

Climate Change and Demand for Freight Transportation in Atlantic Canada

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Introduction

This study is aimed at analysis of potential climate change impacts on demand for freight transportation in Atlantic Canada through its links with other sectors of the regional economy. The main idea of the study is to model climate change impacts as productivity shocks in relevant sectors of the regional economy and then trace consequences of these shocks for demand for freight transportation on the basis of computer simulation. This paper defines the research methodology, approach and the preliminary analysis of the freight transportation demand in Atlantic Canada.

At large, the likelihood and severity of climate change impacts mainly depend on the extent of global temperature increase. Temperature increase may, in turn, cause secondary impacts such as sea level rise, global hydrological patterns change, and general human health degradation. These impacts are usually discussed at a wide-ranging, global level. Examples of studies, dedicated to specific sectors of national economies, are rather scarce and mostly focused on agriculture and water habitats. The regionalism approach is almost undeveloped considering all impacts at a national scale.

Analysis of the existing practices in North America, particularly in U.S. and Canada (for example, Government of Canada Action Plan 2000 on Climate Change), has revealed that the main focus in the relationship between climate change and transportation had been on reduction in greenhouses gases (GHG) by transportation followed by evaluation of climate change impacts on transportation infrastructure. These two are direct cause and effect of climate change, both coming from supply side in an economic sense.

Less attention has been given to indirect effects of climate change that come through changes in demand for transportation. This study is dedicated to these indirect effects. It recognizes that freight transportation is produced to meet demand for transportation by other sectors of an economy which means that demand for freight transportation is derived or factor demand. Therefore, the objective is to analyze potential climate change impacts on demand for freight transportation in Atlantic Canada through its links with other sectors of the regional economy. The ultimate goal is to model climate change impacts as productivity shocks in relevant sectors of the regional economy and then trace consequences of these shocks for demand for freight transportation on the basis of computer simulation.

In this regard, three problems must be solved: (i) identification of potential impacts of climate change in Atlantic Canada in wide range, (ii) identification of sectors of regional economy affected by these potential impacts, and (iii) establishing links

between transportation and affected sectors. This paper briefly discusses all three and presents preliminary analysis of the demand for the freight transportation in Atlantic Canada, generated by the major export/import industries of the region.

Potential climate changes and Atlantic Canada

According to the U.S. Environmental Protection Agency (1990), increase in carbon dioxide emissions, and atmospheric levels of water vapour supplemented by geophysical and biogenic feedback will result in a potential warming of between 1.5° and 5.5° C.

Global warming will also cause sea level to rise and hydrologic cycle to change. Models developed by the International Panel on Climate Change (IPCC, 1995) show average increase in sea level between 20 and 86 cm by 2100 with 50 cm considered as most likely. Total loss from a one-meter rise was estimated to be between US\$270 and US\$475 billion (Titus, 1991). Potential consequences include erosion of soil, infrastructure damage, shifts in population density, changes in flows of freight transportation, changes in consumption patterns and others.

In addition, global warming will cause changes in the hydrologic cycle. The hydrologic cycle traces movement of water among the oceans, atmosphere, land and vegetation, and ice caps and glaciers. Scientists agree that significant warming will intensify the global hydrologic cycle and have major impacts on regional water resources (IPCC, 1990). The increase in temperature could increase average global

precipitation from 7 to 15 percent (U.S. Congress Office on Technological Change, 1990). Precipitation will increase at high latitudes and decrease at low to middle latitudes. As well, the potential for more-intense or longer-lasting drought will increase. This means that water-dependent activities such as agriculture are likely to be greatly affected by a change in hydrologic patterns (Innes and Kane, 1995) or hydrologic changes are likely to cause changes in production and consumption activities. Transportation systems, particularly for freight, must adapt to these changes.

Climate change will also increase the precipitation patterns potentially causing droughts, and frequency of extreme weather events such as thunderstorms, tornados, hailstorms, floods, and heat waves. In general, it is expected that rainstorms will be less frequent and more severe, and the dry periods will last longer. Other problems that are likely to result from climate change include increased risk of fires, pests, and disease to farms and forests, and damage to water and wetlands.

Since this study focuses on the Atlantic Canada region, it is necessary to define the particular impacts of the global climate changes on the local economy. The Government of Canada projects that over the next 50 years temperature will increase by 3 to 4°C for the Atlantic Provinces. The climate changes are expected to be the largest and most rapid of the last 10,000 years (Government of Canada, 2000).

