ASSESSING THE IMPACT OF THE COMPREHENSIVE ECONOMIC AND TRADE AGREEMENT (CETA) ON CANADA'S TRANSPORTATION NETWORK

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1. Introduction

Canada signed the Canada-European Union (EU) Comprehensive Economic and Trade Agreement (CETA) in October of 2016, which was later ratified by the European Parliament in February, 2017. This agreement eliminates tariff barriers and enhances accessibility to the EU market (Government of Canada, 2016). The Canadian government investigates the future impacts of CETA on the nation's economy, regulation, society, and employment size, but evaluation of Canada's transportation system under the CETA is almost forgotten (Bachmann, 2017). The objective of this paper is to assess the potential impact of CETA on the Canadian transportation network by estimating the origin-destination trade flows, mode share, and transportation flows before and after the CETA.

Lack of analysis in evaluating a nation's transportation system under intercity freight flows is not limited to CETA. Despite the crucial role of freight transportation in economy, little work has been contributed to this subject both in academia and practice, unlike the passenger demand modelling (de Cea Ch and Soto,2003; Guélat, Florian, and Crainic, 1990; Maia and Do Couto, 2013; Uddin and Huynh, 2015). Unavailability of appropriate datasets and complexity of the problems are the two major limitations of analyzing intercity freight flows (Guélat, Florian, and Crainic, 1990; Maia and Do Couto, 2013). Unavailability of appropriate datasets is more transparent in Canada as there is no Canadian freight demand database that includes shipments or commodity flows by all freight modes. To overcome this limitation, we utilize the US commodity flow survey database, because it is reasonably comparable to Canada in terms of economy, geographical scale and network. We further discuss the data acquisition process in the following section. The modelling framework is presented in section 3, which is followed by results and conclusions.

2. Data

We employ the traditional four-step model to assess the movement of commodities across Canada. This method is a common approach in modelling global, national, and regional freight flows, and it comprises commodity generation, distribution, mode share, and route assignment (De Jong and Ben-Akiva, 2007). Each step of the four-stage model requires reliable data. The datasets that correspond to each stage of our model are explained in detail below.

Commodity Generation & Distribution
Commodity generation specifies the magnitude of commodities that need to be transported, and commodity distribution identifies the magnitude of commodities by origin and destination. The outcome of these two stages is an origin-destination (OD) freight flow database.

A dataset, developed by University of Waterloo (Bachmann, 2015, 2016), was used to obtain the origin-destination (OD) freight flows in Canada. This database contains information about the total annual weight and value of Canada's exported and imported commodities before and after the CETA. The OD freight flow database also outlines the commodity classification, province of origin/destination, province of entry/exit, port of clearance, trading partner, and international mode of transport. A computable general equilibrium (CGE) model, a multi-scale multi-regional input output (MRIO) model, and a value to quantity transformation were developed by Bachmann (2016) to generate these results.

Mode Share
This stage forecasts the likelihood of selecting a transport mode to ship the generated and distributed commodities from the previous steps. Developing a model that estimates the mode share requires a demand database. Since no appropriate Canadian freight demand database is available, we use the US commodity flow survey (CFS) public use microdata (PUM). CFS microdata is prepared with the collaboration of U.S. Bureau of Transportation Statistics (BTS), U.S. Census Bureau, and U.S. Department of Commerce. It contains information about 4,547,661 shipments that were shipped by approximately 60,000 establishments in United States in 2012. Shipments have been recorded based on their area of origin/destination, industry classification, domestic mode of transport, shipment value, shipment weight, OD routed distance, OD great circle distance, country of export, commodity group, and quarter of 2012 in which the shipment transported. We utilize US CFS microdata and Bachmann (2015,2016) dataset to perform our mode share analysis.

Route Assignment
This is the final stage of a four-step approach where commodities are assigned onto a transportation network as the origin, destination, and mode of transport of the trade flows are previously determined. Execution of route assignment requires fully connected road, rail, marine and air networks. The employed road network maps the geospatial location and attributes of Canada's major roadway system such as number of lanes, speed limit, and road classification. The rail network depicts the location and attributes of rail lines and rail stations, such as main track owner, rail-line operator(s), and track classification. The air and marine network identify the locations of Canadian airports and marine ports respectively. Locations of major intermodal facilities are also considered to allow for the transfer of shipments between rail and road network.

