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The ties that bind: Bi-national trade implications of the US and Canada using bi-national freight movement network via border crossings☆

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ABSTRACT

This study combines US-Canada bi-national highway network data with a freight flow dataset using ports of entry (POE) via highway border crossings. Through several sub-procedures, the US and Canada highway systems are integrated into a single network dataset. In addition, border wait time dataset was monitored and analyzed to set the border delay baseline. This dataset enables us to explore the freight traffic pattern between the US and Canada. Weighted Eigenvector Score is computed using a Social Network Analysis tool. The results demonstrate that major regional bodies are the primary users of major POE between the US and Canada. This study not only offers an improved understanding of the economic implications of US–Canada border crossings, but also contributes to developing a simulation tool, a bi-national Transportation-combined National Interstate Economic Model. Such a tool is expected to extend and apply to other contexts, such as transportation and national and bi-national security, among other applications. Additionally, this study suggests several important considerations for US and Canadian officials charged with devising policy to protect against security threats while facilitating legitimate flows of goods, services and people across the border.

1. Introduction

Freight transportation involves moving diverse commodities to satisfy global supply and demand for goods and services. These commodity outputs, which are connected with many diverse inputs, are often imported or exported via ports of entry (POE), primarily by truck. In 2010, the daily value of all modes of goods exchanged between the US and Canada was nearly $1.8 billion, making US–Canada trade the largest bi-national trade relationship in the world (Park, Kwon, & Son, 2014a). The supply chains of both countries are highly integrated, with the majority of this trade being intra-industry. With the final outputs of these tightly integrated bi-national industries exported worldwide, significant disruptions of the bi-national freight network could cause tremendous economic consequences not only for the US and Canada, but for global trade.

The US and Canada are linked by many modes of transport, including trucks, trains, ferries, pipelines, and airplanes. Efficient connections are essential to the economic productivity of both countries. In the past decade, this efficiency has been threatened by several significant disruptions caused by man-made or natural disasters. Many public and private stakeholders now are aware of the magnitude that transportation disruptions could have on national economic systems. Once a border crossing is closed or its capacity diminished, freight movement via other border crossings in the transportation network could be seriously impacted by freight diverted from the affected crossings. This has the potential to cause adverse economic ripple effects for the various suppliers involved in producing a product. These disruptions could affect supply chains that extend far beyond nearby regions.

A secondary issue affecting bi-national trade is the delay that results from border security measures and inspections. Even though interstate and interprovincial trade may have larger impacts on each national economy than US–Canada trade (Andresen, 2009; Hewings, Sonis, Guo, Israilevich, & Schindler, 1998; Hitomi, Okuyama, Hewings, & Sonis, 2000), border crossings and their highway network approaches are often subject to high levels of congestion due to such measures, and hence, need a distinctive examination. This is especially true in the Niagara Falls area, where the highway network connecting Toronto and Buffalo is congested almost every day by passenger and freight vehicles. It is valuable to measure how congestion cost externalities

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affect the US and Canadian economies, from local communities to each nation as a whole.

Separated from the US by the Great Lakes and the waterways that connect them, a significant amount of Canadian trade with the US is by way of freight transportation via border crossings. Cross-border studies, however, have focused on the magnitude of trade (Anderson & Smith, 1999; McCallum, 1995) instead of on freight disruptions. Filling this void, we seek to measure how these disruptions can simultaneously impact the proximate regions of both countries. To address this issue, it is necessary to develop complex economic impact models linking the two countries with the highway network. Complex and disaggregated models can lead to a better understanding of how economic impacts that result from traffic pattern changes on border crossings affect local economies.

As an essential element for building a bi-national Transportation-combined National Interstate Economic Model (TransNIEMO), this study aims to develop a novel bi-national highway network combined with freight trade information between the US and Canada via POE connected by highways, in order to provide a stronger foundation of understanding for the economic implications of border crossings. Using the bi-national freight network dataset, we explored binational trade patterns and analyzed the role of POE. A general framework of the US-version of TransNIEMO is suggested in Appendix 6 and the theoretical and empirical details can be found in Park et al. (2011), Park et al. (2014a), Park et al. (2014b) and Cho et al. (2015).

Border entries include facilities for entry and departure of people and goods, such as airports, seaports, railways, and border crossings. Since this study only focused on border crossings on highways and examined bi-national freight movements, we established each border crossing dataset. However, as Detroit and Buffalo ports each have two border crossings, we pooled these two border crossings for various analyses applied in this study and neat visualization of the analyzed results.

