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Logistics sprawl in North America: methodological issues and a case study in Toronto

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Abstract

This paper focuses on the spatial patterns of freight and logistics activities in North America. The recent interest in logistics and warehousing and its impact on the urban environment has prompted research investigating the 'sprawling' nature of these firms. Logistics sprawl, i.e. the spatial deconcentration of logistics facilities and distribution centers in metropolitan areas has been examined for several metropolitan areas (Dablanc and Ross 2012; Dablanc 2014; Dablanc et al., 2014), yielding contrasting results: Atlanta and Los Angeles have experienced strong logistics sprawl between 1998 and 2008 while Seattle has not. The objective in this paper is two-fold. An additional case study (Toronto) is investigated to expand the current understanding of North American logistics sprawl and methodological issues, particularly related to facility identification and location data are discussed. An updated method for analyzing spatial patterns of logistics activity in North American cities is subsequently proposed. This updated method may then be used in the future to re-examine former case studies (Los Angeles, Atlanta, Seattle) as well as to investigate new ones.

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

Keywords: Logistics sprawl; NAICS and SIC; Warehousing; Locational patterns; Freight transportation

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1. Introduction

This paper focuses on the spatial patterns of freight and logistics activities in North America, with Toronto as a case study. In several urban regions (see literature review below), 'sprawling' patterns have been identified for logistics firms. Warehouses and distribution centers tend to move away from urban areas toward more suburban and exurban ones, offering lower land prices and good access to highway networks. However, negative consequences of this sprawl are additional truck-miles traveled and subsequent emissions and congestion, causing concern among city managers together with a growing interest from research.

A Canadian case study (Toronto) is investigated to expand the current understanding of North American logistics sprawl. The Canadian perspective brings an interesting addition to U.S. studies, as Canadian cities are both similar in many ways (general urban form, economic structure) and different in several ways, such as more stringent land use controls.

This paper also looks at methodological issues, particularly related to facility identification and location data. Recent studies of logistics and warehousing facilities have not examined the representativeness of the definitions of logistics and / or warehousing firms. This work focuses on facilities whose primary function it is to enable the movement and storage of goods, as opposed to primarily being a place of manufacture or consumption. Additionally, the use of the North American Industry Classification System (NAICS) classification system has not been adopted in a widespread manner by private vendors of data, causing potential problems with both longitudinal studies as well as comparisons to government data sources. By examining these methodological issues, our objective is to identify updated methods for analyzing spatial patterns of logistics activity in North American cities.

The paper begins with a presentation of context and a review of the literature on locational issues of freight facilities. Three sections follow presenting the Toronto study area, our methods, and our main findings. A discussion of findings and some concluding remarks are presented at the end.

2. Context and Literature Review

2.1. Classification of Logistics Facilities

The past 20 years have seen enormous changes in logistics processes, and the functionalities of buildings that support logistics activities (Urban Land Institute 2004). Mainly, as the functions of the supply chain evolve, the functions of the 'warehouses' shift and they occupy different uses than in the past. These locations are characterized by high levels of traffic, and often large buildings with sometimes low levels of employment considering their size. Value added activities, such as repackaging, labelling, etc. may occur at these locations but they also may be used for storage. The complexity of modern supply chain and logistics presents difficulties in defining facilities and sites that house logistics activities. Storage warehouses, where goods are kept waiting are good examples of a logistics facility. Truck terminals and cross-docking facilities are also logistics facilities. However, within government classifications, a small trucking company may have listed the home address of the owner of the company as their location of domicile. They may park their truck there but these locations are not the location of any 'logistics' activity. In spite of this, they will be classified as a trucking company and be included in studies describing the movement of such companies (Cidell 2010).

Hesse (2008) classifies logistics facilities as those belonging to NAICS codes 41 (Wholesale Trade), and NAICS 48 & 48 (Transportation and Warehousing). Other recent studies have used the term "Freight Transport" and include only the NAICS 48 & 49 classifications (Cidell 2010). Finally, there have been studies that look only at the specific Warehousing and Storage NAICS 493 classification as a proxy for all logistics firms (Dablanc et al. 2014).

Table 1. Types of Logistics Firms Studied

Author	Firm Classification	Data Source
(Bowen 2008)	NAICS 493 - Warehousing	US County Business Patterns
(Cidell 2010)	NAICS 48&49 - Transportation and Warehousing	US County Business Patterns
(Dablanc et al. 2013)	NAICS 493 - Warehousing	US County Business Patterns
(Sivitanidou 1996)	Survey of Firms	Survey of Warehousing Firms
(Dablanc & Ross 2012)	NAICS 493 - Warehousing	US County Business Patterns

The methodologies used to examine sprawl in these studies with the exception of Sivitanidou's (1996) study have been to examine establishment counts recorded in the US County Business Patterns, a record of establishments that is derived primarily from tax information. This data is aggregated either to the zip code or county level by US government agencies, and made available to researchers.