The databases used in the analysis require modifications to be suitable for mode share analysis and route assignment. For this reason, we examine the OD freight flow database, US CFS microdata, and the network database to ensure their availability, compatibility, and rationality. The modifications applied to each database are explained below.

OD Freight Flow Database
Bachmann (2015, 2016) reports the origin and destination of trade flows at the provincial level. However, allocation of the commodities onto the transportation network requires a greater degree of disaggregation. Statistics Canada divides Canada into 69 economic regions and outlines their population and employment size. We disaggregate provinces into economic regions, which are smaller in size, and distribute the imported commodity flows based on the population size and exported trade flows based on the employment size. Then, we identify the locations of Canada's major population centres from the dataset published by Statistics Canada and select a representative location per economic region that is close to the major population centres. Representative locations have been selected using the method of Kulin and Kuenne (1962), which locates a point on a plane while minimizing travel cost from that point to a cluster of points. We later find the shortest routed distance between the representative locations and the ports of clearance in ArcGIS 10.4 using the road network. The importance of this piece of information is explained later in the paper.

One of the limitations of using US CFS microdata is the commodity classification. The OD freight flow database categorizes exports and imports into 42 commodity groups on the basis of Global Trade Analysis Project (GTAP) Sector Classification (GSC-2) whereas the CFS microdata classifies commodities based on the Standard Classification of Transported Goods (SCTG-2). Although there exists a concordance between the two commodity classifications, there are instances where one GSC-2 commodity group corresponds to multiple SCTG-2 commodity classes. To resolve this problem, GSC-2 commodity groups are aggregated using the SCTG Groups, which are defined in the CFS microdata. Concordance between GSC-2 commodity group, SCTG-2 commodity class, and SCTG Group are presented in the Table 1.

Table 1. Concordance between GSC-2 commodity group, SCTG-2 commodity group, and SCTG group

SCTG Group	SCTG group description	SCTG-2	GSC-2
A	Agricultural products and fish product	1,2,3,4,5	1,2,3,4,5,6,7,8,9,10,12,14,19,20
B	Grains, alcohol, and tobacco products	6,7,8,9	11,21,22,23,24,25,26,45
C	Stone, nonmetallic minerals, and metallic ores	10,11,12,13,14	18
D	Coal and petroleum products	15,16,17,18,19	15,16,17,32,44
E	Basic chemicals, chemical and pharmaceutical products	20,21,22,23,24	33
F	Logs, wood products, textiles and leather	25,26,27,28,29,30	13,27,28,29,30,31
G	Base metals and machinery	31,32,33,34	34,35,36,37
H	Electronics, motorized vehicles, and precision instruments	35,36,37,38	38,39,40,41
I	Furniture, mixed freight, and miscellaneous manufactured products	39,40,41,43	42

The OD freight flow database records 242 ports of clearance. However, it does not specify their geographical location, types of infrastructure (e.g. border crossing, marine ports, airports, or inland offices), or types of offered services (e.g. water, rail, road, or air). We use information obtained from Canada Border Services Agency (CBSA) to obtain these statistics that are helpful for predicting the selected domestic mode of transport.

US CFS Microdata
CFS microdata summarizes information about domestic and international shipments. Domestic shipments have been removed from the survey since the OD freight flow database reports only international flows. Extreme outliers have also been removed from the dataset using the boxplot method. Accessibility of available modes of transport, such as marine, rail, and air, has been tested against the recorded mode of transport, and the unmatched results have been removed from the dataset. These procedures reduce the size of the CFS dataset to 117,847 shipments.