This article is organized into five subsequent sections. Section 2 provides background on this study. Sections 3 and 4 present an overview and analysis of border wait times and trade issues on US-Canada border crossings, respectively. Section 4 also includes the data processing method and structure of bi-national freight movement data. Section 5 combines origin and destination freight value and truck movement with descriptive statistics, and applies social network analysis (SNA) to understand central border crossings. The article concludes with a brief summary and future discussions to be investigated for border security and policy issues using the bi-national transportation network-combined economic model. We expect to examine the economic and freight transportation importance of border crossings on the US–Canada economies, with emphasis on the various US states proximate to the province of Ontario in ongoing research using bi-national TransNIEMO.

2. Background

2.1. A bi-national freight network model

TransNIEMO has three sub-models, a national highway network model, a transportation cost impact model, and NIEMO. A national highway network model refers to the baseline highway network combined with freight flow data. A user equilibrium (UE) model is applied to allocate freights volume on the highway network. A transportation cost impact model generates additional shipping costs for network disruption scenarios. NIEMO generates nation-wide ripple effects for each scenario (Park et al., 2011; Cho et al., 2015).

To propose a novel bi-national TransNIEMO, an integrated understanding of both the transportation network and the economy of the US and Canada is crucial. POE via highway border crossings that connect the US and Canada tie industries and local economies of the two countries together. Freight arriving from all over the world converges and diverges at POE by truck. Given that neighboring regions of the US and Canada are connected with border crossings and trade dataset is aggregated at these points relative to origin/destination states or provinces per commodity type, it is important to take a closer look at border crossings in order to explore the patterns and magnitude of freight flow on the bi-national economy.

In order to investigate freight flow between the US and Canada through POE by truck, we require data on the import and export of goods between the US and Canada by commodity type for each POE. This dataset provides a comprehensive description of bi-national economic relationships at each border point, with specific states or provinces, or at a national scale, for either the US or Canada. This is only a snapshot of commodity flow at border crossings, however. Since the ultimate goal of linking the economies of the two countries at border crossings is to develop a TransNIEMO-type bi-national model, our interest is in building a complex dataset that includes not only the total amount of goods traded between both countries, but also their regional origins and destinations.

To obtain this dataset, we required crossing-specific trade data in terms of import and export value of goods by respective origins and destinations, and also by commodity type. After much investigation, we concluded that there is no comprehensive data that records both origin and destination information from regions in the US to Canada or vice versa through specific POE. Instead, there are several freight-related data sources related to specific POE, which have regional origin or destination information available. By connecting the two countries with POE in our network model, we could collect geographically combined freight origin and destination data.

2.2. Social network analysis and its applications in various domains

The concept of Social Network Analysis (SNA) has been discussed among sociologists since the early 19th century. Sociologists regarded societies as networks of reciprocal influence. Due to computational complexities and difficult data collection procedures, however, sociological researchers were challenged in utilizing SNA.

With recent developments in computational technology, many fields, including sociology, have been utilizing SNA due to the theoretical flexibility of its applications. De Montis, Barthélemy, Chessa, and Vespignani (2005) employed a weighted network approach to examine inter-municipal commuting network at the inter-city level and its relation with the topological structure. Municipalities and flow of commuters are regarded as nodes and links, respectively, in this study. Shih (2006) applies network analysis to tourism in Taiwan. This study used survey data collected from 21,412 respondents asking about up to sixteen destinations visited, and the sequence in which these destinations were visited. The destinations are treated as nodes and the tourists' routes among destinations are treated as a series of links in the tourism network. Cantner and Graf (2006) applied SNA methods to describe the evolution of the network of innovation in Jena, Germany. The study constructed two different networks, the “inventor overlap” network, and the “technology overlap” network. The inventor overlap network treats innovators (corporations) as nodes, while a link is created when they share an inventor. The number of inventors that two innovators share becomes the weight of a link. A link is created when two innovators produce the same type of commodity in the technology overlap network, with nodes defined the same way as in the inventor overlap network. Fagiolo, Reyes, and Schiavo (2010) constructed World Trade Web (WTW) to explore the regularities of global trade relationships and its evolution over time using international trade data for 159 countries between 1981 and 2000. Countries and trade flow (US dollar) are defined as nodes and links, respectively. This paper explores WTW with many SNA approaches from simple global network properties to vertex specific properties such as connectivity, assortativity, and cluster coefficient analysis for each country.