Methods used by researchers to assess patterns of concentration and dispersion of establishments include using average distance to the mean location to determine if businesses are sprawling or utilizing Gini indices to determine whether establishments are concentrated in particular areas. The advantage of using these data sources are that they are well documented and the methodology of collecting and including businesses is transparent. Unfortunately, because of requirements for maintaining the anonymity of individual records, it is not possible to identify the exact nature of the business, instead the researcher relies on the classifications provided, nor is it possible to identify the exact location of the businesses.

As logistics facilities appear within the listings of both NAICS 48 & 49 "Transportation and Warehousing" and within NAICS 493 "Warehousing and Storage," both these classifications are of interest. Past studies have examined spatial trends related to both classifications and drawn conclusions about the nature of the logistics industry. This study has examined both classifications to draw conclusions, but will use NAICS 493 for comparability with previous studies such as (Dablanc et al. 2013) and (Dablanc & Ross 2012).

2.2. Locations of Logistics Facilities

The findings of studies that have recently examined how logistics and warehousing firms have changed locations can be classified as occurring on a national scale, or on a regional or city wide scale. Firstly, logistics activity across the United States is moving to central locations like the Ohio valley as well as concentrating in the vicinity of ocean terminals for the import and export of goods (Cidell 2010; Bowen 2008). Inland centers are being promoted by government institutions as locations that can cater to the supply chain needs of companies as a way of meeting economic development goals (KC Smartport 2015). On the whole, polarization of logistics facilities towards large urban regions at the relative expense of smaller areas has been noted in several world regions (O'Connor 2010; Dablanc & Rodrigue forthcoming). The observation of clusters of logistics activity across the mega-regional scale of investigation is examined in the Atlanta region (Dablanc & Ross 2012) and some clustering of areas within the Toronto region is described as having an importance much larger than the size of the city's internal market (Ferguson et al. 2014).

On a smaller scale level, there are other factors of interest as well. When looking at the importance of location factors, highway and airport accessibility have been found to be important for firms today, when locating their facilities (Bowen 2008; Jakubicek & Woudsma 2011). The relative position of warehouses within the urban region is more nuanced, with some regions exhibiting classic signs of sprawl, as measured by Gini indices (Cidell 2010) or average distance of locations to the geographic center of the region (Dablanc et al. 2014). Within a metropolitan area, the role of land prices to locate a warehouse was identified for Paris (Raimbault, 2014). Additionally, the provision of modern logistics facilities by a fast growing logistics real estate industry has been critical in explaining locational decisions since the 2000s (Hesse, 2004; Raimbault, 2014).

3. Study Area

The City of Toronto is Canada's largest city and is at the center of its largest urban region – the Greater Toronto Area (GTA). In the 2011 census, the GTA plus its environs had a population of over 6 million people. The logistics

activity that is taking place in this area supports a diverse economy that has a strong manufacturing base, among other transportation intensive economic activities. According to a 2010 study, the province of Ontario attracted about 14.2 million shipments and shipped about 16.2 million (Ferguson et al. 2014). The Toronto area plays a major role in generating and attracting these shipments, and many of these shipments rely on a logistics facility at one or both ends of each trip.

The Toronto region has grown substantially in recent years and this study examines two different geographic scales (see Fig. 1) centered on Toronto to understand the pattern of logistics facilities in the region. The Greater Toronto Area (GTA) comprises of the city of Toronto and immediately adjacent cities/regions. Immediately adjacent to the city of Toronto, within the GTA, is Peel region, which contains the largest industrial cluster in the region as well as Pearson International Airport. Outward development pressure on this core urban region has lead to the legislated establishment of a "Greenbelt" growth boundary area surrounding the GTA. One of the key aims of this legislation is to discourage outward growth into surrounding regions (Ministry of Public Infrastructure Renewal 2006). The Greater Golden Horseshoe (GGH) region contains the GTA, the Greenbelt, and other satellite communities that lie outside of the Greenbelt. The GGH is often considered in planning exercises with the Toronto Area, and has been defined as part of the GTA's 'commuter shed', an area with a substantial portion of residents living in the periphery and travelling to work in the core GTA employment areas (Axisa et al. 2012). Finally, 'Southern Ontario,' is the functional region of the province that stretches west from the GTA towards Windsor/Detroit in the US and East towards Ottawa/Montreal.