Network Database
A well-connected transportation network needs to be constructed before for the assignment of trade flows. Ports of clearance and representative locations of economic regions are connected to the road network with a set of direct links, since the roadway system is available at all locations. Shipments are transloaded onto the rail network at shipyards and intermodal facilities. Therefore, representative locations are connected to the rail network via the nearest intermodal facilities and the road network. Ports of clearance that offer rail services are situated near the rail lines, and they are connected to the rail network through direct links. Marine ports and airports, that are not listed in the OD freight flow database as ports of clearance, are removed from the network database.

3. Modelling framework

As previously stated, data availability is the primary limitation of modelling intercity freight flows, and we adjust our modelling framework to overcome this limitation. The methodology and assumptions that are made to evaluate the mode share model and execute the route assignment are discussed in this section.

Mode Share

Developing a mode share model based on the US database to forecast the behaviour of Canadian shippers or carriers in selecting a mode of transport is unrealistic. Nevertheless, we can predict the selected domestic mode of transport based on the services that are provided by the ports of clearance. For instance, if the port of clearance is a highway border crossing or an airport, we can assume that the domestic mode of transport is truck. We specify the services that are provided by each port of clearance based on it's offered services defined by the CBSA database, geographical location, and international mode of transport, specified by Bachmann (2015, 2016). Pipeline was not incorporated into the modelling process because data for shipments by pipeline are not available in the US CFS database.

We assume that a port of clearance can provide one or two types of services, and the offered services are air, rail, road, or marine. Ports of clearance that process air shipments are most likely to be airports. Since the majority of airports only have road access and aircrafts can carry light-weight and low volume goods, we assume that trucks are selected for shipments that are cleared by these ports. Ports of clearance that offer railway services are rail depots located on US-Canada borders. Railways are often accessed by roadways through domestic rail terminals (intermodal facility). Therefore, the assumed domestic of mode of transport for rail depots is truck-rail. Ports of clearance that provide roadway services are US-Canada roadway border crossings, and their assumed domestic mode of transport is truck. For ports of clearance with marine-only services, the domestic mode of transportation is either truck or rail since marine ports are accessible by truck and rail and commodities that are cleared by these ports are not restricted by their weight or volume. This assumption ignores the occasions where a shipment is loaded onto a vessel at a Canadian port and transloaded onto another vessel at another Canadian port. We develop a cross-classification model for this case based on the filtered US CFS microdata to estimate the mode share between rail and truck. This model forecasts the likelihood of selecting truck or rail based on the routed distance between economic region representative locations and ports of clearance and SCTG Group. Table 2 shows the cross-classification model in which the likelihood of each class is determined by the annual tonnage. Since we assume that rail is only available at domestic rail terminals, rail represents truck-rail in the cross-classification model. Ports of clearance that provide two types of services are similar to ports of clearance that offer one type of service except the mode share process also depends on the international mode of transport. Table 3 outlines the assumed domestic mode of transport for every port of clearance.

Table 2. Cross-classification mode share model for ports of clearance that offer marine services

Likelihood: Annual Tonne (%)	**Routed Distance (Km)**											
	0-250	0-250	250-500	250-500	500-750	500-750	750-1000	750-1000	1000-1750	1000-1750	>1750	>1750
SCTG Group	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
A	0.1%	99.9%	14.7%	85.3%	18.3%	81.7%	53.3%	46.7%	17.9%	82.1%	31.7%	68.3%
B	1.5%	98.5%	15.0%	85.0%	16.2%	83.8%	24.8%	75.2%	40.3%	59.7%	61.9%	38.1%
C	36.2%	63.8%	7.1%	92.9%	62.9%	37.1%	58.0%	42.0%	72.1%	27.9%	74.0%	26.0%
D	1.4%	98.6%	20.0%	80.0%	15.2%	84.8%	31.1%	68.9%	22.8%	77.2%	62.0%	38.0%
E	8.8%	91.2%	19.2%	80.8%	58.5%	41.5%	51.3%	48.7%	31.3%	68.7%	55.4%	44.6%
F	3.7%	96.3%	18.4%	81.6%	12.8%	87.2%	30.5%	69.5%	33.8%	66.2%	27.8%	72.2%
G	0.4%	99.6%	15.1%	84.9%	9.3%	90.7%	13.1%	86.9%	28.4%	71.6%	19.5%	80.5%
H	8.9%	91.1%	17.5%	82.5%	6.5%	93.5%	6.2%	93.8%	21.8%	78.2%	20.7%	79.3%
I	6.3%	93.7%	35.7%	64.3%	6.1%	93.9%	8.0%	92.0%	30.5%	69.5%	40.8%	59.2%

