1-1-2013

Spatial Analysis Of Large Scale Freight Commodity Survey Data For Systems Planning

Heather Nottbeck
Ryerson University

SPATIAL ANALYSIS OF LARGE SCALE FREIGHT COMMODITY SURVEY DATA FOR SYSTEMS PLANNING

by

Heather Nottbeck, P.Eng, Ryerson University, June 2009

A Major Research Paper (MRP)
presented to Ryerson University
in partial fulfillment of the
requirements for the degree of
Master of Engineering
in the Program of
Civil Engineering

Toronto, Ontario, Canada, 2013

AUTHORS' DECLARATION FOR ELECTRONIC SUBMISSION OF A MRP

I hereby declare that I am the sole author of this MRP. This is a true copy of the MRP, including any required final revisions.

I authorize Ryerson University to lend this MRP to other institutions or individuals for the purpose of scholarly research.

I further authorize Ryerson University to reproduce this MRP by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my MRP may be made electronically available to the public.

Executive Summary

The Ministry of Transportation Ontario (MTO) Systems Analysis and Forecasting Office (SAFO) presented a case to determine if there is a relationship between the nationally collected Trucking Commodity Origin and Destination (TCOD) survey data and the provincially collected Commercial Vehicle Survey (CVS) data. The MTO performs the CVS every five to six years across the province of Ontario. It is conducted by roadside surveyors at 150 locations. The survey is very costly and requires a substantial amount of time and resources to complete. Though the CVS collects a large amount of trucking data, more information is required to gain a better understanding of freight movements within the province. The TCOD survey is a more comprehensive survey with more data points. The survey data is collected via phone interviews, electronic data reporting and on-site visits to shipping companies. A relationship between the two databases could allow for TCOD survey data to be used to populate the CVS database with additional information, without the costs associated with performing a CVS.

In this Master of Engineering project, raw data collected by both CVS and TCOD surveys has been aggregated on municipal and zonal levels with the purpose reducing the size of the databases to include only the Greater Golden Horseshoe (GGH) area and to compare the characteristics of the two databases. The TCOD database contained information for all data collected in Canada, with 215,001 data records. The CVS database contained all freight information for Ontario, with 10,758 data records. To reduce the database sizes, ArcGIS was used to link the locations of data points to the municipalities and transportation assignment zones in the GGH. The output from ArcGIS listed all locations with associated municipal and zonal identification numbers. This information was linked to the TCOD and CVS databases using Microsoft Access, resulting in a complete table of locations, identification numbers, municipality names, trucking company type, truck weights, and commodity type within the GGH.

Density maps were created to provide a qualitative assessment of the two surveys. This demonstrated that most of the trucks that were surveyed were either originating or arriving in the Greater Toronto Area (GTA). The CVS highest daily weights were located in Toronto, Mississauga and Hamilton. This is expected as these municipalities are three of the largest economic centers in Ontario. The TCOD data follows the same trend where Toronto,

Mississauga and Hamilton are at the top of both origin and destination highest density daily weights. Though the density trends are similar, the TCOD survey differs from the CVS because it has more data for the outer regions of the GGH. This is expected because the CVS is only performed at a limited number of roadside locations while TCOD uses phone, mail and visits to shipping companies to provide extensive coverage of the GGH.

The effectiveness of the CVS site locations was evaluated with a point density spatial analysis. All CVS origin and destination weight values were plotted on the GGH map and centres of high densities were identified with dark circles. These locations were not restricted by an assigned municipal zone, allowing the natural centres of high densities to be identified. The centres do not always falls within municipal boundaries, which indicates that evaluating truck activity centres from a municipal perspective may not provide a true representation of where the high freight activities are located. Based on the high density points found in this analysis, the existing CVS sites appear to be positioned in ideal locations which may provide good coverage of these freight activity centres.

A commodity distribution comparison was performed for the overall weight values for CVS and TCOD surveys in the GGH. The distributions had some similarities, but also varied in some areas. Additional commodity distribution comparisons were performed for three cities; Toronto, Mississauga and Hamilton. Overall, the commodity distributions for the CVS appeared to be more evenly distributed and consistent than the TCOD survey. This may indicate that the TCOD should improve its effort toward the less represented commodity types.

Although this study is thorough for areas within the GGH, the results could improve if both data sets were collected in the same year; in this case CVS data was collected in 2006 and TCOD data in 2010. During this time, the freight movement trends may have changed, particularly because of the 2008 economic recession. All aspects of the economy were impacted during this time, and the effect on the shipment of goods must be kept in mind when conducting comparative studies. This analysis only considered data points within the GGH. This may have affected the results, as it is possible that a stronger relationship between the databases may exist outside the GGH. An evaluation of freight movements throughout the Province of Ontario is recommended.

The municipality density maps, point density maps and commodity distribution analysis indicate that the coverage between the two surveys show some similarities, but overall are inconsistent. In some cases, the CVS had more data points for a particular municipality or commodity; while other times the TCOD survey had more data. This may indicate that finding a relationship which produces a conversion factor that can be applied to the TCOD database to populate the CVS database may be challenging. However, this analysis confirms that the CVS has much fewer data points than the TCOD survey, for the majority of the municipalities in the GGH. Finding a potential relationship between the two surveys would be very beneficial to the MTO as it could provide a more complete database of freight movements in Ontario. A regression analysis between the two databases is recommended as it may be able to identify a potential conversion factor between the CVS and TCOD databases.

Acknowledgements

I would like to thank my project group members, Fadwa Behnam and Mohammand Bari, for providing support and helping develop ideas for this report. I would also like to thank Dr. Joseph Chow for supervising this project and providing direction and advice along the way. Furthermore I would also like to acknowledge with much appreciation Rob Tardif, Arthur Tai, and Sundar Damodaran from the Ministry of Transportation Ontario Systems Analysis and Forecasting Office for presenting me with this research topic and providing guidance throughout the project. Special thanks to Dr. Wai Yeung Yan and Bernard James for dedicating time to help me learn and understand some of the technical programs used in this paper.

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

Every year, Ontario's provincial highways carry $1.3 trillion worth of goods. These freight vehicles account for more than 15% of the vehicles on Ontario roads. Ontario's highways are an essential part of Ontario and Canada's economy, and it is necessary to ensure that accurate trucking data is consistently collected and remains up-to-date for both economic analysis and transportation planning (Earth Tech, 2008). Recently, there has been an increase in demand for access to and usage of a wide selection of freight modeling and analysis. The changes in freight movements can influence the road capacity and impact the daily routes of users. This information can assist in prioritizing infrastructure investments and help anticipate the province's future needs (OTA, 2013).

The Ministry of Transportation Ontario (MTO) Systems Analysis and Forecasting Office (SAFO) presented a case to determine if there is a relationship between the nationally collected Trucking Commodity Origin and Destination (TCOD) survey data and the provincially collected Commercial Vehicle Survey (CVS) data. The TCOD and CVS surveys are used to populate two critical databases for freight activity. The CVS is conducted by the MTO by interviewing truck drivers at roadside locations. This survey requires a substantial amount of time and resources to complete. Though the CVS collects a large amount of freight data, more information is required to gain a better understanding of freight movements within the province. The TCOD survey is a more comprehensive survey with more data points. The survey data is collected via phone interviews, electronic data reporting and on-site visits to shipping companies. A relationship between the two databases could allow for TCOD survey data to be used to populate the CVS database with additional information, without the costs associated with performing a CVS. This data was analyzed in a variety ways by the three members of the project group (H. Nottbeck, F. Behnam, M. Bari), in individual major research papers.

The main objective of this research project is to sort the TCOD and CVS databases in terms of origin and destination municipalities and transportation assignment zones (TAZ) in the Greater Golden Horseshoe (GGH) and to analyze the characteristics of each. The GGH area is the largest urban area in Canada, centered on the City of Toronto, extending east and west around Lake Ontario and north of the city. It is made up of large, medium and small sized cities and towns. It

was selected for this study because this area is a large part of Ontario's economy and is dependent on freight transportation of goods (MOI, 2013).

The scope of work includes aggregation of both TCOD and CVS data into municipal and zonal levels using the XY coordinates and postal codes provided in the TCOD and CVS databases. The daily average weight values were summed based on origin and destination municipalities and intra-municipal movements. Maps displaying weight densities for all municipalities were created to visually illustrate the characteristics of the databases. Point densities were also evaluated to determine the best locations for the CVS to be performed. A breakdown of commodity type was analyzed to determine if the commodity distributions of the CVS and TCOD surveys shared any similarities. Strengths, weaknesses and recommendations for both databases were identified.

The other two components of the related research projects include a regression analysis and traffic assignment. Conclusions from all three papers will provide the MTO with a better understanding of how the TCOD and CVS databases may be related to each other. Recommendations for improvement of data sources and analysis techniques will be provided in each individual research paper.

2.0 Assumptions

The data provided by MTO is assumed to be in its entirety and has been collected uniformly within the Great Golden Horseshoe (GGH) region in Ontario. The shapefiles provided are assumed to have no missing information (or holes) thus all data extracted is a fair representation of the freight activities collected by both TCOD and CVS databases for the GGH area.

3.0 Data

3.1 TCOD Survey

The TCOD Survey is a Canadian survey that collects information about commodities transported by the Canadian trucking industry. This annual survey is used by the federal and provincial governments, trucking industry, and research institutions. This information can be used to

determine the volume of traffic on Canadian roads, trucking industry growth rate, and provincial and intra-provincial trips (Statistics Canada, 2013). Currently, there is not a large amount of freight data available which is why it is important to improve freight data collection programs, including improvement of coordination of freight data analysis with multiple jurisdictions (Tardif, 2011).

Statistics Canada uses the Trucking Commodity Origin Destination (TCOD) survey for analysis of freight movements throughout Canada, focusing on commodity tonnage. Though this survey collects large amounts of geographic and commodity data for all of Canada, it falls short in some areas as a result of gaps in the analysis framework. TCOD uses commodity tonnage; however, this is not a measure of vehicles and there is no relationship between tonnage and number of vehicles. Also, empty trucks are not accounted for. This is a problem because these empty trucks will still require capacity on provincial roadways. Survey records from the NRS were used to associate the growth of empty trucks to the commodity (Tardif, 2011). MTO is looking to fill these information gaps to provide more consistent and reliable data. Despite these short falls, TCOD is still a much larger source of trucking information than CVS.