Due to a warming trend in the Atlantic region, the number of mild days in winter has been increasing and large peak flows onto the rivers in early spring are becoming more

common event. If this trend continues, ice breakup and flooding on the rivers will become more ordinary and less predictable. It can cause increased damage to public and private property, highways, and bridges. Due to the ongoing warming, businesses can change their manufacturing and inventory management strategies, which will eventually lead to the change in the freight transportation demand. According to the Canadian Government, the Atlantic Provinces can anticipate that:

“The risk of trees blowing down may increase, as storms become more frequent and intense as a result of climate change. For example, a massive blowdown in 1994 caused 30 million trees to be felled and cost \$100 million in damages. Warmer winter temperatures may allow invasive insects such as the gypsy moth to become more pervasive. This is because prolonged temperatures at or below -9°C” (2004).

The agricultural sector of the regional economy will be the primary “beneficiary” of the climate change. Due to the warming, the growing season for such crops as soybeans, corn and other cereals will be prolonged producing the larger yields. At the same time, the probability of droughts is going to increase, therefore raising the issue of supplementary irrigation. In addition, the warmer winters will boost the insect reproduction forcing local farmers to apply bigger amount of insect pesticides. Along with draughts, some other natural phenomena such as floods and hails can substantially damage crops as well as livestock. In extreme situations, they can cut off local power lines changing the pattern of the electricity supply.

It is common knowledge that the entire Atlantic region is under the strong influence of the seawater. Recent estimates project that the level of the sea will rise

from 70 cm to about a meter above the normal. Strong wind combined with the increased water level will flood the areas that have been never exposed to water before. *“Low-lying coastal areas will be the most threatened. Sinking of coastal land could compound the problem as much of the New Brunswick, Nova Scotia and Prince Edward Island coast is low-lying and sensitive to erosion and flooding”* (Government of Canada, 2004).

Climate changes may increase risks to forests in the Maritime as well. For example, *“warmer winter temperatures may allow invasive insects, such as the gypsy moth, to become more pervasive, while warmer, drier summers would increase the threat of forest fires in the Atlantic Provinces”* (Government of Canada, 2004). In addition, as temperatures rise, temperate forests may progressively replace the existing regional northern forests.

In terms of quantitative estimates, the impacts of the global climate change on the economy of the Atlantic Provinces are as follows. Growth of gross domestic product will be about 0.3 percent less by the year of 2010. Over the same period, there will be created 0.4 percent less jobs. Climate change will also affect personal earnings. It is projected that earnings will be approximately 0.2 percent less than under the “no climate change” scenario (Government of Canada, 2004).

At first glance, these numbers do not seem to be very impressive. However, it should be noted, that these changes in the economy are expected to occur in the very

short period of time. Given the most recent decisions by Russia and the US about their non-alignment to Kyoto Protocol, it is reasonable to expect that the current attempts to reduce the greenhouse gas emissions drastically will likely fail. This failure might further aggravate the situation causing the economic losses to increase geometrically.

Analysis of the key industrial emitters in the Atlantic Provinces shows that the adjustment to the global climate changes will have the following economic results (Government of Canada, 2004):

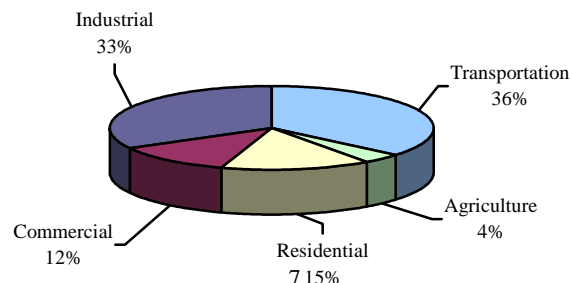
- pulp and paper will rise by 0.06 percent to about 59 cents per tonne
- electricity (coal) will rise by 0.14 cents per KWH, or by 1.94 percent
- electricity (gas) will rise by 0.04 cents per KWH or 0.60 percent
- steel (conventional) will rise by 0.29 percent to about \$2.10 per tonne
- natural gas will rise by 0.5 cents/million cubic feet, or 0.14 percent

These changes will inevitably affect the demand for freight transportation since the latter is generated by the affected sectors of Atlantic economy.

Sectors affected by climate change

In 1999, the Environment Canada estimated that Canada's transportation sector accounted for 36 percent of total GHG emissions (see Figure 1).

