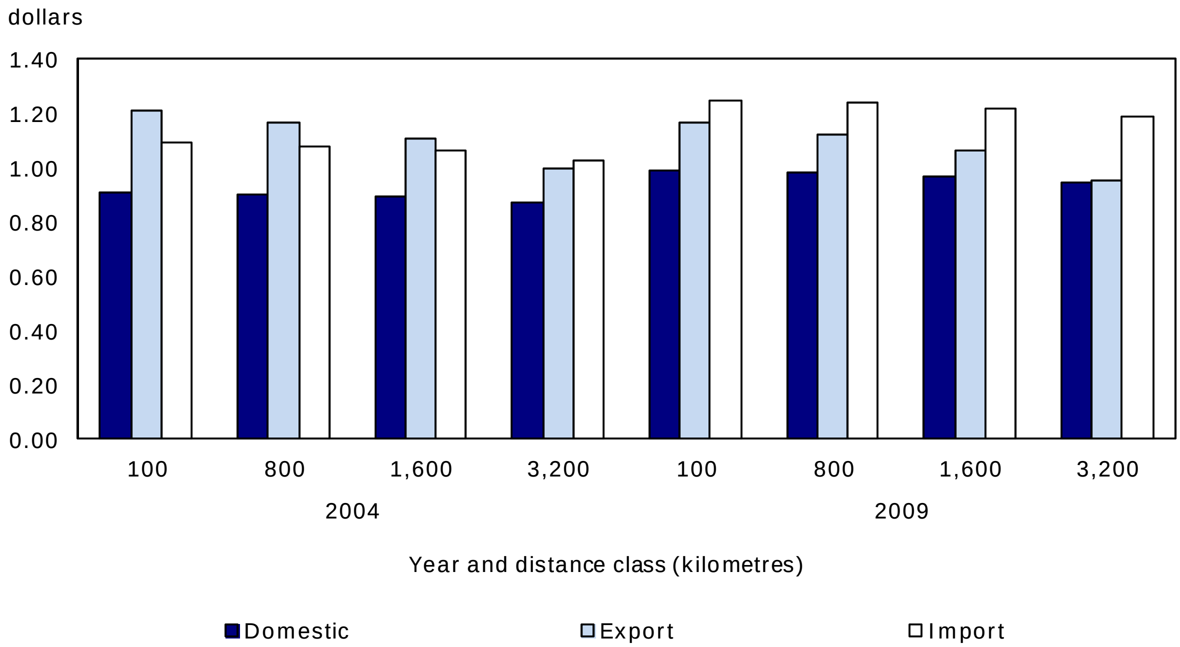
For a 100 km shipment of a 10-tonne load in 2004, the model predicts line-haul costs of domestic shipments to be $0.91 per kilometre, compared with $1.21 per kilometre and $1.09 per kilometre for exports and imports, respectively (Chart 6).[13] Line-haul costs per kilometre are higher for cross-border shipments because the effect of distance and its interaction with the number of tonnes shipped (tonne-kilometres) are higher. As distance increases, its marginal effect declines, which explains the falling line-haul costs with distance for exports, and, to a lesser extent, imports. Hence, for longer-distance shipments, domestic and international line-haul costs converge, though not completely. At 3,200 km, domestic shipments' line-haul costs are $0.87 per kilometre, compared with $1.00 per kilometre and $1.03 per kilometre for exports and imports, respectively.

Between 2004 and 2009, line-haul costs per kilometre for a 10-tonne shipment rose 10% and 14% for domestic shipments and imports, respectively, but fell 4% for exports. As a result, line-haul costs per kilometre tended to converge for domestic trade and exports, but diverge for domestic trade and imports (Chart 6).

13. Line-haul costs for exports and imports are statistically different from domestic flows across all distance classes at a critical value of 1% or less in 2004.

Chart 6

Line-haul costs per kilometre for a 10-tonne shipment for truck-load carriers, by distance class and trade type, 2004 and 2009