The TCOD survey is conducted using three different methods; electronic data reporting, on-site visits and computer-assisted telephone interviews. Electronic data reporting consists of trucking companies sending in their trucking data electronically. On-site visits, the most common collection method, are interviews that take place at the shipping company. Computer assisted telephone interviews are carried out when the electronic data reporting and on-site visits are not possible. The TCOD survey is a mandatory survey (Statistics Canada, 2013).

A data dictionary was provided by MTO giving a description for each TCOD data category (see Appendix A). The dictionary also provided information about standard codes for Canadian provinces, alpha codes for Canadian provinces, alpha codes for US states, alpha codes for Mexican provinces, and data type descriptions. This TCOD survey data was collected in the year 2010. The relevant TCOD data categories used in this analysis include survey year, total weight of shipment (kg), and origin and destination postal codes, commodity code, city, and province.

3.2 CVS

The MTO began surveying trucking movements with the Commercial Vehicle Survey (CVS) in the late 1970s. The goal of this survey is to collect provincial freight flow information by performing roadside truck surveys throughout the province of Ontario (Earth Tech, 2008). The CVS collects data for truck trip characteristics, vehicle classification, weights, commodity details, border crossing, routes, and trip origin and destination. It is completed every five to six years across the province of Ontario at 150 locations. Survey locations include truck inspection stations, roadside locations on the Ontario provincial highways, and southern Ontario border crossings (OTA, 2011). Information collected includes origins and destinations, routes, goods carried, vehicle weights, axle weights, commodity weights, vehicle dimensions and driver characteristics (Earth Tech, 2008).

This survey information is used by the MTO's Systems Analysis and Forecasting Office to improve their understanding of the trucks moving within the province, as well as across provincial borders. This information and understanding can help the ministry prioritize infrastructure investments and anticipate the province's future needs (OTA, 2013). It can also help develop or improve upon freight related provincial policies and planning (OTA, 2011).

The most recent available CVS data for analysis is from the 2006-2007 survey. This survey involved 27,719 hours of roadside interviews with commercial vehicle drivers and recording observations about the trucks, and 20,832 hours of traffic classification counts in conjunction with the surveying. Vehicle selection for the survey was random, and only trucks weighing a minimum of 4,500 kg, 2 axles and 6 tires, were considered. An MTO Enforcement officer was required to be present during each survey as they can legally pull in trucks to the inspection area. One surveyor interviewed the driver while the other recorded vehicle information (Earth Tech, 2008).

The CVS Program in 2010-2012 cost approximately $1.9 M to complete. The 2012-2014 CVS is estimated to cost $2.8M. The ministry receives some additional fundin; $300K is provided by the Federal Highway Association (FHWA) for surveys conducted at Canada-U.S. border crossings (Tardif, 2012).

A data dictionary was provided by MTO giving a description for each CVS data category (see Appendix A). The dictionary also provides information about jurisdictional codes, data collection sites and codes, truck body styles, Standard Classification of Transported Goods commodity codes, dangerous goods classes, zone system, border crossings, and equivalent single axle loading (ESAL) calculations. This CVS data was collected in 2006. The relevant CVS data categories used in this analysis include type of trucking company, commodity code, average daily weight, daily trips, and origin and destination longitude, latitude, and city. The trucking company type was for-Hire for all data used in this analysis. For-Hire does not include trucks that work for private companies nor does it include freight transported by rail.

4.0 Methodology

4.1 Database Sorting

The TCOD and CVS databases provided by MTO were very large scale Microsoft Excel files with 215,001 TCOD records for all of Canada, 93,855 of which were in Ontario, and 10,758 CVS records in Ontario. This information was more than what was required for this specific study. The focus of this project was to investigate freight trips whose origins and destinations fell within the GGH. Evaluating freight data flowing into and out of Ontario is beneficial to the MTO and other transportation agencies; however, it is outside the scope of this research project. To reduce the large size of the databases, unnecessary data points were removed from each database in a multistage process. Figure 1 illustrates the process for database sorting. High level filtering was performed in Excel to remove any data points entering or exiting into the province of Ontario from another province or country. With the reduced databases, all points located outside the GGH were then removed. There was no common characteristic between the two surveys to relate them to each other. As a result, aggregating both databases to a common municipality origin and destination was required to perform a comparison between the two surveys. The two surveys also did not use the same location identification feature. The TCOD survey used postal codes to identify origin and destination locations, while the CVS used longitude and latitude coordinates. Since the location information differed, the removal of points outside the GGH was completed using a different method for each database.

4.1.1 Spatial Join

A spatial join connects attributes from one layer to another based on location. This analysis technique was required in several steps of the database sorting process. For example, it was used to combine the attributes from the GGH municipalities to the TAZ shapefile based on a common location field. The municipality shapefile contained all municipalities in Canada, while the TAZ shapefile only displayed zones in the GGH. TAZ's are smaller zonal divisions; there are 3836 in the GGH. To accomplish this, the target layer was "selected by location". The target layer was set to intersect the source layer feature. This will highlight any points within the source layer feature. The shapefiles were then joined so that attributes from both files were within the same shapefile. This was completed by using the ArcToolbox analysis tools, were an overlay was selected and a one-to-one spatial join was performed. The same spatial join process was performed to join the postal code shapefile to the municipality/TAZ zonal joined shapefile.

4.1.2 TCOD

The geospatial location of each data point was identified with postal codes in the TCOD survey database. In order to map these postal codes on a coordinate map, a Canadian postal code shapefile was required. This file was retrieved from the Ryerson Online Repository and imported into the ArcGIS. ArcGIS is a geographic information system software package that allows users to create, edit and display geospatial data. Using this program, geospatial data can be compiled and analyzed. In addition to the postal code shapefile, two other shapefiles were also imported into ArcGIS; the GGH municipality map and the TAZ map. In order to connect and combine the information contained in both shapefiles, a spatial join was performed, as described in section 4.1.1. This resulted in one shapefile containing information for both TAZ and municipality zones, and reduced the number of municipalities to the 134 that are within the GGH area.

An Excel spreadsheet listing the postal codes for each origin and destination in the TCOD database were added into ArcGIS as "XY data". This data was linked to the zonal/postal code joined shapefile. An output table was created in ArcGIS displaying the origin and destination postal codes and the corresponding municipality and TAZ information. This output information was linked to the TCOD file provided by MTO, using Excel. Any points that did not have origin and destination zonal information were removed as they were not part of this study area.

4.1.3 CVS

The CVS information provided by MTO identified origin and destination locations with longitude and latitude coordinates. With the locations being identified with two coordinates, a different approach was taken to successfully connect the zonal information and identify specific data points when manipulating the data in ArcGIS and Microsoft Access. Identification (ID) numbers were created for all origin and destination trips in the CVS database spreadsheet. Origin ID numbers started with a '1' and destination ID numbers started with a '2'; for example the first line of data was given origin ID number 100001 and destination ID number 200001. Six digit numbers were required because the total number of data points in the CVS database was five digits; the final origin and destination ID numbers were 144141 and 244141, respectively. An Excel spreadsheet was created with columns for the newly created ID numbers, and the corresponding longitude and latitude values.

In ArcGIS, the TAZ zone and GGH municipality zone shapefiles were joined, as described in section 4.1.1.The spreadsheet containing the ID numbers, and longitude and latitude values was added to ArcGIS as XY data. The "x field" was set as longitude, the "y field" was set as latitude and the coordinate system WGS 1984 was selected. In order to join the longitude and latitude information with the zonal information, the longitude and latitude data points were converted into a shapefile. To convert to a shapefile, the longitude and latitude data layer must be exported and saved as a shapefile file type. To remove data points outside the GGH, the points within the GGH were selected by location with a target layer of longitude and latitude shapefile and the source layer of the municipality/TAZ zonal shapefile. Using the ArcGIS toolbox, analysis tools were selected, followed by an overlay and finally the spatial join. This spatial join was performed with the same steps outlined in section 4.1.1.The results of the spatial join provided a database with all data in the GGH. The attribute table for the joined shapefile was opened and the data was exported to a database file. The database file was opened in Excel; listed were the ID numbers, municipality ID number and zone ID number.

The spreadsheet exported from ArcGIS was imported into Microsoft Access. The CVS Excel spreadsheet was also imported as a table. A query design was created and was used to link the ID numbers from the ArcGIS output spreadsheet to the origin and destination ID numbers in the CVS spreadsheet; 2 links were required. The desired columns were placed in the bottom table of

the query design (ID, Municipality ID#, Zone ID#, plus all information provided in the CVS file). The query was run and the results were exported to an Excel spreadsheet. This Excel spreadsheet now displayed Municipality ID number and Zone ID number for all trips in the CVS Excel spreadsheet provided by MTO.

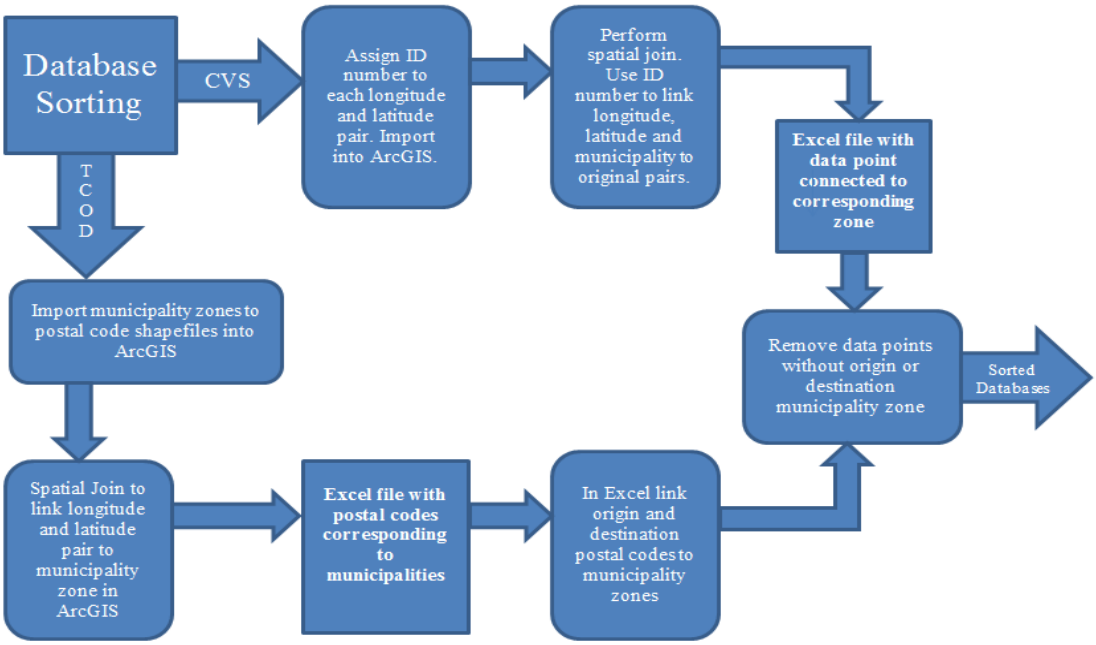


Figure 1 - Database Sorting Process

4.2 Characteristics Development

After both databases were sorted, the sum of the total weights based on origin, destination and intra-municipality were calculated in Excel for each of the 134 municipalities in the GGH. ArcGIS was used to display average daily weight values in a graphical, qualitative representation. Density maps were created for origin, destination and intra-municipal weights for TCOD and CVS data. In ArcGIS, the shapefile for GGH municipalities and the Excel sheet with the origin, destination and intra-municipal summed weights were imported. The two files were joined based on field. To display the weight densities, in the layer properties, the layer symbology was selected to show quantities and display colour. In the layout view, other features such as bar and north arrow were added. The maps were printed to JPGs.