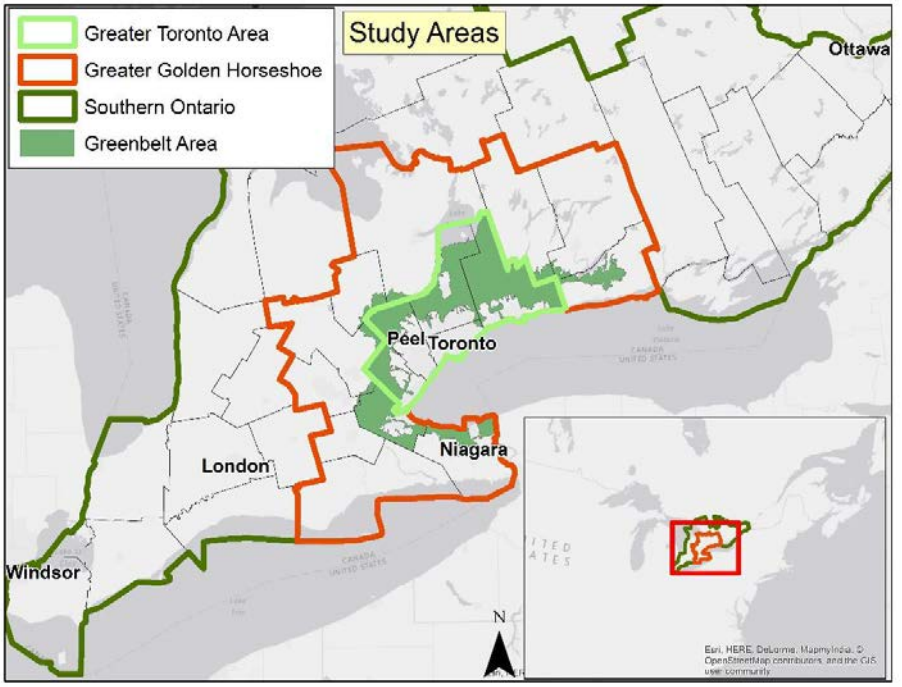

Fig. 1. Map of Study Area

3.1. Logistics sprawl in Toronto

The case study described in this paper focuses on the Toronto, Ontario, Canada city-region. In this area, there have been some investigations into the present locations of logistics firms, (Jakubicek & Woudsma 2011; Ferguson et al. 2014; iTrans Consulting 2004), but none have looked at the evolution and locations of logistics firms over time. The Toronto area has been sprawling for some time, and in 2006 the provincial government put forth legislation that

limited the development of lands surrounding the integrated GTA area (Ministry of Public Infrastructure Renewal 2006).

Freight traffic generated by logistics areas in Toronto has been examined and Ferguson et al. (2014) identified 19 major clusters of freight attractors and generators in Ontario, 10 of them in the GTA. When examining the patterns of freight facilities in Ontario, they comment that "'Sprawl' of freight facilities and trucking generators seems like too strong a word for the patterns that have emerged in Ontario." p.98. This study reveals that while the growth in warehouses has not grown substantially over the smaller geographical area of the GTA, there has been logistics sprawl occurring, and logistics businesses are sprawling more than other businesses over the larger GGH region.

4. Data and Methods

Looking at logistics businesses in general and not only warehouses provides more insight into the industry as contemporary 'warehouses' are difficult to classify (Bowen 2008; Hesse 2008). Facilities that perform distribution center and warehousing activities may not be classified as NAICS 493 warehouses because of the array of services that are provided under different classifications (Hesse 2008). Logistics firms identified as SIC 40 – 47 (Transportation and Warehousing coded) firms include businesses of interest such as warehouses and 3rd party logistics providers, but also include independent truck drivers, taxi companies, marinas, etc.

Whether to include logistics firms broadly depends on the goal of the research. If the research hopes to identify a broader set of logistics-related businesses, including support services, then it is appropriate to examine the entire range of businesses classified as "Transportation and Warehousing." If the goal is to identify specific warehouses and distribution centers, the use of NAICS 493 Warehousing is more appropriate.

4.1. Dataset Development

The general approach used in this research is to build on analysis of freight sprawl in other North American cities. In order to do so, data on logistics firm locations for the study area over the 2002 and 2012 time frames is needed. The data source used in this study is the Enhanced Points of Interest (EPOI) dataset by DMTI, a Canadian provider of geographic and marketing data. DMTI's data included a 2002 dataset with businesses listed in SIC format and a 2012 dataset with businesses listed in NAICS and SIC formats which offered the opportunity for longitudinal comparison. Statistics Canada does not provide similar data at a fine-grained geographic level. DMTI's product was not available in the NAICS format in 2002, in spite of NAICS being introduced in 1996. Additionally, businesses continued to be classified in the SIC classification system in 2012.

There were two separate datasets used in the study that were extracted from the purchased list of businesses. A broadly defined 'Logistics' dataset which was classified as SIC 40-47 Transportation establishments, and is made up of SIC classified businesses from 2002, and SIC classified businesses from 2012. This dataset is referred to as Logistics (SIC 40-47) businesses throughout this work. The 2012 listing of businesses in this list were not converted from SIC to NAICS because of conversion problems. Additionally, a narrower definition of businesses were identified, specifically warehousing businesses. The 2002 SIC 422 Public Warehousing and Storage list of businesses was converted to NAICS 493 businesses. The 2012 list of NAICS 493 businesses remained the same. This dataset will be referred to throughout this work as the NAICS 493 dataset.

In order to facilitate comparison with previous studies completed by (Dablanc & Ross 2012; Dablanc et al. 2014), the definition of warehousing businesses as NAICS 493 is necessary. The issue of converting between SIC and NAICS were not an issue for this narrow classification as the definitions for SIC warehousing businesses and NAICS warehousing businesses did not change between the two systems.