Figure 1. GHG Emission by Economic Sectors in 1999



In the same year, road transportation accounted for about 77 percent of total GHG related to transportation. Rail emitted almost 8 percent for the same period. Therefore, the total emission of the GHG from the surface transportation is as high as 85 percent of all GHG emission of the transportation industry. It has been estimated that by 2020 total transportation demand could boost up to 50 percent of its 1990 level. This way it will have further aggravating impact on GHG emission as a primary cause of the global climate change.

The Atlantic region as a whole accounts for 6 percent of the heavy and mid-size truck fleet of Canada (Transport Canada 2001). Heavy truck is predominantly tractor-trailer combination with a separated power unit and cargo area whereas mid-size one is a straight truck with its integrated power unit and cargo area. The freight road transportation, especially inter-provincial and trans-border movement are mostly represented by these two categories of trucks.

The volume of rail transportation in Atlantic Canada accounts for over 11 percent of all Canadian National Railways' total traffic (Transport Canada 2000). Although the share of Atlantic's road and rail freight traffic is relatively small on the national scale the impacts of global climate change can be very substantial for the entire eastern Canada. However, as it was already mentioned, this comes from the supply side of the transportation industry.

Consequences of climate change impacts on demand for freight transportation can be traced through productivity shocks to the sectors of regional economy the most affected by the climate change. Therefore, it is necessary to identify these sectors first, and then rank them in terms of the generated volume of freight transportation.

The Atlantic Canada economy relies heavily on export/import activities. The economic strength of the region lies in traditional Canadian export industries such as lumber, paper, minerals, and agriculture. Atlantic provinces also provide refined petroleum, hydroelectricity, and natural gas. Among the top export activities that generate the largest demand for freight transportation are refined petroleum; lumber, wood and wood pulp; iron ore and scrap; newsprint paper; coated and treated paper; transport equipment, and frozen fruit and vegetables. Import to Atlantic Canada is even more important economic component. Crude oil, motor vehicles, machinery, technology and consumer goods dominate the region's import composition. The top import activities include fertilizers, construction materials, road motor vehicles and chassis, and agricultural products. Predominantly these sectors of regional economy generate the highest demand for freight transportation in Atlantic Canada and, once affected by climate change impacts, will cause changes in demand patterns for freight transportation over time.

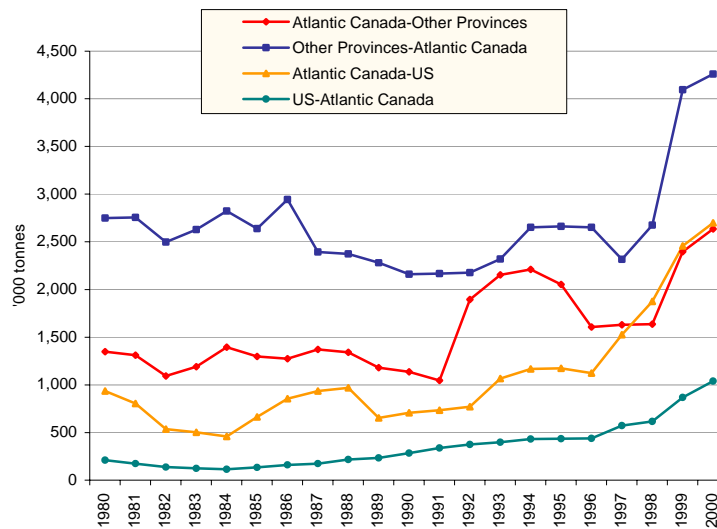
This study is limited to land-base surface transport, which is defined as rail and highway transport. The demand for air freight in Atlantic region is not substantial

enough to be counted. For years the share of air freight in the total tonnage transported into and out of Atlantic Canada has not been higher than 1 percent. Only in 1998 it was slightly over 1 percent (Brander 2000). Overall importance of water transport in the region has been declining: its share in the regional freight transportation dropped from 33 percent in 1991 to 28 percent in 1998 (Brander 2000). The analysis of the marine freight going through Atlantic Canada's ports though still handling the significant volume of 63 million tonnes is beyond the scope of this research.

It is necessary to note that some explanation is needed to interpret changes and sharp short-term fluctuations in regional transportation flows that have occurred over the last two decades. No single factor can explain these changes. In addition, the interregional flows of freight transportation, reported by the Statistics Canada, were not consistent from year to year, yielding larger probability of error. The situation is also complicated by the fact that beginning in 1989, the Statistics Canada stopped reporting the total tonnage hauled by private trucking companies considering this as private information. Therefore, in order to estimate the trucking demand, the use of approximation procedure became inevitable. In this study, the approximation was based on the fuel consumption rate, fuel costs and total distance, hauled by both for-hire and private trucking companies. The study excludes marine imports and exports, which are usually treated as if they had their origin or destination in the region in which the railways picked up or delivered the freight at a port.