The difference in weight values between the two databases was determined for the origin, destination and intra-municipal weights and density maps were created to illustrate the differences. An Excel spreadsheet showing the CVS weight subtracted from the TCOD weight

values was imported into ArcGIS. As described above, the densities were displayed in the GGH municipality shapefile. The colour green represents municipalities that have a greater weight value for TCOD survey data, red represents a greater weight value for CVS and yellow represents no difference between the weights.

Point density maps were created by importing the CVS origin and destination data points and the municipality shapefile into ArcGIS. The CVS origin and destination points were both converted to individual shapefiles. In the ArcGIS Toolbox, the spatial analyst tool was used and the point density option was selected. The analysis was performed and circles were displayed on the map in locations with high point densities. The properties of the points were adjusted so that darker circles represented higher point densities. TCOD data does not have point location information and was not included in the point density analysis.

A comparison based on weight by commodity type was performed. The total weight for each commodity was totalled in Excel for each database. Pie charts were created to illustrate the distribution of commodity by weight for both surveys. The distributions were compared and analyzed. Similarly, the total weight of each commodity was totalled for the three cities that produced and received the greatest weight value of commodities in the CVS and TCOD surveys; Toronto, Mississauga and Hamilton. Pie charts were created for each city's origin and destination weight values, for each survey. An analysis of the commodity distributions was performed. A visual representation of the characteristic development is illustrated in Figure 2.

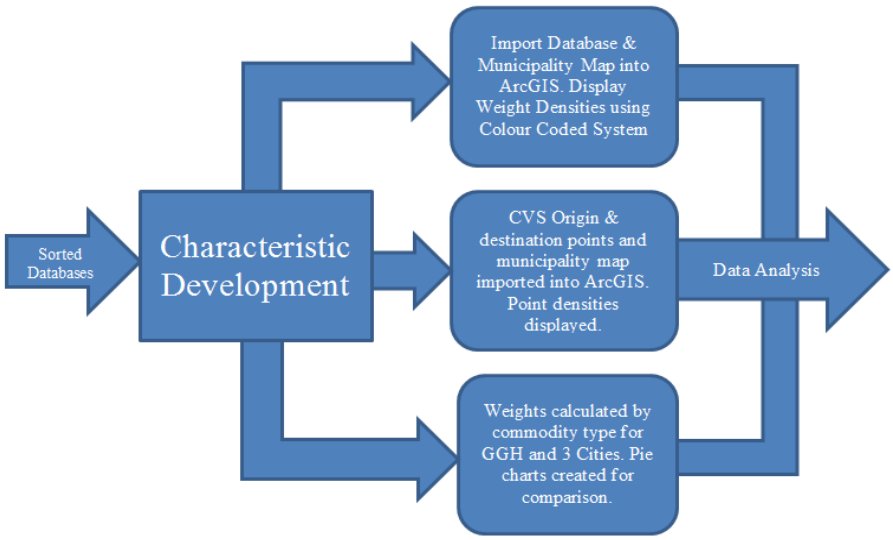


Figure 2 - Characteristic Development Process

5.0 Database Characteristics Analysis

5.1 Density Maps

5.1.1 CVS Origin and Destination Trips

The summations of the average daily weights based on municipality were plotted on maps of the GGH to visually illustrate which municipalities had the highest density of goods by weight originating in, arriving to and travelling within them. These visualizations, referred to as density maps, can be seen in Figures 3, 4 and 5. Figure 3 illustrates the CVS origin weight densities and it can be seen that the majority of the trucks surveyed originate in a municipality in the GTA. The municipalities with the highest densities by weight value are Toronto, Hamilton and Mississauga (Table 1). This was expected as these municipalities are three of the largest economic centers in Ontario. The City of Hamilton is known for its production of steel; 36% of the origin trips are for metal commodities. The City of Toronto and City of Mississauga have a wide variety of industries and are highly populated areas. The municipality of Havelock-Belmont-Methuen, identified as number 124 on the density map, is located outside the GTA but has a high origin weight density. This may be a result of the area's mining industry and rail yard (HBM, 2013). The Kawartha Lakes Railway runs through Havelock-Belmont-Methuen which may indicate that freight is unloaded from trains to trucks. This may account for the large number of origin weights outside the GTA.

With Toronto, Mississauga and Hamilton being large economic centres, this would suggest that they also have high demands for the goods. The destination based density map (Figure 4) and destination summary table (Table 2) demonstrate that Toronto, Mississauga and Hamilton again rank in the top three based on highest density destination daily average weights.

Information in these density maps can be used to assist in determining the locations of major warehouses by observing areas with high origin and destination weight movements. By identifying centres of truck activity in the GGH, the MTO can use this information for policy and planning purposes. When planning for future highway infrastructure, identification of high truck concentrations may assist in determining the highway needs in a specific area and help predict the number of trucks anticipated to use a particular section of roadway. This information could

also be used to evaluate or implement policies to regulate freight movements with respect to delivery times and lane restrictions.

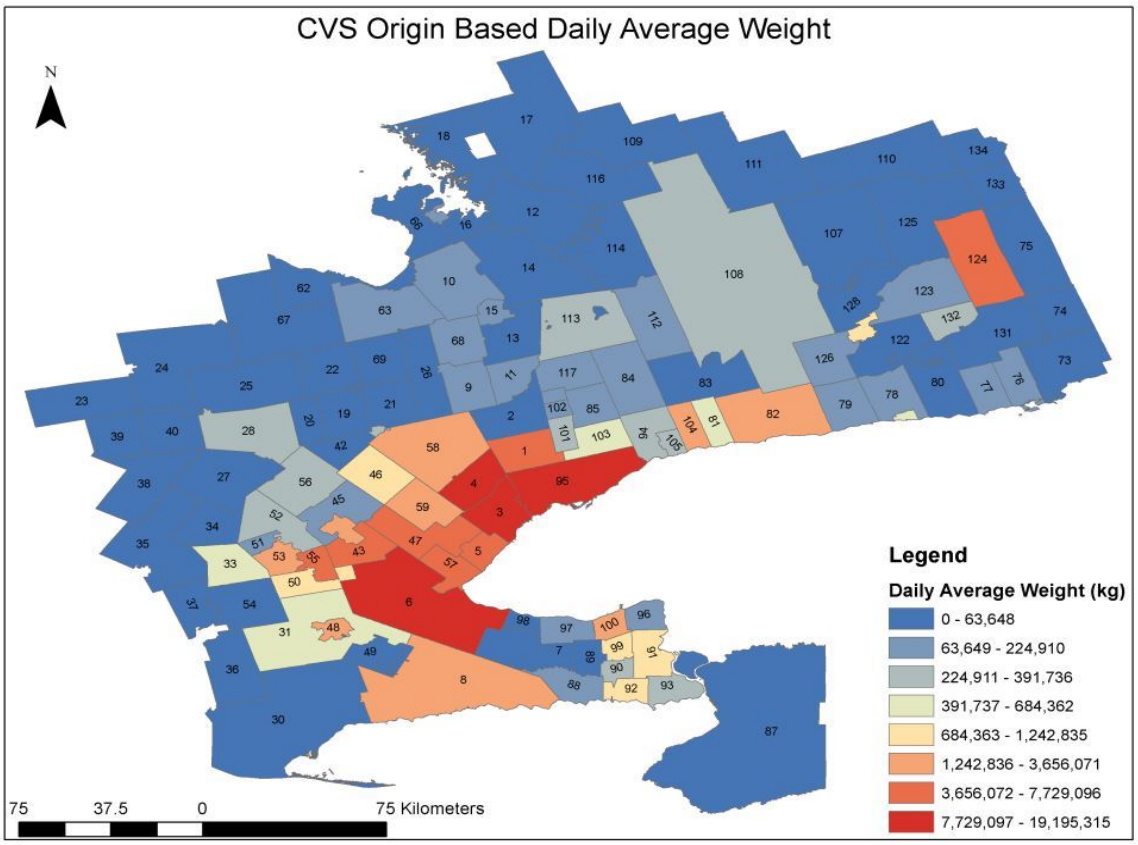


Figure 3 - CVS Origin Based Daily Average Weight

Table 1 - Top 10 for CVS Origin Based Daily Average Weight

Rank	Municipal Name	Origin ID	Daily Average Weight (kg)
1	Toronto	95	19,195,314.86
2	Hamilton	6	14,408,461.87
3	Mississauga	3	13,126,111.16
4	Brampton	4	10,913,788.71
5	Milton	47	7,729,096.44
6	Puslinch	43	6,279,725.35
7	Cambridge	55	5,076,953.39
8	Oakville	5	4,923,628.07
9	Havelock-Belmont-Methuen	124	4,623,581.14
10	Burlington	57	4,446,801.15