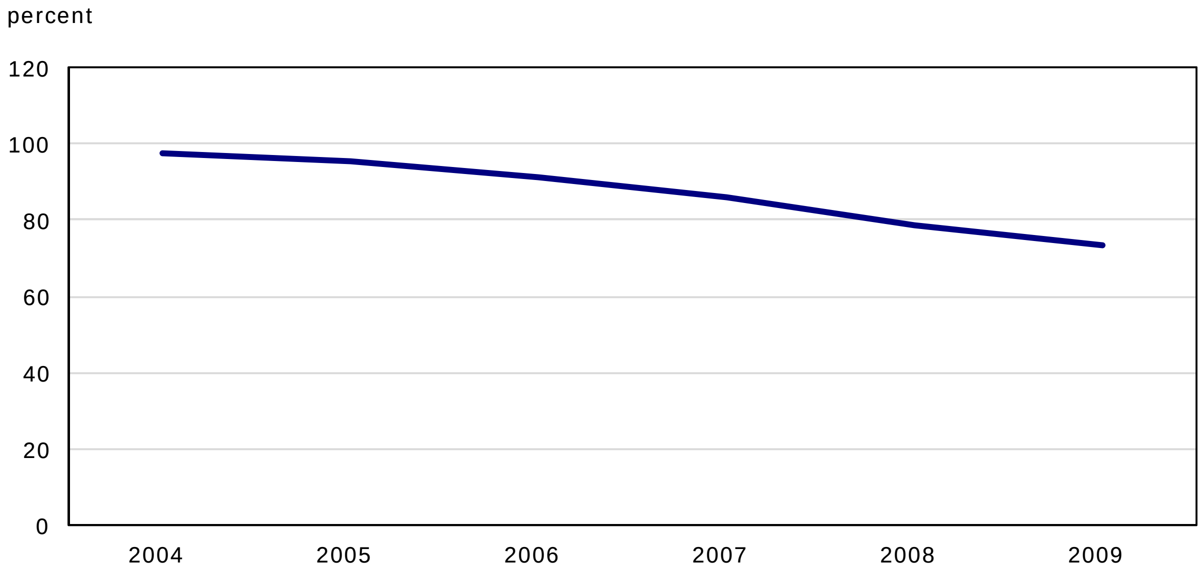


Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

The divergent trends in line-haul costs per kilometre for exports and imports suggest a change in the trade regime, whereby the 'empty backhaul' problem switched from primarily affecting shipments of Canadian exports to shipments of imports. In other words, while it was once more frequently the case that trucks shipping goods from Canada to the U.S. would return empty, now trucks carrying U.S. goods into Canada face this problem. Over the study period, a rising Canadian dollar and macroeconomic weakness in the U.S. coincided with declining merchandise trade surplus with the U.S.[14] At the same time, the share of oil and gas, which are transported via pipeline, in Canadian exports steadily increased. Thus, when truck-borne trade is considered alone, the surplus of goods movement shifted to the U.S. side (Chart 7). In 2004, the value of truck-borne Canada-U.S. trade was balanced, but by 2009, exports were only 79% of the value of imports. While additional factors may be involved, this pattern of trade is consistent with the shift to higher line-haul costs for imports than for exports.

14. Statistics Canada, CANSIM, table 228-003.

Chart 7
Value of truck-borne exports as a percentage of value of imports, 2004 to 2009



Source: Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009.

Although patterns of fixed and line-haul costs for LTL and Specialized carriers are generally similar to those of TL carriers, some differences are notable. First, the additional fixed costs associated with cross-border trade are higher for LTL carriers than for TL and Specialized carriers. This is consistent with potentially longer border delays, as LTL carriers are more likely to be pulled aside for secondary inspections. The effect of additional fixed costs associated with exports and imports was essentially the same at the start of the period, but the trend for exports was positive and significant.

Second, the effect of distance for LTL carriers was less than for TL carriers, though insignificant, while for specialized carriers, the coefficient on distance was higher than for TL carriers. Again, this pattern is consistent with the nature of these carriers. LTL carriers specialize in moving between terminals, where backhauls are likely to be found. Specialized carriers, because they are less likely to obtain backhauls, would be expected to have a positive coefficient on distance. As is the case for TL carriers, the coefficient on distance is higher for cross-border than for domestic shipments.

4 *Ad valorem* trucking costs

As noted above, the *ad valorem* cost of trucking goods is simply trucking revenues divided by the value of the goods shipped. They vary depending on the cost of moving the good and its value. The goal here is to estimate the *ad valorem* cost of transporting goods domestically versus across the border.

Over the 2004-to-2009 period, trucking costs accounted for an average of 2.2% of the value of goods shipped domestically. Between 2004 and 2007, the *ad valorem* rate rose from 2.1% to 2.6%, and then dropped to 2.0% in 2009 (Chart 8).[15] This pattern is consistent with rising fuel

15. The sample has been restricted to reflect those used in the models reported in Table 3 for Truck-Load, Less-than-Truck-Load and specialized carriers, so that the actual and predicted *ad valorem* costs are comparable.

costs, which may have induced the run-up in *ad valorem* rates between 2004 and 2007. Although diesel prices peaked in 2008,[16] a weakening macroeconomic environment in 2008 and 2009 would have put pressure on transportation rates. This, combined with an increase in the estimated value per tonne of goods shipped, probably accounts for the decline in *ad valorem* trucking costs after 2007.

Ad valorem trucking costs for exports and imports surpassed those for domestic shipments (Chart 8) in all years, but followed different trends over time. While rates for exports trended down, rates for imports trended up, so that by 2009 the *ad valorem* rate on imports was above that on exports, reversing the relationship in 2004. These rates, of course, do not account for variability in distance shipped and commodity composition across trade classes, which affect the comparability of domestic and cross-border *ad valorem* trucking costs.[17]

To address this problem, revenues per shipment for exports and imports are predicted based on the parameters for domestic trade. These counterfactual revenue estimates are, in turn, used to calculate counterfactual *ad valorem* costs. The difference between the predicted *ad valorem* trade costs and predicted counterfactual *ad valorem* trade costs can be thought of as the tariff equivalent of the extra costs of shipping goods to and from the U.S. This tariff can be further divided into the fixed and line-haul costs. The former is associated with the additional costs of the border (for example, delays or compliance costs) passed on to shippers by carriers, while the latter is partially attributable to higher backhaul costs. This interpretation of the line-haul portion of the tariff equivalent must be treated with caution, however, because it is unclear how much of these higher line-haul costs are attributable to backhaul concerns.