Over the study period for rail from 1980 to 2000, the volume of transportation by the regional export industries almost doubled. The largest increase of 288 percent in the volume of transportation by rail is reported by the regional industries exporting their commodities to the international markets, predominantly to the U.S. (see Figure 2).

Figure 2. Rail Transportation in Atlantic Canada

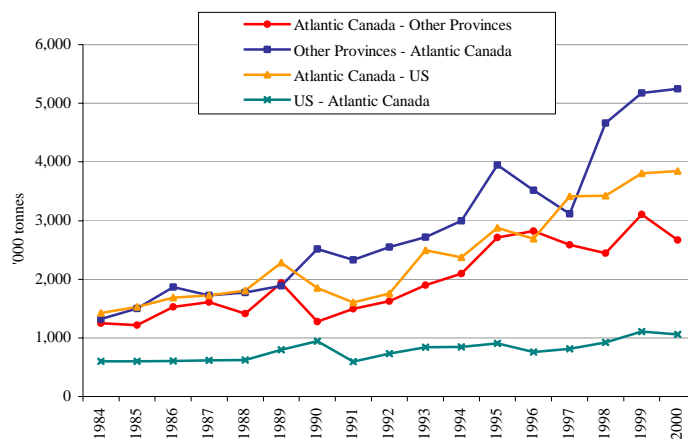


The largest increase in transportation volumes occurred at the beginning and then at the end of the 1990s. It is worth mentioning that the survey approach, used for collecting the statistics data, has been changing over time contributing to the inaccuracy of the reported data with respect to the inter-provincial rail flows. However, the southbound trans-border movement for rail has always been reported correctly making it a consistent indicator for estimating the actual demand.

Overall Atlantic Canada - US rail traffic increased by over 150 percent during the study period. In both absolute and relative terms, the demand for rail transportation in Atlantic region grew steadily with a higher increasing rate beginning in the mid-1990s. The strongest growth for the rail was transportation to the U.S. North Central and South regions.

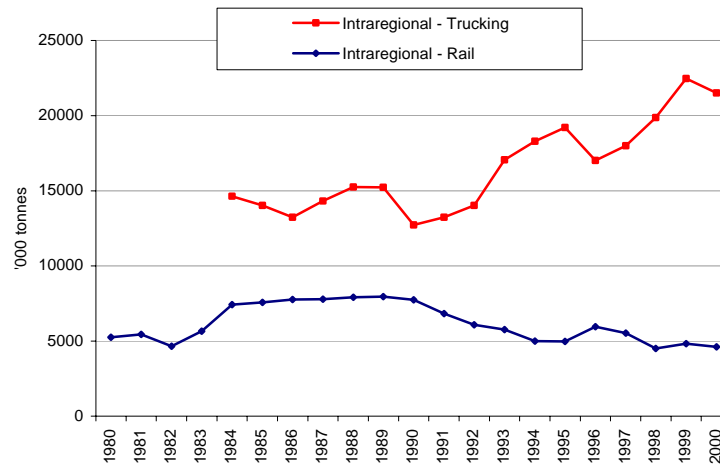
The volume of freight trucking has been growing at a different rate over 1984-2000. Atlantic industries have generated a substantial demand for inbound trucking. The consumption of various commodities from other provinces almost tripled in Atlantic Canada, which is not surprising since Atlantic region has negative trade balance with the rest of the country. At the same time southbound export activities of the Atlantic economy increased by over 200 percent whereas the incoming traffic remained relatively stable over time. This reflects the faster growth in international trade especially with the U.S. Given this pattern, it is possible to conclude that the regional economy is highly dependent on the international trade making the demand for trucking a crucial component.

Figure 3. Freight Trucking Transportation in Atlantic Canada



Intra-provincial trade of commodities accounts for the most of Atlantic Canada trade. In the trucking sector, it has increased from 14.5 to 20.5 million tonnes annually from 1984 to 2000 (see Figure 4).

Figure 4. Trucking and Rail Transportation in Atlantic Canada



The situation with the rail demand is more complicated. Rail connection between the Atlantic Region and the rest of North America exists only in New Brunswick and Nova Scotia. Rail tracks were removed from Prince Edward Island and Newfoundland. Rail service to both provinces is performed through multi-modal transportation via Moncton and Halifax.