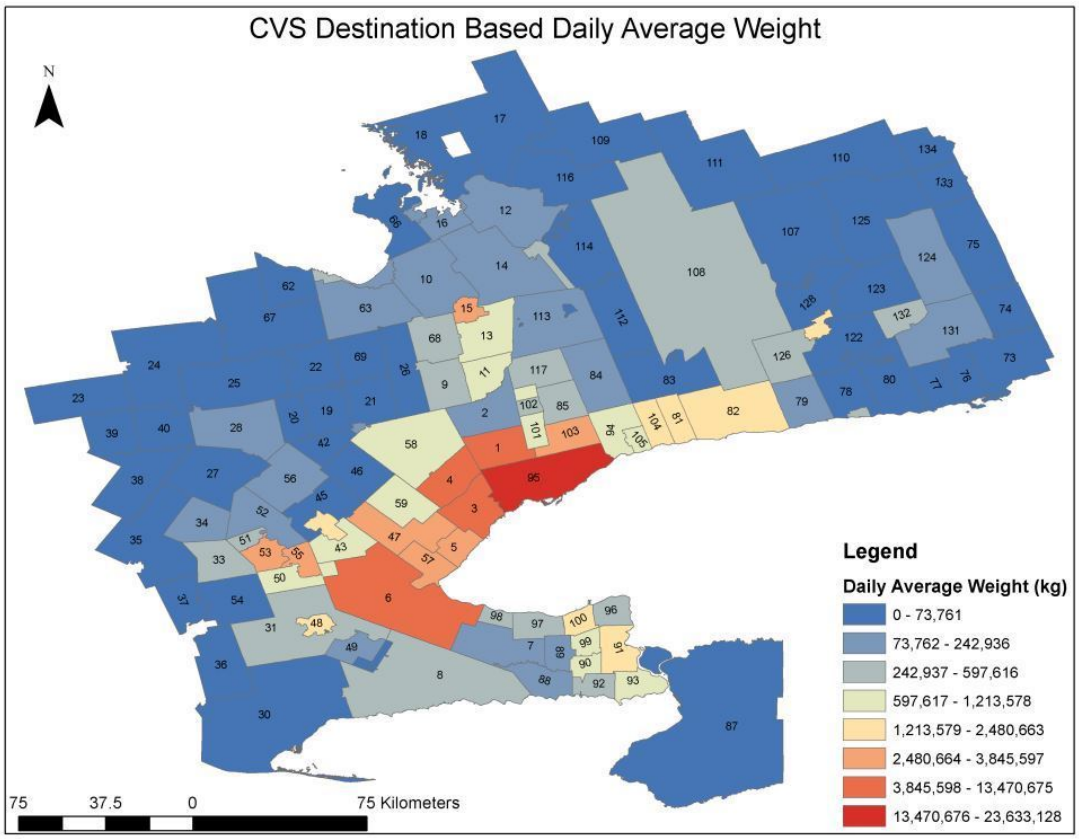


Figure 4 - CVS Destination Based Daily Average Weight

Table 2 - CVS Destination Based Daily Average Weight

Rank	Municipal Name	Destination ID	Daily Average Weight (kg)
1	Toronto	95	23,633,128.29
2	Mississauga	3	13,470,675.08
3	Hamilton	6	12,495,990.25
4	Brampton	4	10,625,407.70
5	Vaughan	1	7,945,856.09
6	Burlington	57	3,845,597.17
7	Cambridge	55	3,755,364.90
8	Oakville	5	3,408,549.45
9	Barrie	15	3,369,819.28
10	Milton	47	3,311,364.82

From the CVS density maps, it is seen that the majority of origins and destinations are within the GTA. This is indicative of how the data was collected for the CVS. When performing the CVS, surveyors stop trucks along the roadside and record responses from truck drivers about their current freight trip such as their origin, destination and the type of commodity they are carrying.

By collecting information in this fashion, there is confidence in the accuracy of the data with minimal discrepancies. However this survey is time exhaustive because of the amount of time it takes to physically collect the data at the survey locations. The survey is also very costly, limiting the resources available to perform the survey. This is a drawback to the CVS because there is not full coverage of freight movements, especially in the outer regions of the GGH. This can lead to a misrepresentation of the freight activity in those areas by having more complete data for some regions (i.e. GTA) than others.

5.1.2 CVS Intra-Municipal Trips

Intra-municipal weight values represent freight movements within one municipality. From the intra-municipal density map (Figure 5), Toronto, Oakville, and Hamilton topped the list of largest amount of commodity weight moving within the municipality, with 791,463.73kg, 520,494.02kg and 430,574.59kg, respectively (Table 3). The type of commodities moving within Toronto are manufactured products, machinery and electrical, and waste and scrap. In Oakville, the most intra-municipally transported goods were petroleum products, chemical products, waste and scrap, and transportation goods. Hamilton transports chemicals and products, machinery and electrical, minerals and products, manufactured products, and waste and scrap intra-municipally. The transport of waste and scrap within a municipality was common among Toronto, Oakville and Hamilton indicating that each municipality may be responsible for a portion of their own waste disposal.

For intra-municipal trips to be captured by the CVS there must be survey locations within those municipalities. Intra-municipal trips will not be identified if there is not a physical survey site set up in that particular location. This may explain why there are so few intra-municipal trips outside the GTA for the CVS. The CVS locations are displayed in Figure 6 and listed in Appendix D. Many of the survey locations are at truck inspections stations or border crossings. These stations are placed along busy corridors, such as 400 series highways or heavily travelled king's highways, so they experience a large amount of truck traffic. In this evaluation, the border crossings do not have an impact because only trips which both originate and arrive in GGH are considered.

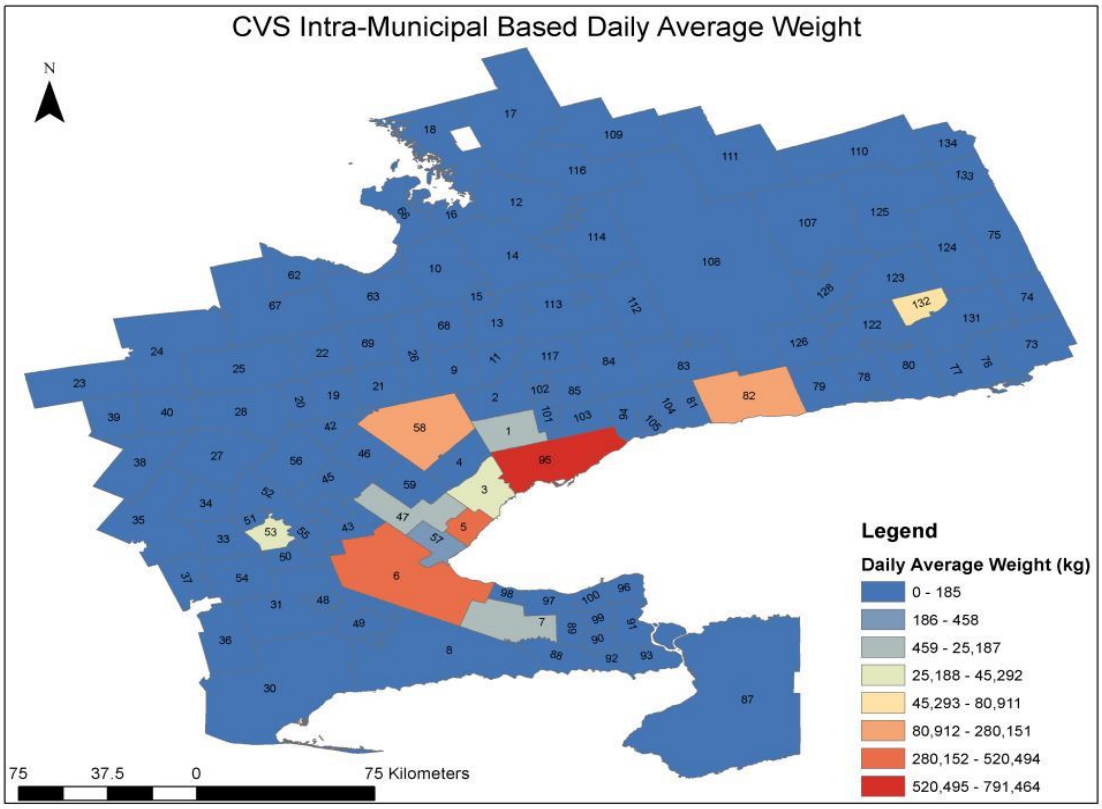


Figure 5 - CVS Intra-Municipal Based Daily Average Weight

Table 3 - Top 10 CVS Intra-Municipal Based Daily Average Weight

Rank	Municipal Name	Intra-municipal ID	Daily Average Weight (kg)
1	Toronto	95	791,463.73
2	Oakville	5	520,494.02
3	Hamilton	6	430,574.59
4	Caledon	58	280,151.08
5	Clarington	82	276,753.85
6	Asphodel-Norwood	132	80,911.20
7	Mississauga	3	45,291.91
8	Kitchener	53	33,466.68
9	Milton	47	25,186.81
10	West Lincoln	7	11,345.40