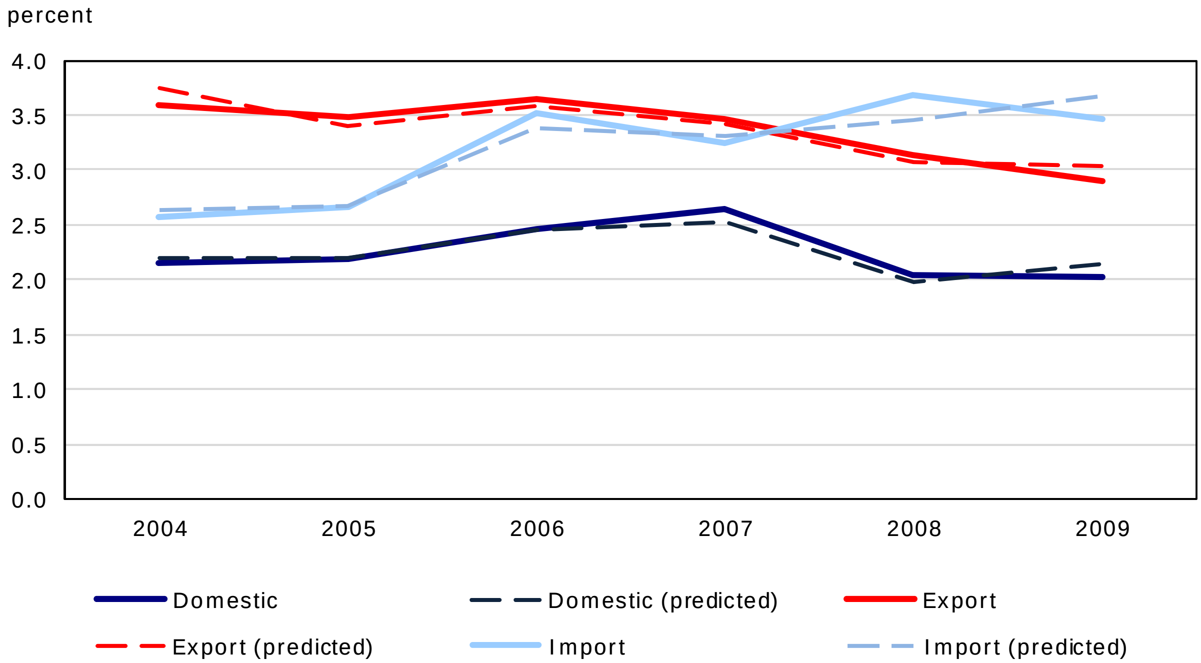
The first step in estimating the counterfactual trade costs for exports and imports is to predict *ad valorem* costs based on the parameters in Table 3 (Chart 8). In all instances, predicted *ad valorem* costs and actual costs match quite closely.

16. See CANSIM Table 329-0065.

17. *Ad valorem* trucking costs vary considerably across distance and commodities. For instance, the average *ad valorem* trucking cost for a shipment of less than 800 km is 1.9%; this more than doubles to 4.4% for a shipment of 1,600 km to 3,299 km. Variability across commodities is even greater because the value of shipments differs. For a shipment of 800 km to 1,599 km, the average *ad valorem* cost for pharmaceuticals is 0.3%, while for pulp, newspaper and paper board, it is 7.2%.