4.2. Data Representativeness

A benefit of using data from private vendors as opposed to government data is the ability to identify exactly the name and address of the business that is being investigated. Because of privacy concerns, this is not possible with government sourced data. During the course of examining the NAICS 493 Warehousing dataset in this study, it was found that there were significant numbers of mini-storage businesses within the sample based on the business name

- see Table 2. These should have been classified under "NAICS 53113 - Lessors of Mini-warehouses and self-storage units." Additionally, to understand whether the NAICS 493 data is representative of the population of Warehousing and Storage firms, firms were sampled and their business classified into one of several categories. Every 30th firm was sampled from the original list of 1077 warehousing firms in Southern Ontario for a sample of 37 firms. 22/37 firms (59.4%) were confirmed as mini-storage based on web verification. The rest of the 37 were a variety of warehousing types of businesses, with some of the firms being moving and storage, 3PL's or Public Warehouses (see Table 3).

Table 2. Effects of Mini-Storage within NAICS by Region

	2002				2012			
	All 493 Warehousing	Non Mini-Storage	Mini-Storage	% Mini Storage	All 493 Warehousing	Non Mini-Storage	Mini-Storage	% Mini Storage
GTA	285	165	120	42%	380	228	152	40%
GGH	382	217	165	43%	677	350	327	48%
S. Ontario	474	271	203	43%	1,077	520	557	52%

These are significant figures that indicate a substantial portion of the data is incorrectly classified within this privately owned dataset. Removal of the incorrectly classified businesses made a substantial difference on the study outcomes. Additionally, examination of a sample of businesses in the dataset specifies the types of businesses that can be found in the data, and reveals that the rest of the businesses listed do in fact correspond to the types of businesses under investigation.

If government data contain similar misclassifications, previous studies may have errors. It would be worthwhile for future studies in this area to compare government census figures to other independent sources to determine if there are discrepancies.

Table 3. Types of Firms within NAICS Warehousing 493 – Sample of EPOI Data on Southern Ontario

Counts	Type of Firm	Name of Example Firm	Additional Description	Website
22	Mini Storage	Public Storage	Mini Storage	http://publicstoragecanada.com/
3	Farm Warehousing / Storage	Oakley Apple Storage	Grain Elevator / Farm Storage	
3	Cold / Refrigerated storage	Trenton Cold Storage	Trenton Cold Storage is a full service refrigerated warehousing and distribution company that operates one of Canada's largest temperature controlled freight consolidation programs.	
2	Public Warehousing / Contract Warehousing	Cornwall Warehousing	CWL offers public warehousing, contract warehousing and space for lease. Our service area is the northeastern United States and all of Canada. Our 800,000 sq. ft. of heated floor space is complimented by a further 60 acres of outdoor storage.	http://cornwallwarehousing.com/ware.html
2	3PL	Kuehne & Nagel	3PL, mix of warehousing, transportation, brokerage services	http://www.kn-portal.com/
1	Moving and Storage	Cube it Moving and Storage	This type of business offers moving and storage services for households and businesses	www.cubeit.ca
1	Not Related to Warehousing	Extreme Auto Detailing	Not Related	
1	Unidentifiable	Gencon Storage	Could be very small warehouse - unidentified	
1	Specialized Storage	Holt Renfrew Fur storage	Specialized Storage	
1	Outdoor Storage	Peacock's outdoor storage	Fenced lot for Storage	
Total: 37				

5. Toronto Case Study Findings

The examination of the logistics industry locations in the Toronto area and its surrounding regions involves both the Logistics SIC 40-47 businesses, and the Warehousing NAICS 493 businesses described in the previous section. First, a summary of figures is presented to show the changes in the numbers of all of these businesses over the time period. Next, the locations of logistics businesses is described, followed by a deeper examination of the warehousing classification issue.

5.1. Summary of Figures

Table 4 shows the total number of businesses of all types, Logistics (SIC 40-47) businesses, and warehousing (NAICS 493) businesses over the two study time frames and comparing the GTA against the broader regional context of the GGH. Increases in the number of SIC 40-47 Logistics businesses are higher than the increases evident for all businesses. NAICS 493 Warehousing businesses are also increasing by large percentages, although not as high as the SIC 40-47 Logistics businesses. What is consistent is the higher levels of growth in the broader region (GGH) compared to the core metropolitan region of the GTA.

Table 4. Summary of Logistics and Warehousing Firm Data: 2002 and 2012 Changes

		2002	2012	2002-2012 change
GTA	Total Establishments	199,939	294,849	47%
	Number of Logistics (SIC 40-47) Establishments	4,315	8,981	108%
	Number of Warehouses (NAICS 493)	165	228	38%
GGH	Total Establishments	270,301	422,226	56%
	Number of Logistics (SIC 40-47) Establishments	5,919	12,993	120%
	Number of Warehouses (NAICS 493)	217	350	61%

The results in Table 4 must be interpreted with caution. It is not possible to guarantee that the methodology used by the data provider to collect the data allows for direct comparability of gross figures over the time period.