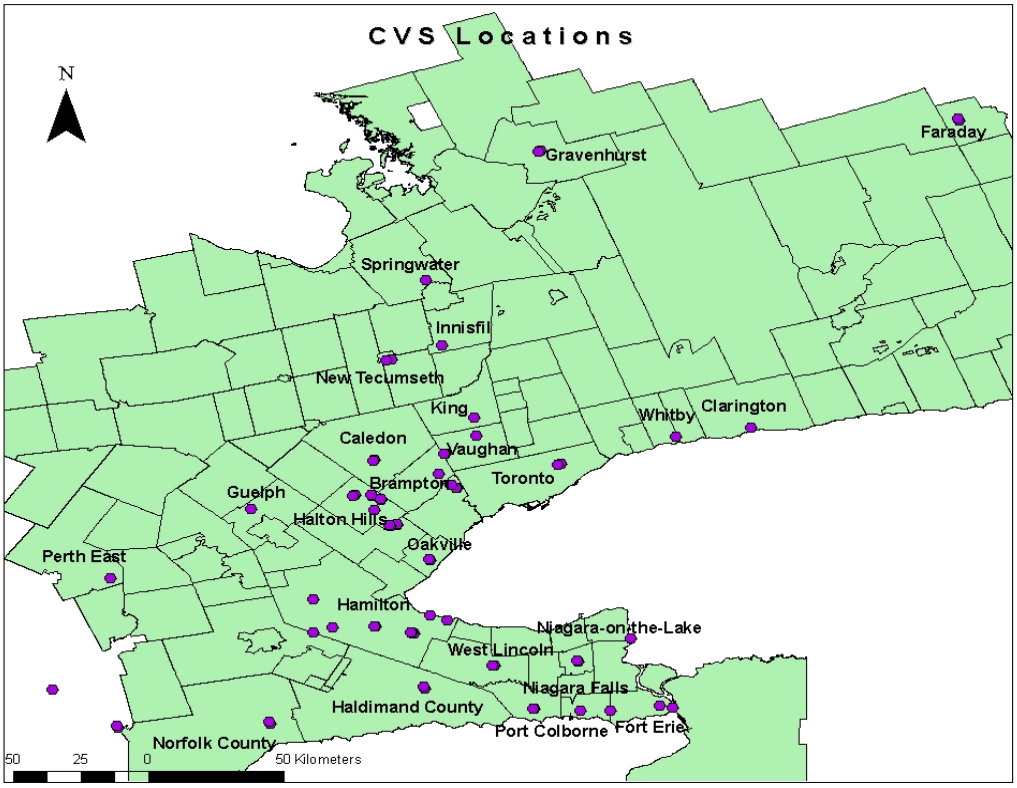


Figure 6 - CVS Site Locations

5.1.3 TCOD Survey Origin and Destination Trips

The summations of the average daily weights based on municipality were plotted on maps of the GGH to visually illustrate which municipalities had the highest density of commodities by weight origin and destination for the TCOD survey. The TCOD origin and destination weight densities are illustrated in Figures 7 and 8, and Tables 4 and 5. It can be seen that most of the trucks surveyed originated or arrived in a municipality in the Greater Toronto Area (GTA). As with the CVS weight density maps, it can also be seen that a significant amount of the trips comes from Toronto, Hamilton and Mississauga. The density maps demonstrate that the TCOD survey data provides some coverage in the outer areas of the GGH for origin trips. Destination weight values in the outer areas of the GGH appear to be lower than the origin weight values for the same locations. This may be because municipalities with smaller populations would require less freight shipment deliveries, therefore more goods are shipped by these regions than are received.

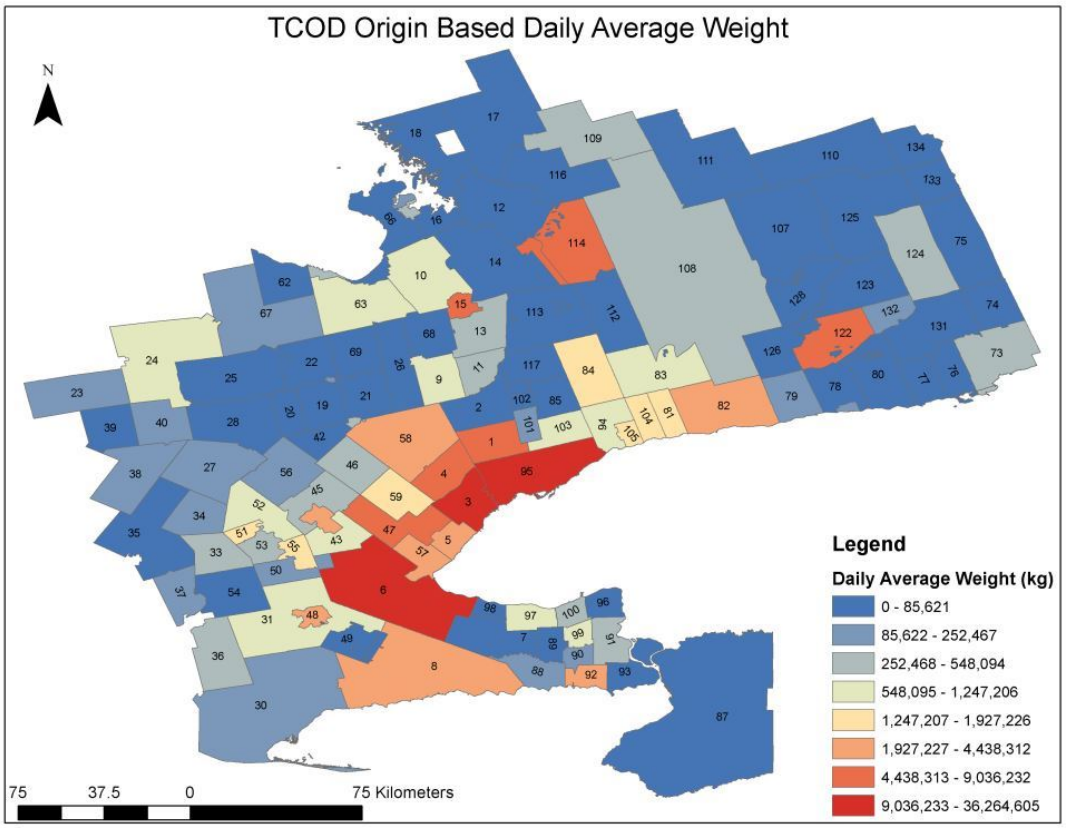


Figure 7 - TCOD Origin Based Daily Average Weight

Table 4 -Top 10 TCOD Origin Based Daily Average Weight

Rank	Municipal Name	Origin ID	Daily Average Weight (kg)
1	Toronto	95	36,264,604.87
2	Hamilton	6	23,056,676.14
3	Mississauga	3	18,123,195.56
4	Brampton	4	9,036,231.68
5	Vaughan	1	7,239,713.03
6	Barrie	15	6,684,767.56
7	Milton	47	6,216,320.89
8	Orillia	115	5,729,693.62
9	Ramara	114	5,591,395.21
10	Otonabee-South Monaghan	122	5,480,584.46

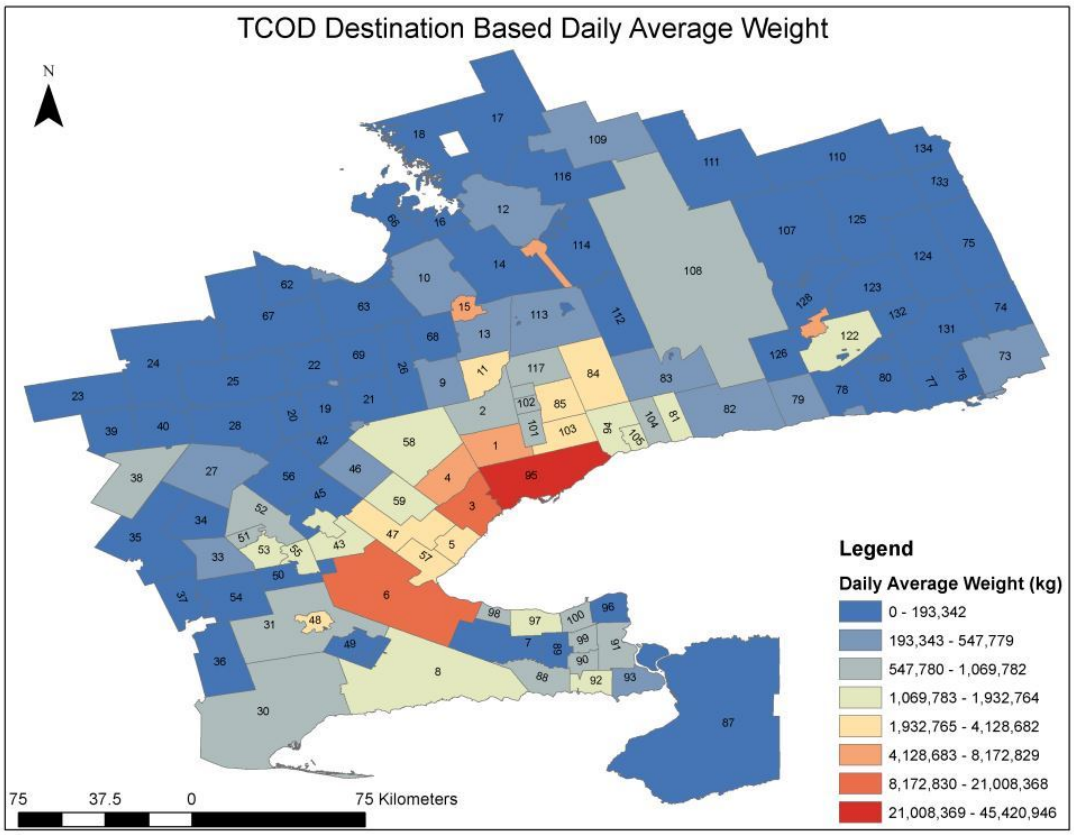


Figure 8 - TCOD Destination Based Daily Average Weight

Table 5 - Top 10 TCOD Destination Based Daily Average Weight

Rank	Municipal Name	Destination ID	Daily Average Weight (kg)
1	Toronto	95	45,420,946.03
2	Hamilton	6	21,008,368.06
3	Mississauga	3	14,688,043.15
4	Brampton	4	8,172,829.27
5	Vaughan	1	7,229,076.62
6	Barrie	15	6,890,931.74
7	Peterborough	127	5,417,823.27
8	Orillia	115	5,039,338.56
9	Milton	47	4,128,681.57
10	Burlington	57	3,806,726.69

5.1.4 TCOD Survey Intra-Municipal Trips

From the TCOD data, the highest intra-municipal weight densities were found to be in the GTA (Figure 10). This was expected as these municipalities have high populations and strong industries, requiring transport for goods within their own regions. The low densities along the

outer portion of the GGH either indicate a lack of survey data, or these regions do not require intra-municipal freight movements. If compared to the TCOD origin and destination densities (Figures 7 and 8), there are not many goods originating or arriving in these areas. The intra-municipal trips follow a similar trend as the origin and destination trips, however the City of Orillia ranked very high for intra-municipal weight values. Upon further examination of the database, the large weight value of freight movements within Orillia consist of water, aggregate, topsoil and heavy equipment. There are several quarries in the Orillia area which can explain the large amount of aggregate shipments. This also may indicate that Orillia uses its own construction materials and does not haul as much material from surrounding areas.