Chart 8

***Ad valorem* trucking costs, by year and trade type, 2004 to 2009**

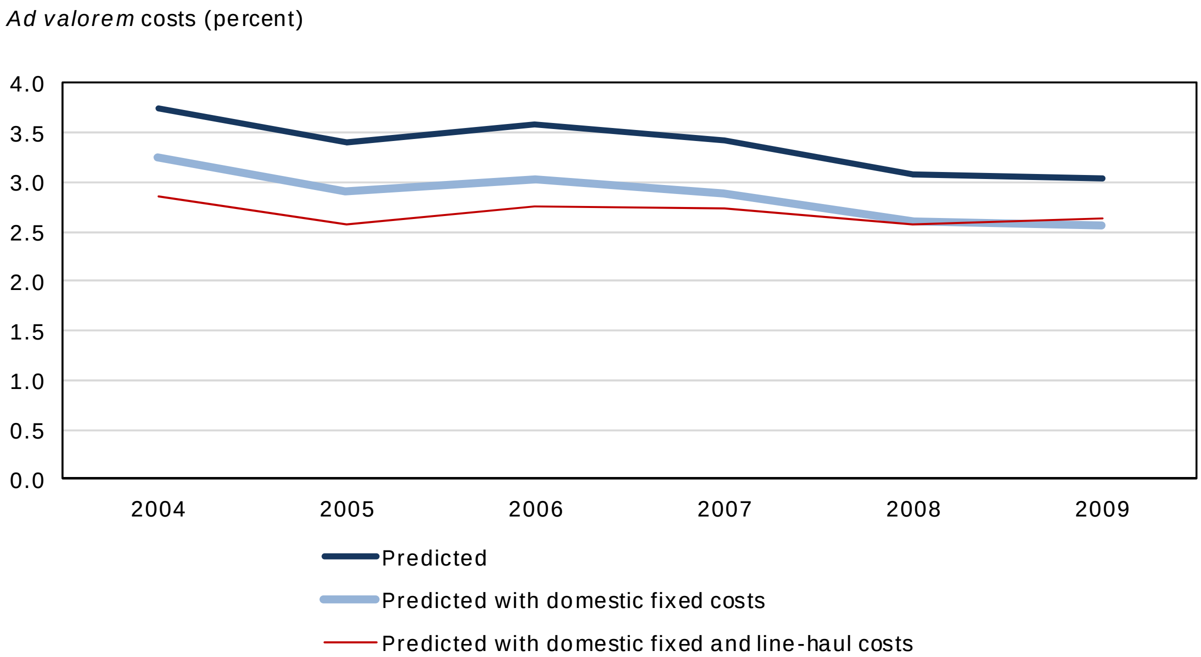


Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

The next step is to estimate *ad valorem* trucking costs based on the counterfactual parameters. In 2004, the *ad valorem* costs for exports fall by about 0.5 percentage points when fixed costs are reduced to domestic levels, and a further 0.4 percentage points when line-haul costs are reduced to domestic levels (Chart 9). By 2009, *ad valorem* fixed costs remained essentially unchanged, even though fixed costs on exports rose through the period (at least for Less-than-Truck-Load and Specialized carries, Table 3). This suggests that the value of exports rose in tandem with fixed costs. The contribution of additional line-haul costs for exports fell through the period, so by 2009, they had no effect on *ad valorem* costs of exporting to the U.S.

Chart 9

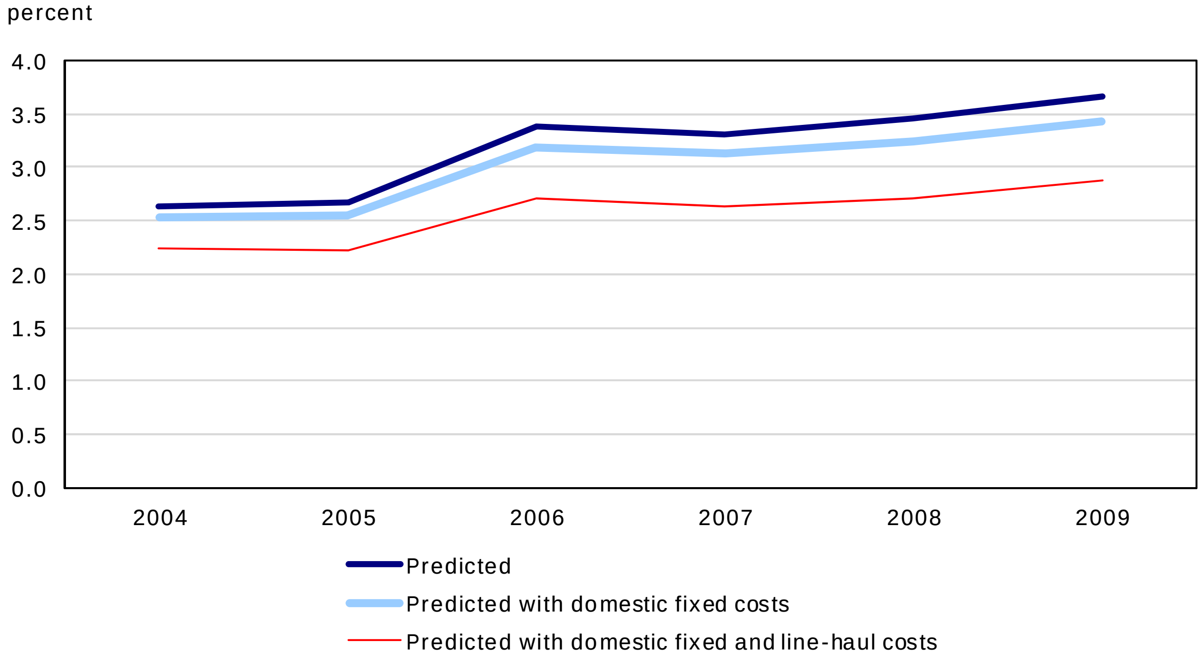
Predicted and predicted counterfactual *ad valorem* trucking costs for exports, 2004 to 2009



Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

For imports, the contribution of fixed costs to *ad valorem* costs above that observed for equivalent domestic shipments rose from about a tenth of a percentage point in 2004 to about a quarter of a percentage point in 2009. These additional *ad valorem* fixed costs on imports were about a quarter of those on exports at the start of the period and about half by the end. Additional line-haul costs associated with imports played a larger role, rising from 0.3 percentage points in 2004 to 0.6 percentage points by 2008. Rising line-haul costs on imports and declining line-haul costs on exports would be consistent with a change in the trade regime, with the backhaul switching from the inbound to the outbound portion of a journey for Canadian-based carriers.