5.2. Logistics business location patterns

This research investigates and quantifies the changing patterns of logistic firm locations in the Toronto area and regional contexts. Fig. 2 shows the locations of logistics activity as summarized by census divisions (CD) (similar in size to US counties). The importance of Toronto and nearby regions as centers of logistics activity is evident in the number of firms, while high relative growth rates are apparent in outlying regions of the province – Southern and Eastern Ontario. The Toronto census division grew from 1,499 to 3,513 businesses between 2002 and 2012, while Peel, another important region for logistics activity, grew from 1,578 to 2,860 businesses. Extremely high rates of growth in logistics activity took place in outlying areas, but these grew from very small absolute numbers in 2002. For example, Huron County, in the western part of the Southern Ontario area, went from 14 logistics business in 2002 to 144 in 2012, an increase of 929%.

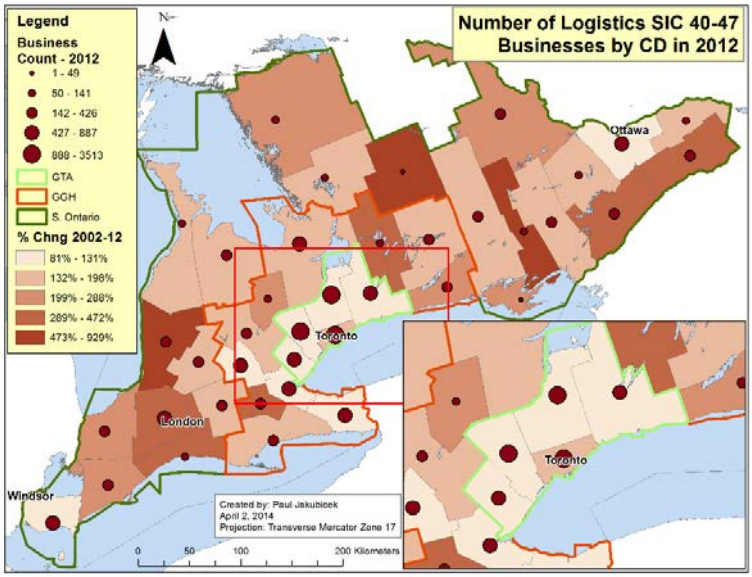

Fig. 2. Map of Logistics Businesses over time

5.3. Warehousing Locations

After removal of the mini-storage units from the data, analysis was carried out on the locations of warehouses across the study areas. A cursory examination of Fig. 3 confirms known trends that Toronto and Peel Regions have the most warehouses and that regions like Brant and Niagara, in the outlying region are growing at faster rates then these core areas (Jakubicek & Woudsma 2011).

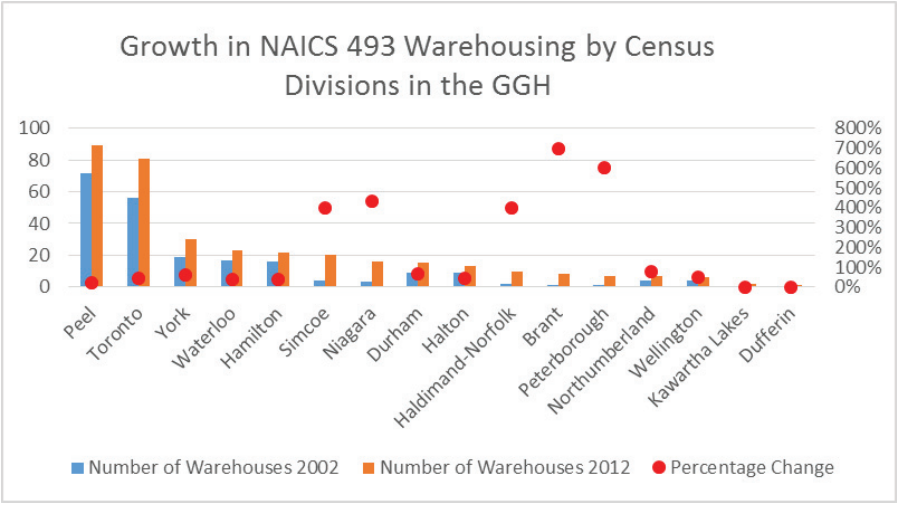

Fig. 3. Growth in Warehousing by Census Divisions

Additionally, when examining a map of where warehouses are located across the entire region, the importance of Peel and Toronto are again evident (Fig. 4). It is interesting to note some of the outlying areas that are growing in numbers of warehousing as well. The London, Ontario region grew from 3 to 28 warehouses over the time period and it is located along major transportation routes between the Toronto area and American markets in Detroit.