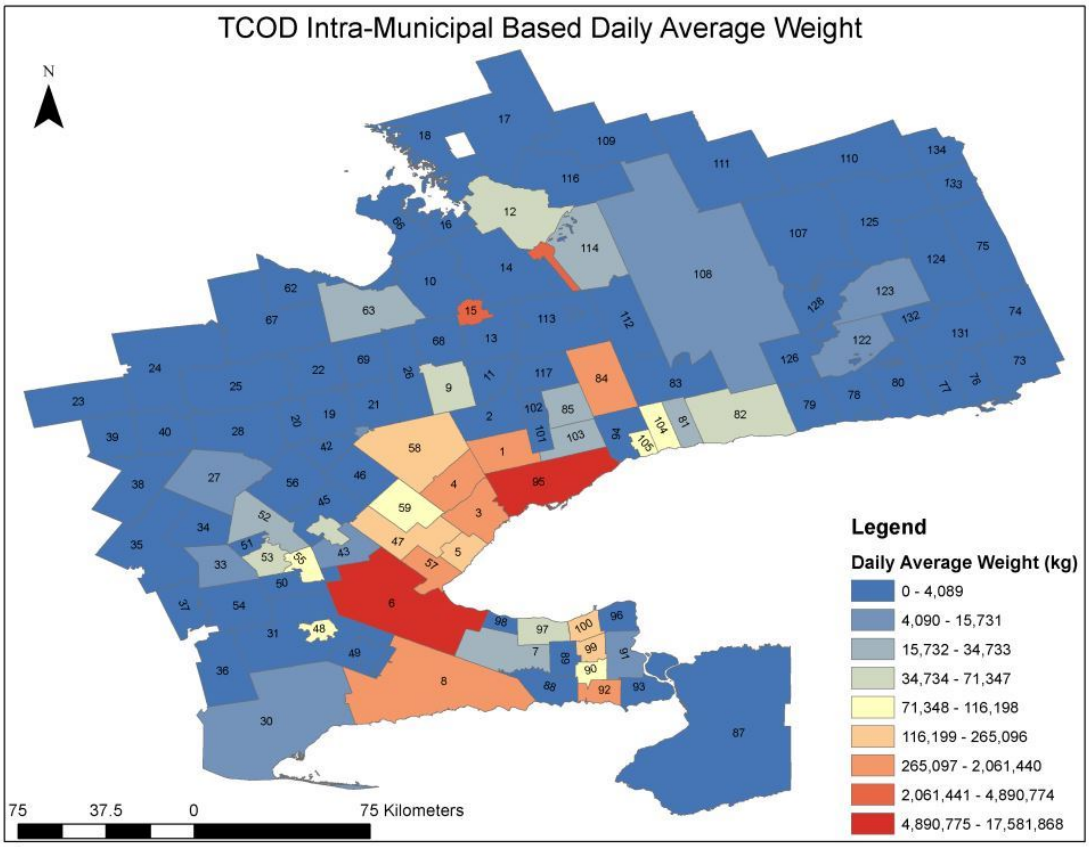


Figure 9 - TCOD Intra-Municipal Based Daily Average Weight

Table 6 - Top 10 TCOD Intra-Municipal Based Daily Average Weight

Rank	Municipal Name	Inter-Municipal ID	Daily Average Weight (kg)
1	Toronto	95	17,581,867.80
2	Hamilton	6	12,845,658.96
3	Orillia	115	4,890,773.98
4	Barrie	15	3,239,114.96
5	Mississauga	3	2,061,440.15
6	Brampton	4	1,324,926.87
7	Uxbridge	84	1,304,807.32
8	Port Colborne	92	1,245,897.37
9	Vaughan	1	899,360.06
10	Burlington	57	850,542.16

5.1.5 Density Map Comparison between TCOD and CVS

The total average daily weights collected for the TCOD survey was 174,682,681 kg and CVS was 132,064,175.7 kg. As a result of the CVS data being collected in the year 2006 and the TCOD in the year 2010, it is difficult to build an accurate comparison between the two. There may have be different freight movement trends during each of the two years, such as impacts from the 2008 economic recession. The CVS data is collected along the roadside and the TCOD data is collected by requesting shipping information from trucking companies, which may also make the comparison of the two databases more difficult. The CVS is limited to the amount of data it can collect based on the resources available, while the TCOD survey does not require a physical survey. This allows the TCOD survey to gather more data than the CVS. This is illustrated in Figures 10, 11 and 12, where the green zones indicate the TCOD survey has a higher value in that zone than the CVS, and the red zones indicate the CVS has a higher value. These density maps do not indicate that the TCOD survey could provide additional information for the CVS in those zones; it indicates that TCOD has more data points in most locations. This suggests that MTO should look to add survey locations to the where the CVS data is zero and TCOD data has a large weight value.

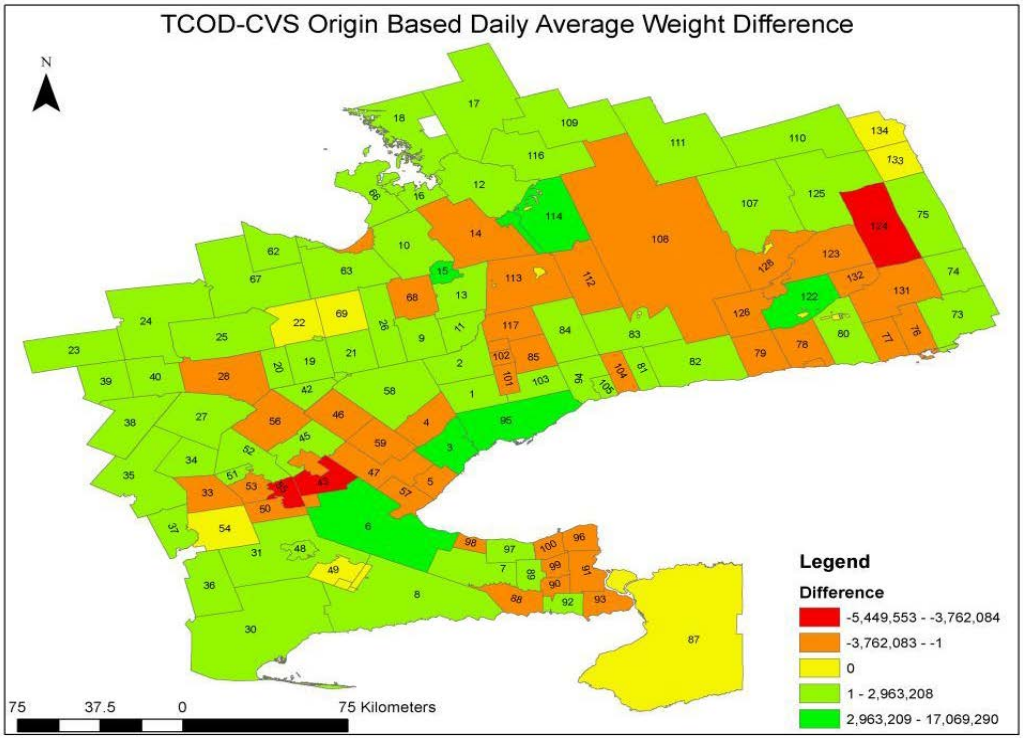


Figure 10 - TCOD - CVS: Difference in Origin Weights

The majority of the municipality zones are coloured green, which is expected because the TCOD survey appears to have a greater coverage of Ontario than the CVS. However, there are several zones where the CVS identifies more daily weight than the TCOD survey. This shows that even though the CVS does not have complete coverage of the GGH, its hands on approach to surveying still provide a significant amount of data for some GGH regions. It should also be noted that there are very few municipalities that are coloured yellow for both origin and destination densities. Yellow indicates that the difference between the two surveys is zero. Since it is very unlikely for the two surveys to record exactly the same value for weights in a particular municipality, this indicates that in these cases both surveys held a zero value weight for that municipality. The small number of yellow zones is a positive result because this means that between the two surveys, there is some type of data collected for every municipality. This does not imply that all possible data for those municipalities has been collected.

In the CVS destination density map (Figure 11), the CVS shows higher density weights for several municipalities along the Highway 401 corridor. A potential explanation for this may be because the CVS has four truck inspection stations and 12 other survey locations along Highway 401. This may allow for the survey to capture more information regarding trips travelling along

this corridor. A similar conclusion may be drawn from the group of municipalities in central/north GGH area (Figures 10 and 11) whose freight movements may have been captured by the two truck inspection stations on the Highway 400 corridor.

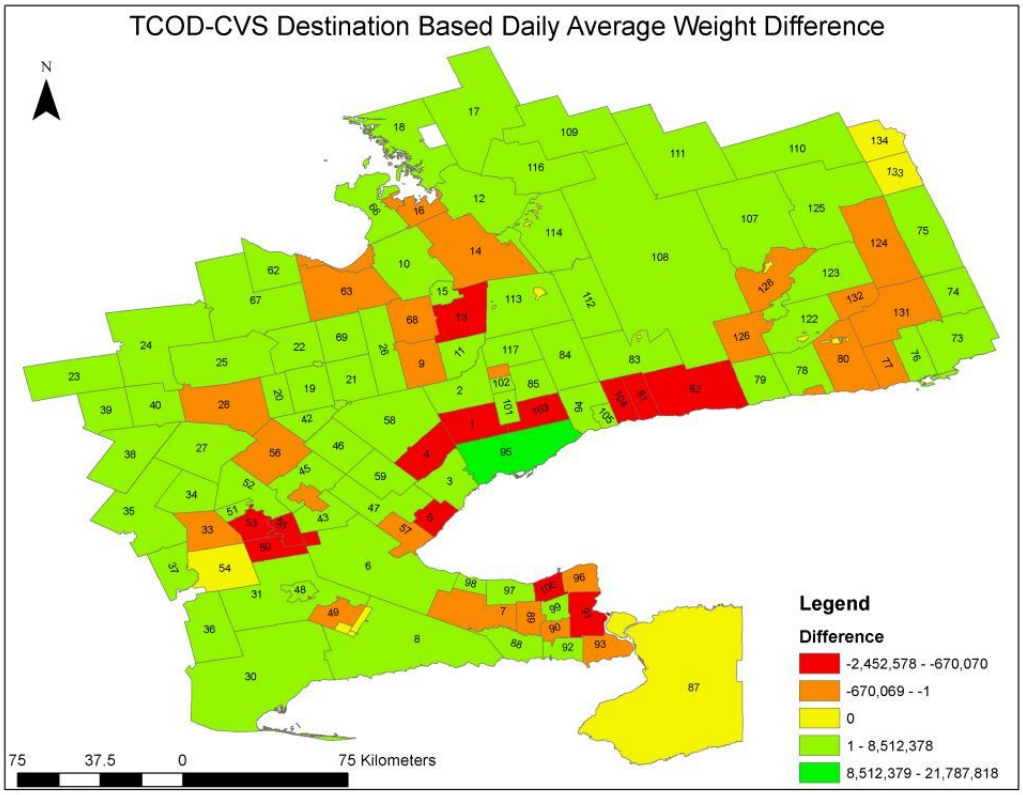


Figure 11 - TCOD-CVS: Difference in Destination Weights

The density map illustrating the difference between TCOD and CVS intra-municipal trips shows that the TCOD survey has better coverage of the intra-municipal trips. This is a clear indication of a drawback of the CVS. In order for the CVS to obtain information about intra-municipal trips, a physical survey location must be placed within that particular municipality. As seen in Figure 7, the CVS locations do not fall within every municipality. There are only three locations that show significantly more information from the CVS. These include Clarington, Caledon and Oakville, all of which have a truck inspection station within them. This may explain why the values are higher than the TCOD survey. Truck inspection stations are located on busy highway corridors, providing a good opportunity for the CVS to capture a significant amount of truck trips. The yellow areas have no intra-municipal weight values associated with them. Based on

where they are these yellow zones are located, around the outer portion of the GGH, it is not likely that commodities would be flowing within these zones.