Chart 10
Estimated and counterfactual *ad valorem* trucking costs for imports, 2004 to 2009



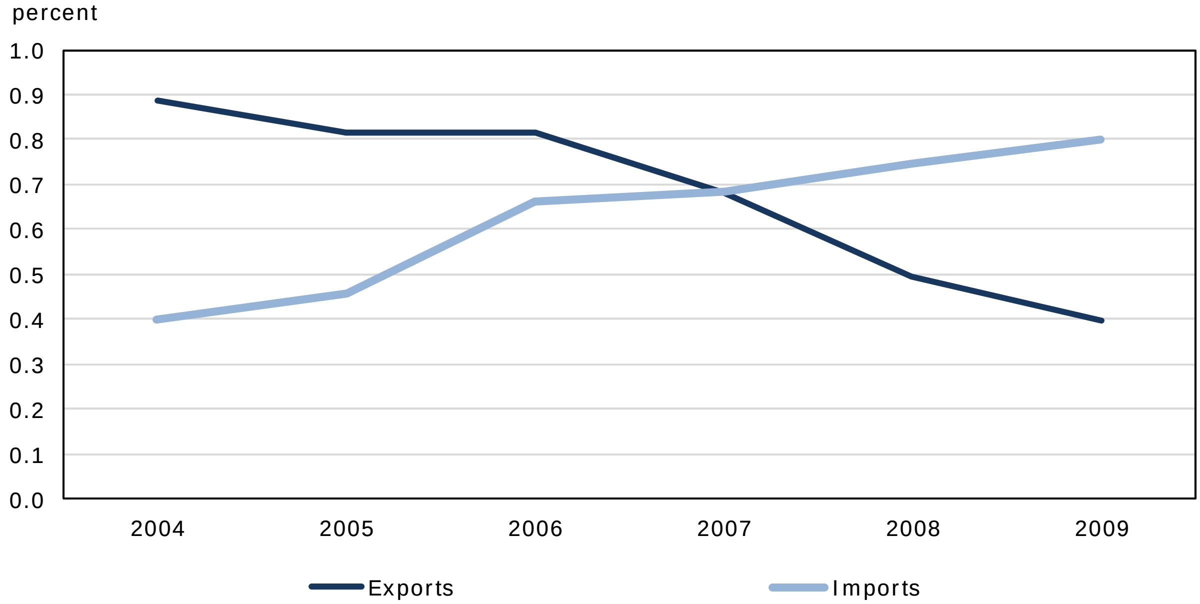
Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

As noted above, the difference between the predicted and predicted counterfactual *ad valorem* trucking costs can be interpreted as a transportation-system-related tariff on cross-border trade (Chart 11). That is, it represents the additional costs that carriers pass on to shippers for moving goods to and from the U.S. At the start of the period, the additional cost of cross-border trade was the equivalent of 0.9% tariff on exports and a 0.4% tariff on imports. Over the 2004-to-2009 period, the *ad valorem* tariff-equivalents on exports and imports followed different trends, ending the period opposite to where they started.

While these tariff equivalents may seem small, they represent a substantial addition to overall transportation costs. For instance, in 2004, it cost 31% more to export goods to the U.S. than to ship the same goods the same distance in Canada. That year, it cost 18% more to import goods from the U.S. than to ship domestically on an *ad valorem* basis. By the end of the period, this relationship had switched. In 2009, it cost 15% more to export and 28% more to import than to ship the same goods within Canada.

Chart 11

***Ad valorem* tariff-equivalent costs for exports and imports, 2004 to 2009**



Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

The overall effect of these tariff-equivalent rates also depends on whether the trade flow is composed of finished or intermediate goods. For instance, consider an intermediate good that is imported from the U.S., assembled into a finished good (comprising 50% of the value of the finished good), and exported back to the U.S. The tariff equivalent would be 0.9% on the finished good (in 2004), plus 50% of the tariff equivalent on the intermediate inputs, which implies a total tariff equivalent of about 1.10%. This compounding effect is especially important in automotive supply chains, where intermediate components often cross the border numerous times (Andrea and Smith, 2002).

5 Conclusion

Despite the elimination of formal tariff barriers between Canada and the U.S., the level of trade between the two countries suggests that impediments remain. The purpose of this paper has been to identify the effect of costs related to the transportation system itself on trade, specifically, costs related to trucking goods across the Canada-U.S. border.

Because trucking is the primary means by which goods are shipped across the border, it plays an important role in the integration of the two national economies. Higher trucking costs for cross-border trade than for domestic trade stem from both higher fixed costs per shipment, especially exports, and higher line-haul costs. Higher fixed costs are consistent with the costs of delays and compliance at the border being passed on to the consumers of trucking services. Higher line-haul costs are associated with difficulties obtaining backhauls, which, in turn, may be related to regulations on cabotage rights. The extra costs of cross-border trade amount to an equivalent *ad valorem* tariff of 0.4% to 0.9%, depending on the year and the type of trade (exports or imports). While seemingly small, this is nearly a quarter of the level of (trade-weight) tariffs before free trade. Moreover, if goods pass across the border multiple times, the effects of these additional transportation-related tariffs are magnified.

The costs measured here are only part of the total cost of shipping goods across the border. Taylor et al. (2004) estimated that the institutional costs borne directly by exporting firms for matters like customs administration were as great or greater than the costs passed on to them by freight carriers. (Although goods pass between Canada and the U.S. without tariffs, the two countries do not have a customs union, which means that customs declarations are necessary for all goods that cross the border.) Still, it is unlikely that the full cost of cross-border shipping exceeds 4% to 5% of the *ad valorem* tariff equivalent. This may be contrasted with econometric studies that infer rates of 20% or more from observed trade flows (Chaney, 2008). The remainder of this effect may be attributed to a variety of factors, including regulations, technical standards, national rather than international marketing strategies, impediments to communication and contracting between Canadian and American firms, and national procurement policies.