Table 3. Ports of clearance offered services and the assumed domestic mode of transport

Port of clearance offered service	**Domestic mode of transport**
Air-only	Truck
Rail-only	Truck-Rail
Road-only	Truck
Marine-only	Truck or Truck-Rail (Table 2)

Route Assignment
Table 3 indicates that road and rail networks are required to execute the route assignment as we rule out other modes of transport in the previous section. Our assumptions about mode shares are justified since 93% of the total Canadian domestic freight is carried by truck and rail (Transport Canada, 2015). For commodities that are transported by truck, we use the well-connected road network to simulate the exports from point of origin to port of clearance and model imports from port of clearance to point of destination. Points of origin and destination are the economic region representative locations. The rail network, explained in Section 2, is used to perform route assignment for rail shipments. Route assignment (on the rail network) requires the identification of the intermodal facility for transferring goods between truck and rail. We assume that shipments are transferred at the intermodal facility that is closest to the point of origin or destination. OD trade flows were assigned onto the rail and road network in TransCAD 4.5 using all-or-nothing assignment.

4. Results
The results from the OD freight flow database suggest that the Atlantic region faces the largest impact under CETA (Bachmann, 2017). Demand for ports of clearance that are located on the east coast of Canada is estimated to increase due to the trade agreement with the EU. For example, annual tonnes exported from the port of Montreal are expected to increase by 2.3% by rail and 3.2% by truck. Bachmann (2017) claims that CETA diverts commodities that are imported or exported from US to other trade partners. To confirm his claim, we map the results from the route assignment stage in ArcGIS 10.4 for every link in the road and rail network, and we represent them in Figure 1 and Figure 2. Figure 1 illustrates the changes in truck freight flows (in annual tonnes) as the result of CETA. This figure shows that the movement of commodities increases in the east-west direction in central and eastern Canada but declines in the north-south direction and in the western provinces. Figure 2 displays the changes in rail freight flows (in annual tonnes) as the result of the CETA. Rail flows also increase in the corridor from central to eastern Canada and decline in the western provinces. The flows presented in Figures 1 and 2 are consistent with our intuition that shipments are more likely to be exported or imported through the Atlantic region under the CETA, and less likely to be exported or imported through the Pacific region or the US-Canada border.