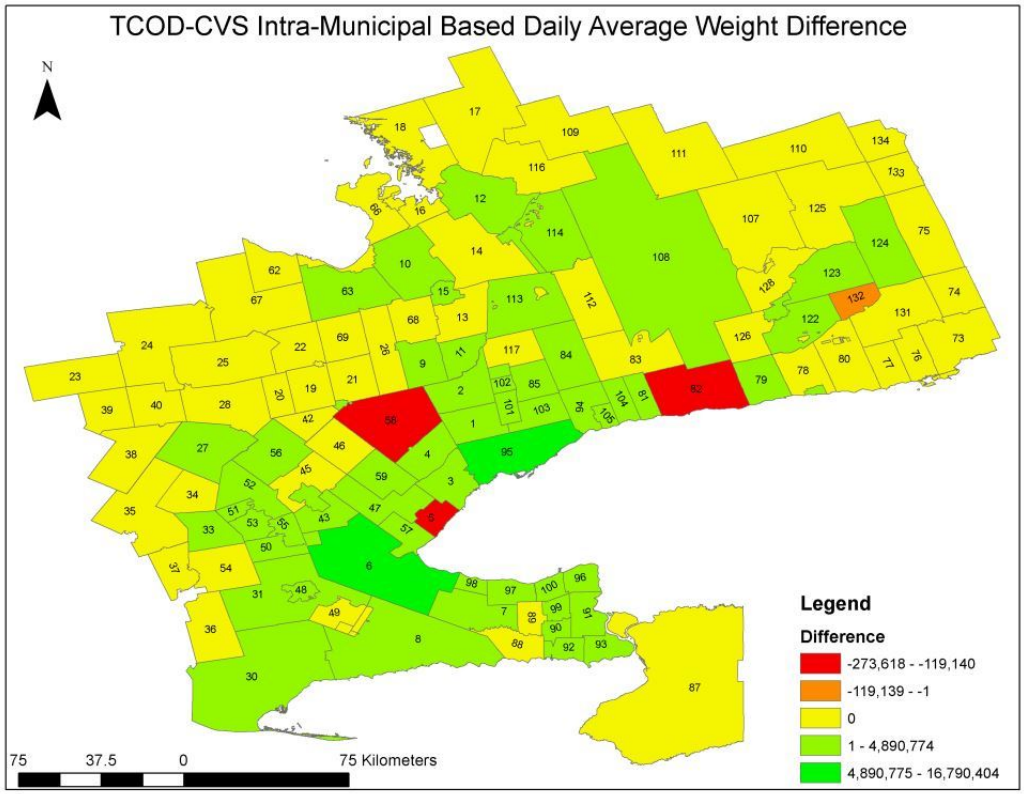


Figure 12 - TCOD - CVS: Difference in Intra-Municipal Weights

5.2 Point Density Maps

Density point maps were developed for CVS origin and destination weight values. This spatial analysis shows where freight activities have high weight densities, without being restricted to a specific municipality. The origin point density map (Figure 13) reveals that several dense pockets of origin trips fall across municipal boundaries. This can be seen on the Brampton and Mississauga municipal border, as well as the Toronto and Vaughan border. The Pearson International Airport lies along the Brampton and Mississauga boundaries, and may be a source of the origin trips.

The destination weight point density map also illustrates that areas of high truck activity do not always fall within municipality borders (Figure 14). The same large cluster is seen on the border of Mississauga and Brampton, near Pearson International Airport. This could explain a higher weight values in this area as the airport may be a freight destination.

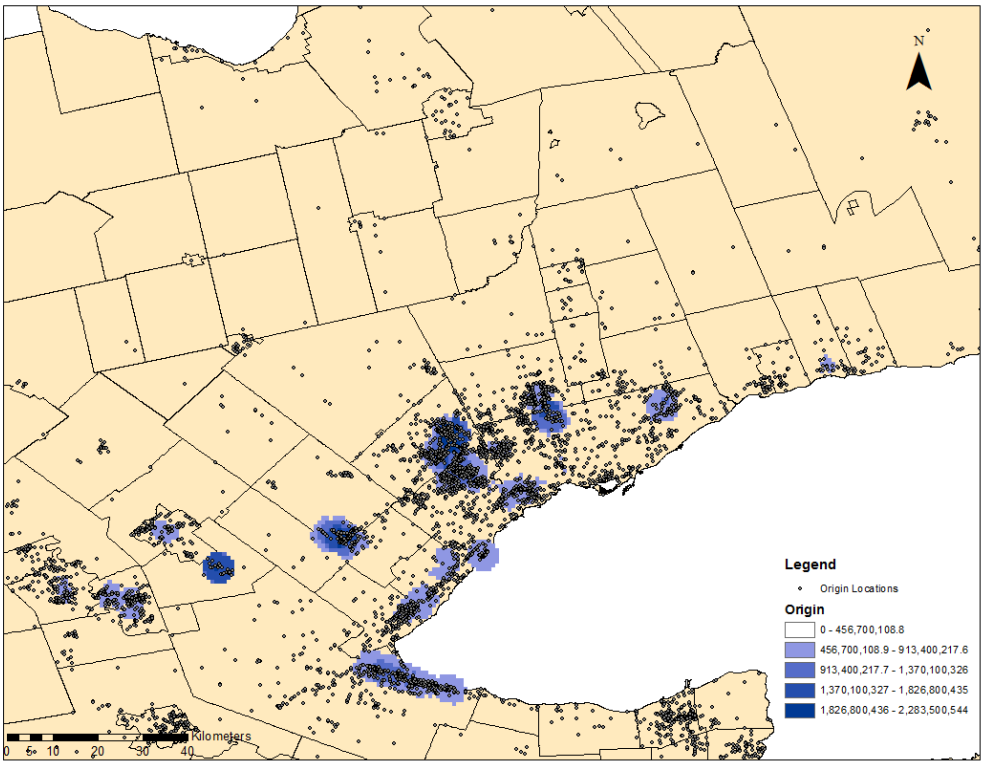


Figure 13 - CVS Origin Point Density based on Weight (kg)

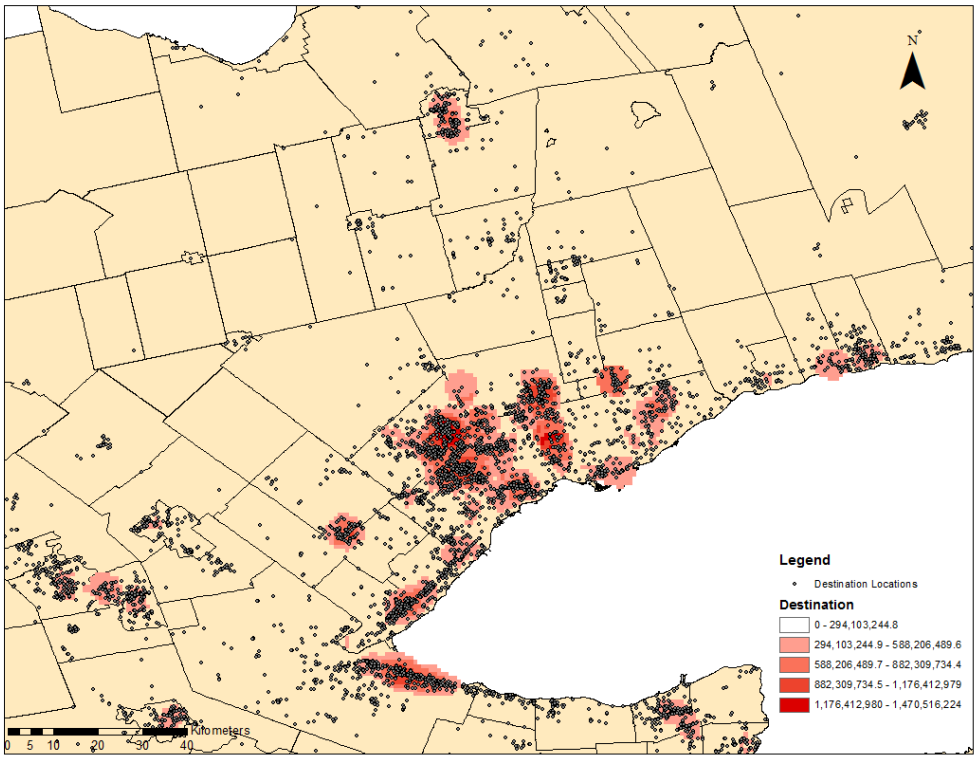


Figure 14 - CVS Destination Point Density based on Weight (kg)

This spatial analysis suggests that truck activities should be investigated on a more detailed level than by municipality. By examining the origin and destination points and the weights associated with them, a more clear understanding of freight movements within the GTA and GGH can be found. In Figures 13 and 14, it appears that most of the origin and destination high density weights fall along the provincial highway systems. This is expected because the CVS locations also fall along those highway corridors. This shows that the current survey locations are able intercept trucks along these routes and capture the trip weights. There is a high density location in Figure 13 which is located just south of Guelph. This area is not a CVS location, and it is recommended that this area be considered for an additional survey location. Overall, the CVS locations appear to be effectively located throughout the GGH area.