6 Appendix

6.1 Estimating the value per tonne by commodity

Estimates of the value per tonne across commodity and distance classes are difficult to obtain from Canadian sources. However, estimates can be derived from two datasets provided by the U.S. Bureau of Transportation Statistics (BTS): the North AmericanTransborder Freight Data (NATFD) and the Commodity Flow Survey (CFS) (2007). The NATFD reports the mode, value and tonnage of commodities exported from Canada to the U.S., by province and state pair. The CFS provides similar estimates by distance class for goods shipped within the U.S.[18]

Arguably, the NATFD offers a reasonable estimate of the value per tonne of Canadian exports, and given that it is based on goods produced in Canada, domestic shipments as well. However, applying the same value per tonne to imports from the U.S. may be problematic. The U.S. tends to produce goods with a higher value per tonne, raising their value-to-weight ratio. To solve this problem, the CFS is used to obtain a value per tonne for imports from the U.S.

Several hurdles must be overcome to combine these datasets. The NATFD and the Trucking Commodity Origin and Destination (TCOD) Survey use different, but related, commodity coding systems. The NATFD classifies trade flows using the 2-digit Harmonized System (HS) codes, while the TCOD Survey classifies commodities based on the 5-digit Standard Classification of Transported Goods (SCTG). To reconcile them, the 5-digit SCTG commodity codes are classified by the 2-digit HS commodity classification using a concordance.[19] Because there is no HS code equivalent for Miscellaneous Transported Goods (SCTG 42), these shipments are dropped from this analysis.

With each shipment classified by 2-digit HS commodity, the value per tonne by commodity from the NATFD can be linked. However, as noted above, the value per tonne will also tend to vary by the distance shipped. To account for this, the value per tonne is measured by commodity and by distance class: less than 800 km; 800 km to 1,599 km; 1,600 km to 3,199 km; and 3,200 km or more.[20] These classes are intentionally broad in order to ensure a reasonable number of state-province pairs in each class. This is important, because some province-state flows proved to be idiosyncratic, with very low/high values per tonne relative to the mean. As an additional step to reduce the effect of these extreme values, the set of flows is trimmed to those whose value per tonne is above the 5th percentile and below the 95th percentile.

Depending on the HS commodity, its value per tonne is measured in one of two ways. For commodities without a clear value-distance gradient, the value per tonne is defined as the total of the value of province-state shipments divided by their total weight. For commodities with a value-distance gradient, the value per tonne is calculated across the four distance classes defined above. These estimates of the value per tonne by commodity (and distance class, if appropriate) are used to estimate the value per tonne for domestic trade and exports.

Commodities classified with a positive value-distance gradient must meet one of the two following criteria:

- There was a monotonic increase in the value per tonne between distance classes; or

18. The NATFD and CFS report all shipments in U.S. dollars. U.S. dollar values are converted to Canadian dollars using the Bank of Canada historical average annual exchange rates.
19. See http://www.statcan.gc.ca/subjects-sujets/standard-norme/sctg-ctbt/sctghs-ctbtsh-eng.htm.
20. The population-weighted centroids of each province and state are used to measure province-state distances. In turn, these are used to classify province-to-state flows into the four distance classes.

- The value per tonne increased between two out of the three distance classes, including the 3rd and the 4th, and the value per tonne for the longest distance class was 25% higher than that for the shortest distance class.

The first criterion recognizes that it is unlikely that idiosyncratic factors would result in a monotonic increase in the value per tonne, regardless of the degree of the gradient. The second criterion balances a weaker rule in terms of an acceptably consistent value-distance gradient against a relatively large difference between the shortest and longest distance classes. The rule that there must be an increase between the 3rd and 4th classes is imposed because, in most cases, when there was a gradient, there tended to be a break between these classes, with a large increase in the value-to-weight ratio, possibly stemming from the (partially) open-ended nature of the longest distance class.

As noted above, estimating the value per tonne of imports using Canadian exports may be inappropriate. To adjust the value of these imports, the values per tonne by commodity and distance class from the 2007 CFS are used. The CFS reports the value of goods shipped and their total weight by the same distance classes above by 2-digit SCTG commodity. The ratio of the value per tonne from the CFS to the value per tonne derived from the NATFD by 2-digit SCTG commodity and distance class is calculated. This ratio is then used to adjust, up or down, the value per tonne across all survey years for imports from the U.S., whose levels were initially derived from the NATFD.

Before import values were adjusted, in order to improve the quality of the estimates, adjustments were made to the initial estimates of the value per tonne by 2-digit SCTG code derived from the export data provided by the NATFD.

In several instances, the 2-digit HS codes mapped to two or more 2-digit SCTG codes. This reduced the variability of the value per tonne of these commodities and/or introduced considerable error. For error correction, the solution is best described through an example.[21] The value per tonne for SCTG 08 (Alcoholic Beverages) is based on the value per tonne for HS 22 (Beverages, spirits and vinegar) derived from the NATFD. Because alcoholic beverages are more valuable per tonne than other beverages, the value per tonne for SCTG 08 would tend to be underestimated. To resolve this problem, the CFS-derived value per tonne for SCTG 08 and its ratio to the (error-ridden) value per tonne for SCTG 08 derived from the NATFD is multiplied by value per tonne for SCTG 08 across all years.