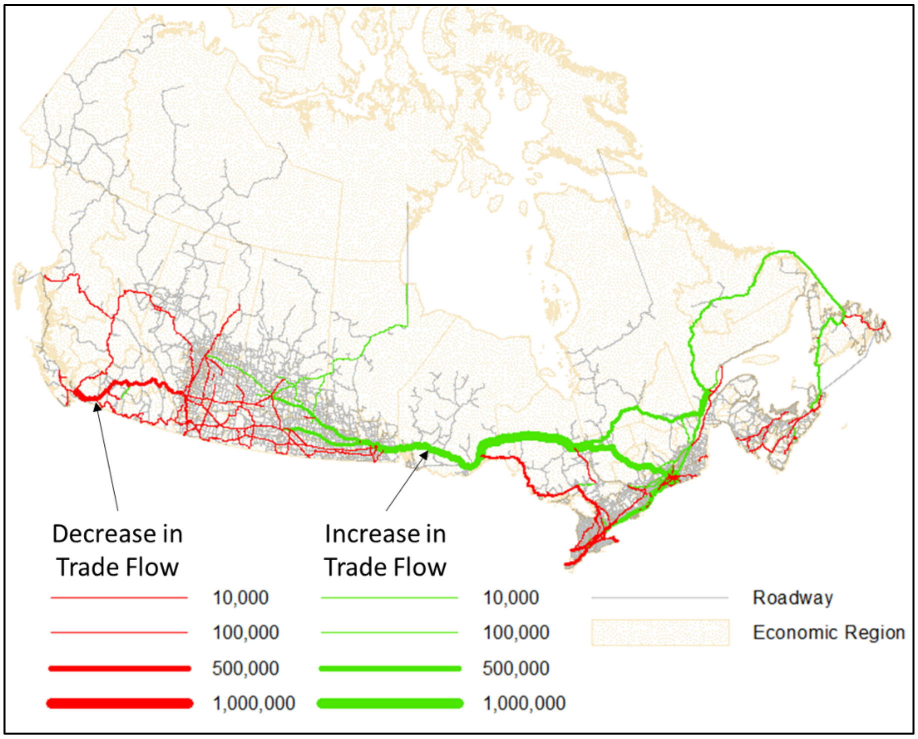

Figure 1. Change in truck freight flow under CETA in total annual tonnes

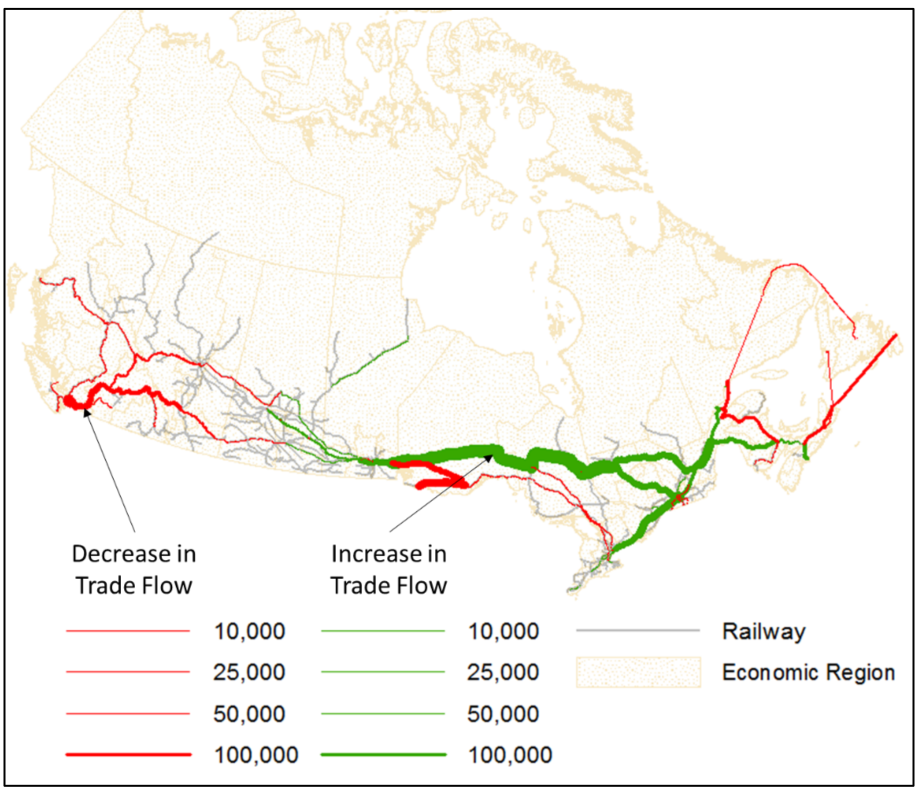

Figure 2. Change in rail freight flow under CETA in total annual tonnes

5. Conclusion

This paper develops a simplified freight network model to assess the impact of CETA on Canadian freight transportation flows. We adjust the Bachmann (2015, 2016) database to comply with US CFS microdata and the transportation network. Since there is no appropriate demand database for Canadian trade flows, mode share is evaluated using the information obtained from the ports of clearance and CFS microdata. We identify the change in trade flows for road and rail network once the OD freight flows are assigned onto the transportation network. Our results indicate that ports of clearance that are located in the Atlantic region increase exports and imports under CETA. Movements of commodity through west cost ports and US-Canada border crossings are expected to decline as Canadian shippers and carriers prefer to export and import their goods via the Atlantic gateway.

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