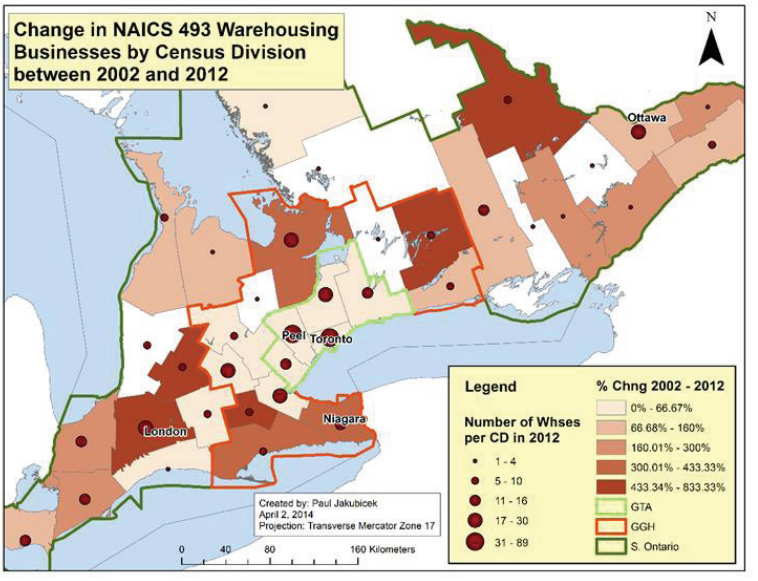

Fig. 4. Map of Warehousing Businesses over time

5.4. Changes within the urban area

Dissemination areas (DA) are a Census of Canada spatial unit used to delineate areas with 400 – 700 inhabitants and can be seen as similar in size to zip codes in the United States. Fig. 5 provides a detailed look at where warehouses are located within the built up area, and within the area most associated with logistics activity in the Toronto region. It is interesting to note the decrease in the number of warehouses in some of the longer established industrial areas, in spite of the overall increase of warehouses in the GTA. Some possible explanations to this may be that the warehousing and storage functions of these areas are moving to greenfield sites at the edge of the region, while the actual buildings in the area may be moving up the commercial real estate value chain and are acting as wholesale or manufacturing locations as opposed to their original purpose as warehouses (Prologis, 2015). A final note on Fig. 5 is the large number (15) of warehousing businesses that appear in one dissemination area in downtown Toronto. Inspecting these businesses further reveals that, they are all warehousing businesses in the Toronto area with address fields missing and are geocoded incorrectly to this one "representative" Toronto location.

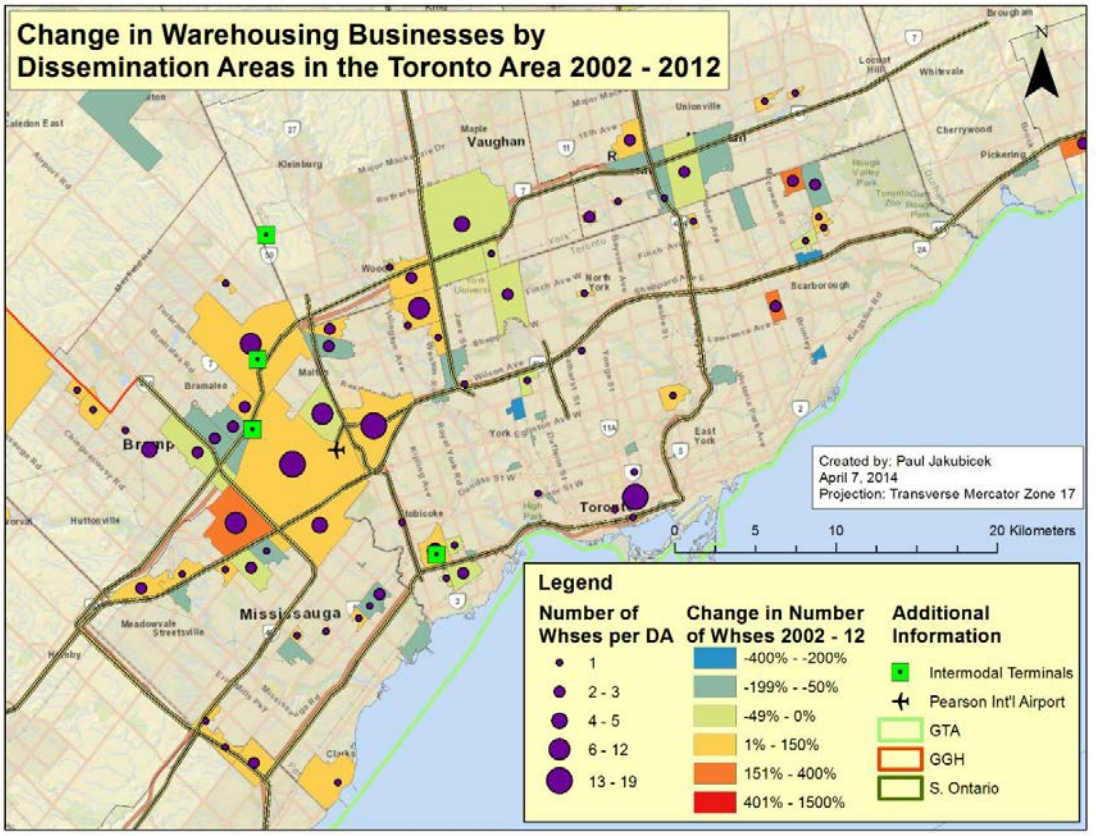

Fig. 5. Warehousing Businesses in the Toronto Area

5.5. Sprawl?

One of the key questions explored in this study is are warehouses sprawling? The magnitude in difference of the average distance to center for warehousing in the GTA compared to the GGH is striking. The average distance to warehousing center within the GTA increased by 7.5%, while the average distance to center in the GGH increased by 32.1% over the same time period. This is evidence that while warehouses are not sprawling within the core

urban area, they are sprawling over the exurban area that includes satellite communities within the economic sphere of the city.