Because of its specific nature, in general rail transportation is not competitive with the trucking over the short-distance haul. However, rail, having experienced increase in

total tonnage after the deregulations in 1980s, has been yielding its intra-provincial market share to trucking since early 1990s.

Having discussed the existing demand for freight transportation in Atlantic Canada through transportation flows, it is essential to define the research strategy to connect freight rail and trucking with the rest of the regional economy. The following principle underlies the proposed approach regarding links of transportation with other sectors. Freight transportation is produced and consumed in a transportation network. Transportation network is indispensable component of regional economy along with other sectors. Since freight transportation is an important input in production of different goods and services in other sectors of regional economy, it can be directly incorporated in production functions of different commodities by priority sectors of regional economy. Demand for freight transportation by priority sectors then follows as derived factor demand.

On supply side, freight transportation is provided by transportation companies who try to meet the demand by priority sectors. In doing so, the providers of transportation create demand for required factors of production such as transportation labour and capital in other sectors of regional economy, called in economic literature secondary markets (sectors). This is how freight transportation is incorporated in the regional economic system.

This framework allows us to consider freight transportation as an integral part of an economic system, which consists of the transportation network, network users, transportation service providers and the various economic activities surrounding the network. Therefore, any change in the productivity of regional industries will have an immediate effect on the transportation demand.

Methodological aspects

Further steps in this research will include the development of a regional growth model. Priority sectors such as petroleum and coal, newspaper and ground paper, lumber and wood and food products will be described on the basis of production functions in which transportation will be incorporated as an input. The growth model will be designed on the basis of state-flow relationships between relevant economic variables over time to capture linkages between different sectors of the regional economy and transportation. As theoretical background for the model, Romer's (1996) growth model in combination with the RICE model (Nordhaus and Yang, 1995) will be used. In the designed model, transportation will be represented by earlier developed dynamic model of transportation network (Yevdokimov, 2001).

After the growth model is complete it will be converted into Vector Autoregression. Demand for freight transportation will become a component of the VAR. Then VAR will be estimated based on historical time-series data described in this paper according to methodology developed by Sims (1980) and refined by Enders (1995). Climate

change impacts will be then imposed as productivity shocks that affect production functions in respective priority sectors. Since demand for freight transportation is a component of the VAR, changes in demand will be obtained as a result of the VAR after-shock dynamics.

Consequences of the climate change impacts as productivity shocks over time will be traced on the basis of Impulse Response Functions. Estimation methodology and inference are described in Enders (1995) and extended by Yevdokimov (2001) for large environmental impacts. The dynamics of consequences of climate change impacts as productivity shocks is as follows:

- a productivity shock or combination of shocks affect production function in relevant priority sector;
- since freight transportation is an input in the production function, demand for freight transportation as factor demand is affected directly;
- supply of freight transportation adjusts according to the cost minimization subject to the new demand;
- demand for inputs to produce freight transportation changes according to the adjustments in supply of freight transportation;
- new allocation of resources between priority sectors and secondary markets (sectors) changes flows in regional economy;
- new allocation affects priority sectors again and a new cycle begins.

Modelling of the productivity shocks represents a problem of itself. Some of them are permanent or long-lasting shocks. In a mathematical sense, they are autoregressive in nature with increasing intensity. Other shocks are temporary imposed in specific time periods with varying frequency, intensity and duration. Therefore, first it will be necessary to classify all potential climate change impacts described above as permanent and temporary shocks, collect information on intensity and duration of these shocks based on the existing and emerging literature, and then choose functional forms to mathematically describe these shocks. Examples of econometric specification of different shocks are presented in Enders (1995).

Conclusion

This paper describes the preliminary stage of the research that is a part of a larger project entitled “Modeling sustainable transportation network”. In that project, sustainability of the transportation network is modeled through its links with economy, society and environment. In this regard, the study presented in this paper explores linkages of the sustainable transportation network with the regional economy and environment. Consequently, understanding of the demand for freight transportation in Atlantic Canada based on time series analysis over the last two decades becomes crucial.

The time-series analysis showed that if the impact of the cyclical pattern of development is eliminated, the demand for freight transportation as measured through

transportation flows has been growing remarkably over the last 20 years. Freight transportation in Atlantic Canada is an integral component of the regional economy. It is linked to other components of the economy in two ways: (i) regional economic activities generate demand for transportation; (ii) transportation, in turn, generates demand for commodities produced in other sectors of the economy as well.

Once these linkages are understood and described in the form of the dynamic state-flow relationships, it will be possible to trace the impacts of the global climate change on the demand for freight transportation as productivity shocks in priority sectors of the regional economy.

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