To increase variability, the solution was to estimate the ratio of the value per tonne from the CFS for each SCTG 2-digit code relative to that of the aggregate value per tonne for the set of SCTG codes that correspond to the one 2-digit HS code.[22] These are then used to adjust the value per tonne for the 2-digit SCTG codes across all years. When these adjustments are made to the value per tonne for all shipments, the additional step is taken to modify the value of imports from the U.S. using the value per tonne derived from the CFS.

6.2 Jackknife model estimates

The analytical standard errors on the coefficient estimates presented above do not fully account for the design of the TCOD Survey. Consequently, the analytical standard errors may be biased. To check for robustness, the models for Truck-Load (TL), Less-than-Truck-Load (LTL) and Specialized carriers were re-estimated using a jackknife routine that better takes the design of

21. This adjustment was made for TCOD 08 (Alcoholic beverages) and TCOD 28 (Paper or paperboard articles).
22. SCTG codes 10 to 13 that encompass various non-metallic minerals map into HS code 25 (Salt, sulphur; Earths and stone; Plastering materials, lime and cement); SCTG codes 15 to 19 that capture various kinds of mineral fuels map to HS code 27 (Mineral fuels, mineral oils and products of their distillation; Bituminous substances; Mineral waxes); and SCTG codes 25 and 26 map to HS code 44 (Wood and articles of wood; Wood charcoal).

the TCOD Survey into account.[23] These routines are computationally intensive and it was not possible to estimate the base model, because of the large number of commodity binary variables, and, in the case of LTL and specialized carriers, the large number of observations.

Tables 4 through 6 present the estimates for TL, LTL and specialized carriers, respectively. Each table presents three sets of estimates. For comparison purposes, Model 1 is based on the model in Table 3. Model 2A is the same as Model 1, except the 5-digit SCTG commodity binary variables have been excluded. Finally, Model 2B is the same as Model 2A, but the p-values are based on jackknife, rather than analytical, standard errors. The estimates for LTL and specialized carrier are based on a 10% random sample of the observations used for the main estimates.

Two points about the estimates are important. First, little qualitative difference exists between the model estimates, whether or not there are commodity-based binary variables. Hence, the jackknife estimates should be broadly comparable with the main model estimates. Second, in almost all instances, qualitative conclusions about the statistical significance of the estimates are unchanged, regardless of whether the p-values are based on analytical or jackknife standard errors. This should provide greater confidence in the robustness of the results in the main body of the paper.

23. The jackknife routine was implemented using Stata. The survey is treated as a one-stage, clustered design with stratification. The jackknife routine divides the sample into strata corresponding to the first-stage of the survey and independently samples the primary statistical units (trucking firms) within each stratum.

Table 4

Model estimates of revenue per shipment for truck-load carriers

	Model 1		Model 2A		Model 2B	
	coefficient	**p-value**	**coefficient**	**p-value**	**coefficient**	**p-value**
Domestic						
Year	12	0.019	13	0.033	13	0.026
Distance	0.0297	0.460	0.0145	0.749	0.0145	0.549
Distance x tonnes	0.124	0.000	0.128	0.000	0.128	0.000
Distance x tonnes x tonnes	-0.00377	0.000	-0.00388	0.000	-0.00388	0.000
Distance x tonnes x year	0.00156	0.017	0.00176	0.016	0.00176	0.062
Distance x distance	-0.00001	0.136	-0.00001	0.240	-0.00001	0.134
Intercept	157	0.000	155	0.000	155	0.000
Export						
Year	9	0.408	12	0.369	12	0.537
Distance	0.331	0.000	0.311	0.000	0.311	0.001
Distance x tonnes	0.135	0.000	0.138	0.000	0.138	0.000
Distance x tonnes x tonnes	-0.00455	0.000	-0.00459	0.000	-0.00459	0.000
Distance x tonnes x year	-0.000875	0.060	-0.000874	0.098	-0.000874	0.239
Distance x distance	-0.00007	0.000	-0.00007	0.000	-0.00007	0.000
Export binary	140	0.001	142	0.005	142	0.052
Import						
Year	25	0.005	26	0.007	26	0.025
Distance	0.13	0.005	0.0888	0.078	0.0888	0.079
Distance x tonnes	0.15	0.000	0.156	0.000	0.156	0.000
Distance x tonnes x tonnes	-0.00574	0.000	-0.00596	0.000	-0.00596	0.000
Distance x tonnes x year	0.0032	0.000	0.00334	0.000	0.00334	0.000
Distance x distance	-0.00002	0.029	-0.00001	0.165	-0.00001	0.295
Import binary	-21	0.599	-9	0.854	-9	0.867

	Model 1	Model 2A	Model 2B
Diagnostic statistics			
Number of observations	337,079	337,079	337,079
F-statistics	472	393	464
R-squared	0.62	0.59	0.59

Notes: For estimates in Models 1 and 2A, p-values are based on analytical, robust standard errors corrected for within-group (trucking firm) correlation. P-values in Model 2B are based on jackknife standard errors. Estimates in Model 1 include commodity fixed effects (using commodities classified under the Standard Classification of Transported Goods at the 5-digit level); estimates in Models 2A and 2B do not.

Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

Table 5

Model estimates of revenue per shipment for less-than-truck-load carriers

	Model 1		Model 2A		Model 2B	
	coefficient	**p-value**	**coefficient**	**p-value**	**coefficient**	**p-value**
Domestic						
Year	5	0.455	3	0.769	3	0.275
Distance	-0.00003	0.996	-0.00147	0.872	-0.00147	0.613
Distance x tonnes	0.11	0.000	0.11	0.000	0.11	0.000
Distance x tonnes x tonnes	-0.0038	0.000	-0.0039	0.000	-0.0039	0.000
Distance x tonnes x year	-0.0003	0.894	-0.0004	0.875	-0.0004	0.787
Intercept	134	0.000	142	0.002	142	0.000
Export						
Year	11	0.234	11	0.266	11	0.385
Distance	0.028	0.237	0.028	0.273	0.028	0.035
Distance x tonnes	0.19	0.000	0.18	0.000	0.18	0.000
Distance x tonnes x tonnes	-0.0072	0.000	-0.0071	0.000	-0.0071	0.000
Distance x tonnes x year	-0.001	0.432	-0.001	0.668	-0.001	0.430
Export binary	211	0.000	215	0.001	215	0.000
Import						
Year	-5	0.653	-7	0.551	-7	0.166
Distance	0.041	0.003	0.040	0.009	0.040	0.000
Distance x tonnes	0.18	0.000	0.18	0.000	0.18	0.000
Distance x tonnes x tonnes	-0.0077	0.000	-0.0077	0.000	-0.0077	0.000
Distance x tonnes x year	0.003	0.094	0.003	0.073	0.003	0.000
Import binary	166	0.002	164	0.008	164	0.000

	Model 1	Model 2A	Model 2B
Diagnostic statistics			
Number of observations	1,697,374	1,697,374	1,697,374
F-statistics	110	132	1,147
R-squared	0.383	0.352	0.352

Notes: For estimates in Models 1 and 2A, p-values are based on analytical, robust standard errors corrected for within-group (trucking firm) correlation. P-values in Model 2B are based on jackknife standard errors. Estimates in Model 1 include commodity fixed effects (using commodities classified under the Standard Classification of Transported Goods at the 5-digit level); estimates in Models 2A and 2B do not.

Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

Table 6
Model estimates of revenue per shipment for specialized carriers

	Model 1		Model 2A		Model 2B	
	coefficient	**p-value**	**coefficient**	**p-value**	**coefficient**	**p-value**
Domestic						
Year	13	0.023	15	0.035	15	0.266
Distance	0.38	0.000	0.31	0.005	0.31	0.001
Distance x tonnes	0.07	0.000	0.08	0.000	0.08	0.000
Distance x tonnes x tonnes	-0.0013	0.000	-0.0014	0.000	-0.0014	0.000
Distance x tonnes x year	0.0016	0.295	0.0014	0.411	0.0014	0.604
Distance x distance	-0.0001	0.000	-0.0001	0.000	-0.0001	0.001
Intercept	222	0.000	213	0.000	213	0.000
Export						
Year	13	0.534	-1	0.959	-1	0.959
Distance	0.49	0.000	0.56	0.000	0.56	0.000
Distance x tonnes	0.07	0.000	0.07	0.000	0.07	0.000
Distance x tonnes x tonnes	-0.0015	0.000	-0.0015	0.000	-0.0015	0.000
Distance x tonnes x year	0.001	0.240	0.002	0.140	0.002	0.302
Distance x distance	-0.0001	0.001	-0.0001	0.001	-0.0001	0.003
Export binary	211	0.015	221	0.020	221	0.066
Import						
Year	9	0.790	17	0.666	17	0.716
Distance	0.75	0.000	0.75	0.001	0.75	0.006
Distance x tonnes	0.06	0.000	0.06	0.000	0.06	0.000
Distance x tonnes x tonnes	-0.0019	0.000	-0.0020	0.000	-0.0020	0.000
Distance x tonnes x year	0.005	0.005	0.005	0.005	0.005	0.000
Distance x distance	-0.0001	0.007	-0.0001	0.033	-0.0001	0.044
Import binary	-58	0.700	-70	0.711	-70	0.751

	Model 1	Model 2A	Model 2B
Diagnostic statistics			
Number of observations	260,947	260,947	260,947
F-statistics	132	101	122
R-squared	0.519	0.352	0.352

Notes: For estimates in Models 1 and 2A, p-values are based on analytical, robust standard errors corrected for within-group (trucking firm) correlation. P-values in Model 2B are based on jackknife standard errors. Estimates in Model 1 include commodity fixed effects (using commodities classified under the Standard Classification of Transported Goods at the 5-digit level); estimates in Models 2A and 2B do not.

Sources: Statistics Canada, Trucking Commodity Origin and Destination Survey, 2004 to 2009; and Bureau of Transportation Statistics, North American Transborder Freight Data, 2004 to 2009, and Commodity Flow Survey, 2007.

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