Table 5 shows that in the GTA in 2012, the average distance to center was 17.9 km for warehouses, compared to 18.7 km for all businesses, a 0.8 km difference. Warehouses within the smaller, core GTA area had moved almost the same distance as all businesses in the GTA from the center. Differences between movements over time were also quite similar for the two dataset in the GTA, with warehouses and all businesses increasing their average distance to center by 1.3 and 1 kilometers, respectively, between 2002 and 2012.

A key finding of this study is that it is important to observe that while warehouses are not growing as strongly inside the core area as they are outside the core area, they are still growing in number. This trend is seen commonly across most of the studies concerning warehousing locations discussed. Within Bowen (2008), Cidell (2010), Dablanc et al. (2013), and Dablanc & Ross (2012) warehouses are maintaining their presence within the core urban areas, with a few exceptions. This is an important observation to consider within the debate around sprawl that sometimes suggests that warehouses are leaving core urban areas. The continued existence of facilities close to customers is a trend that appears across North American urban areas, and there does not appear to be a trend to move existing facilities out of urban areas. This trend is confirmed within industry literature, as Prologis (2015) notes that older warehouses that are obsolete for modern operations are utilized by less demanding logistics companies, or other industrial uses.

A second key finding is that outside of core, or built-up urban areas, growth in facilities is sporadic and possibly polarized in certain areas. This makes sense when you consider the growth in extremely large DCs in areas like Ontario, California (Dablanc et. al. 2013), Reno, Nevada (Bowen, 2008) or as found in Brant county in this study. These may be examples of clustering of warehouses in particular spaces that exist within the context of mega-regional, national or international flows, while warehouses remaining in the existing urban area concentrate on delivering to local clients. Indeed, within this study it appears that there are strong ‘winners’ and ‘losers’ in terms of the destinations of new warehousing facilities outside of the core GTA area. This may strongly suggest a place for planning for new goods movement facilities at the national or at least mega-regional level.

Table 5. Summary Table of Warehouses and all Businesses

Number and Movement of 493 Warehouses										
	2002		2012		Change in Warehouses		Change in Average Distance to Center		Mean Location Moved	
	Number of Warehouses	Average Distance to Center	Number of Warehouses	Average Distance to Center (km)	Number of Warehouses	Per (%)	km change	Per (%)	Distance (km)	Direction
GTA	165	16.7	228	17.9	63	38.2%	1.3	7.5%	0.92	North
GGH	217	29.6	350	39.1	133	61.3%	9.5	32.1%	1.25	North
S. ON	271	75.2	520	104.7	249	91.9%	29.5	39.3%	4.74	North West

Number and Movement of All Businesses										
	2002		2012		Change in Businesses		Change in Average Distance to Center		Mean Location Moved	
	Number of Businesses	Average Distance to Center	Number of Businesses	Average Distance to Center (km)	Number of Businesses	Per (%)	km change	Per (%)	Distance (km)	Direction
GTA	199,939	17.7	294,849	18.7	94,910	47.5%	1.0	5.7%	0.15	West
GGH	270,301	34.6	422,226	38.0	151,925	56.2%	3.4	9.8%	1.18	North West

5.6. Results in the Study Area

Comparing the sprawl patterns of warehouses compared to all businesses is useful to determine whether warehouses are sprawling at the same rate as the urban area. In the GTA, both warehouses and all businesses behaved similarly. This is opposed to mixed results for the GGH, where warehouses were closer to the center than all businesses in 2002 (29.6 km to center for warehouses, 34.6 km for all businesses). However, over the 10 year period, warehouses sprawled at a faster rate over the GGH than did other businesses and in 2012, warehouses were on average 39.1 km away from the center, compared to 38 km for all businesses.

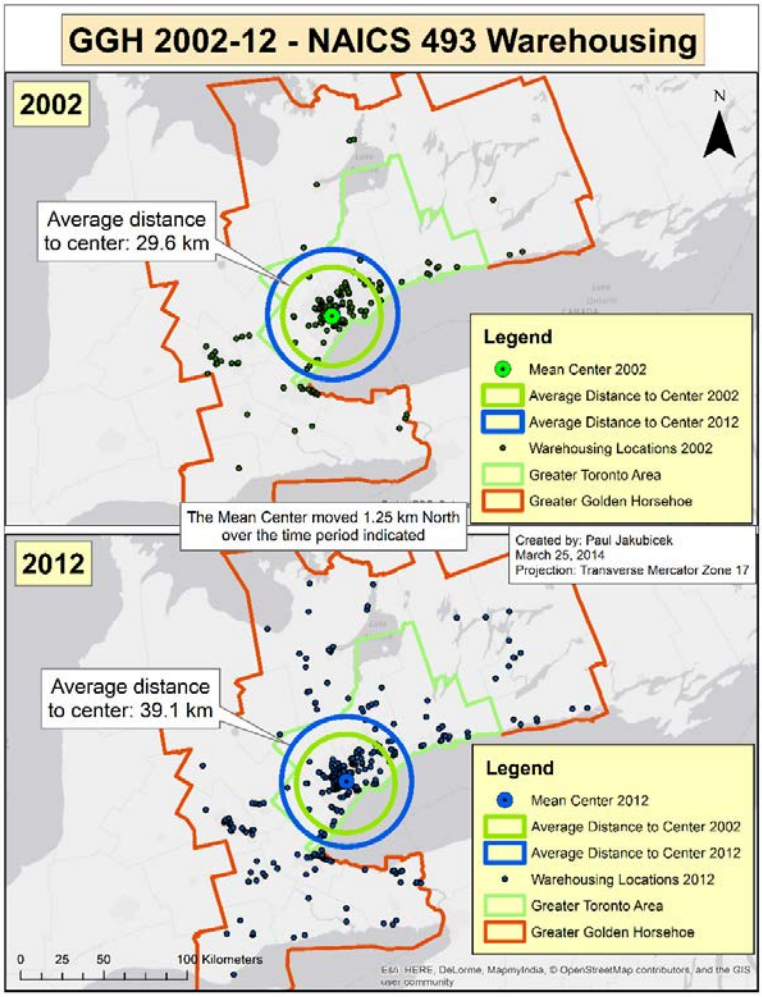

Fig. 6. Comparing Sprawl of Warehouses

Possible reasons for the increase in the relative amount of warehouses can be viewed through the lens of supply and demand differences in the real estate market. The supply of land within the GTA is decreasing (Hemson Consulting 2005), and with this decrease, there is upward pressure on commercial rents within the GTA area. The establishment of the no-development zone of the Greenbelt around the GTA was established in 2006 (Ministry of Public Infrastructure Renewal 2006), and it may be possible that the results that we see in this study are a result of these pressures. Planners in the region speculated that development would 'leapfrog' the greenbelt and cause pressure for more developments to happen in the region just outside the greenbelt, perhaps confirmed in these results.

6. Conclusion

Methodological issues described in this work have relevance to other studies that have been conducted on the same theme (Dablanc & Ross 2012; Dablanc et al. 2014). Several issues have been explored here, including the definition of logistics firms within government and private data sources, the usability and interchangeability of NAICS and SIC classification systems as they pertain to logistics firms, and finally the issue of mini-storage units

incorrectly classified as warehouses. The definition of logistics firms is inherently difficult (Hesse 2008) and we have described the types of firms that are included in the private dataset acquired for this study. After cleaning the data, it confirmed that the firms in the warehousing classification do represent a sample of 'logistics' firms as described in the literature.

The difficulty in creating a broadly defined 'logistics' dataset as used in other studies (Cidell 2010) was particularly troublesome with the use of the private dataset that required use of SIC codes, or conversion to NAICS. The NAICS system is superior in its description of logistics businesses but with the private dataset used, it results in incorrect data when attempting to convert the 2002 SIC transport codes to NAICS codes.

Finally, the issue of mini-storage units classified in the warehousing category was explored. Using private data sources enables a more precise identification of businesses by their name, enabling a verification of the classification used. For this private dataset used in this study, there were numerous errors in mis-classification of mini-storage units as warehouses. After manually removing these records, a more accurate analysis is made possible. Future research should consider the accuracy of government provided records and question whether they are subject to the same errors in classification.

6.1. Logistics Sprawl

The location patterns of logistics and warehousing firms in the Toronto area was examined. Within the GTA area, logistics firms are not sprawling significantly and we speculate that this is because of a lack of land required for expansion because of the development of the greenbelt. Additionally, the growth in logistics firms in the GTA may be attributable to the strong clustering of industrial uses in various areas in the GTA region (Ferguson et al. 2014). Both these potential factors have been found to play also a role in Seattle (Dablanc et al., 2014), which shares some features with Toronto regarding the location of warehouses, within the core urban area.

There was evidence of logistics sprawl, and specifically warehouse sprawl found in the broader GGH region. Presumably, the need for greenfield developments outweighed the need to be closer to customers in some cases, and these firms moved out of the boundaries of the GTA.

When looking across regions, this is also similar to patterns in regions such as Los Angeles (Dablanc et al. 2014), and Atlanta (Dablanc & Ross 2012). In Los Angeles, Dablanc et al. (2014) note the construction of new facilities in the Riverside-San Bernardino-Ontario Metropolitan Area, an area located to the east of Los Angeles. In Atlanta, Dablanc & Ross (2012) note the polarization of logistics facilities outside of the core urban area of Atlanta but oriented towards the Piedmont mega-region. In Toronto, the growth in some census divisions outside of the core area is similar to the patterns observed in Atlanta and Los Angeles.

This is an example of how public policy can potentially affect the development of an industry sector. A more complete accounting of the benefits and drawbacks of logistics sprawl could be a focus of further research to help inform public policy direction.

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