It is recommended that the TCOD survey include specific point locations, similar to the CVS. Without these points, the data can only be linked to a zone or municipality. These predetermined zones may not accurately define the centers of freight activity. When viewing the points without the zonal restraint, the natural epicenters can be observed. These centers of freight activity can be used to determine warehouse and distribution centre locations.

5.3 Commodity Distribution

5.3.1 GGH Comparison

The transport of goods along Ontario's highways is critical to the success of Ontario's economy. There are many industries that have allowed Ontario's economy to thrive, including manufacturing, agriculture, forestry, mineral production and services sector (Government of Ontario, 2013). The Standard Classification of Transported Goods (SCTG) breaks down the commodities transported throughout Ontario into 12 categories: agricultural products, food, minerals & products, petroleum & products, chemicals & products, wood & products, metals & products, machinery & electrical, manufactured products, transportation, waste & scrap, and shipping containers returning empty. The GGH is the largest urban region in Canada whose growth is anticipated to remain steady in the coming years (MOI, 2013). Freight movement of the above categories is crucial to the economic success of the Province of Ontario. From the sorted databases, Table 7 was created to show the quantity of each of the commodities moving within the GGH, by the average daily weight values.

Table 7 - Comparison of CVS and TCOD Weight of Goods Transported by Commodity Type

Commodity Type	SCTG Code	CVS Weight, kg	TCOD Weight, kg
Agricultural Products	01, 02, 03, 04	5,103,920	3,365,343
Food	05, 06, 07, 08, 09	20,347,319	17,214,440
Minerals & Products	10, 11, 12, 13, 14, 15, 31	36,823,764	72,570,309
Petroleum & Products	16, 17, 18, 19	8,196,414	16,380,542
Chemicals & Products	20, 21, 22, 23, 24	11,126,424	3,498,554
Wood & Products	25, 26, 27, 28	8,264,704	2,964,640
Metals & Products	32, 33	10,544,296	20,040,227
Machinery & Electrical	34, 35	5,087,770	4,277,727
Manufactured Products	29, 30, 38, 39, 40, 42000, 42100, 42390	9,949,304	28,799,479
Transportation	36, 37	6,341,337	2,814,698
Waste & Scrap	41	7,444,779	2,747,501
Shipping Containers Returning Empty	42200	1,243,009	9,211
Unclassified	-	1,591,136	10
Total		**132,064,176**	**174,682,681**

This information is displayed graphically in Figures 15 and 16. The overall distribution of the commodities of the CVS and TCOD databases were somewhat variable. Both show minerals and products as the commodity with the highest movements; however this commodity makes up 42% of the TCOD survey and only 28% of the CVS. Similar distributions are seen for food, petroleum and products, metals and products, machinery and electrical, and agricultural products. Varying distributions are seen for the remaining categories. It appears that transportation, waste and scrap, and shipping containers returning empty are not well captured by the TCOD survey.

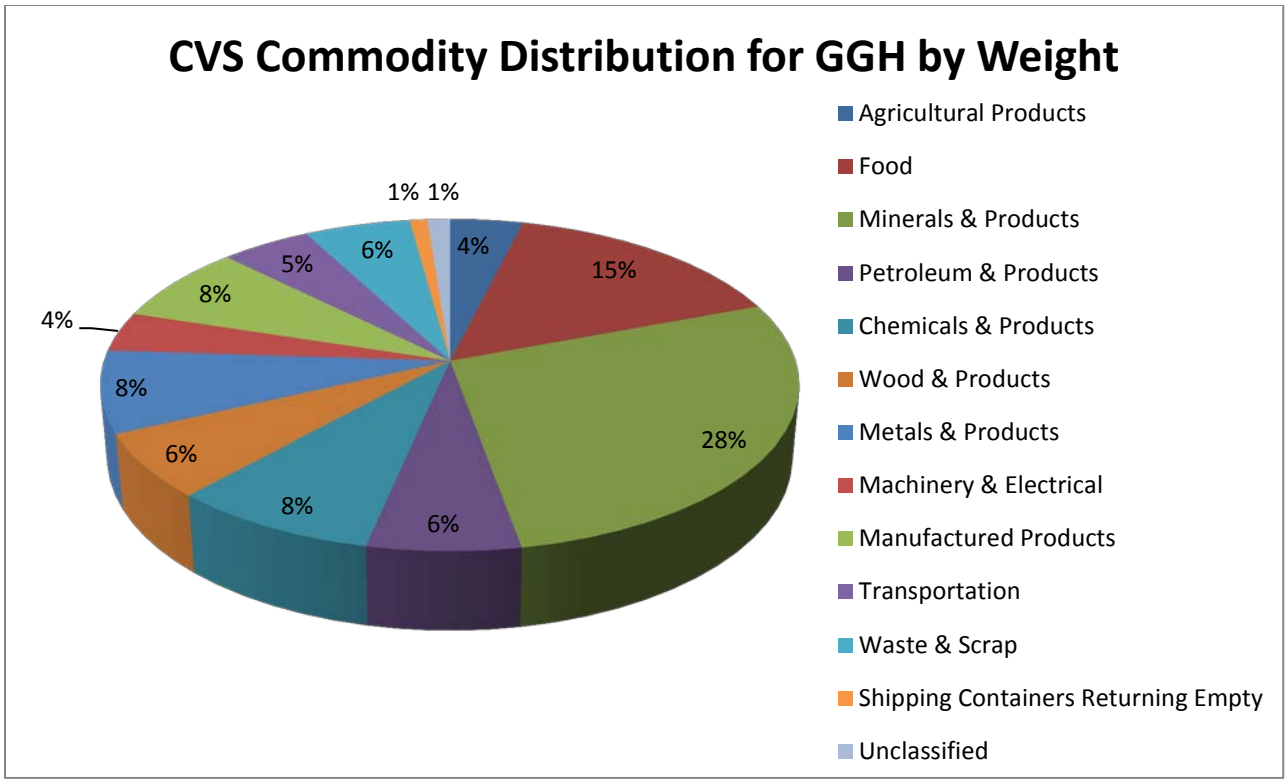


Figure 15 - CVS Commodity Distribution for GGH by Weight (kg)

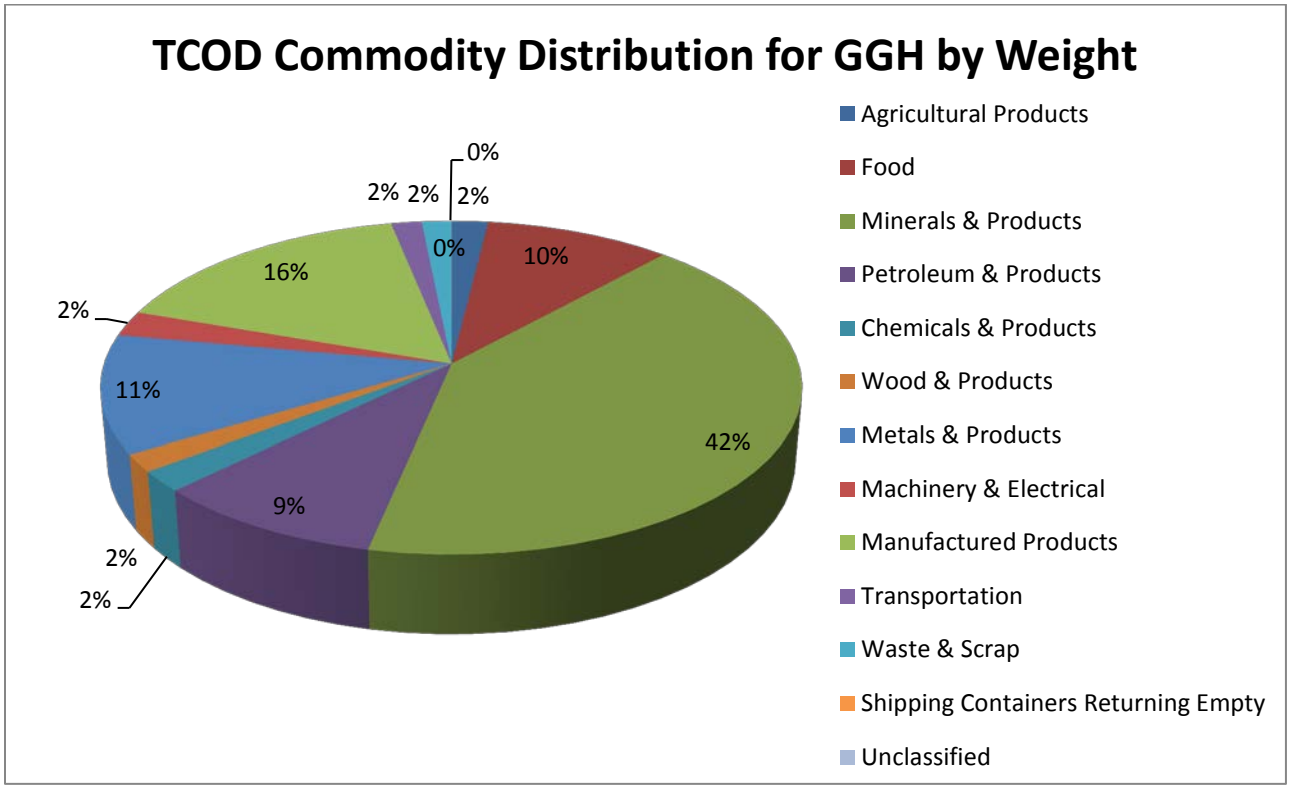


Figure 16 - TCOD Commodity Distribution for GGH by Weight (kg)

5.3.2 Origin Distributions

The commodity distributions were further broken down by municipality. The municipalities selected for this analysis were the three with the highest origin and destination weight values; Toronto, Mississauga and Hamilton. The distributions for Toronto origin weights can be seen in Figures 17 and 18. The distributions between the two surveys are quite variable. The CVS distribution is more evenly distributed among the commodities, while more than half of the TCOD survey represents only two commodities; minerals and products, and petroleum and products. It appears that the TCOD survey should place more effort on the commodities that make up the other half of the distribution, especially chemicals and products, wood and products, metals and products, machinery and electrical, transportation, waste and scrap and agricultural products.

The CVS commodity distribution for Toronto is very similar to that of the CVS distribution for the GGH. The only variance is the distribution of minerals and products, and petroleum and products. The Toronto distribution shows 7% minerals and 20% petroleum, while the GGH distribution shows 28%minerals and 6% petroleum. In this case, there is consistency between the municipal and GGH area collection.

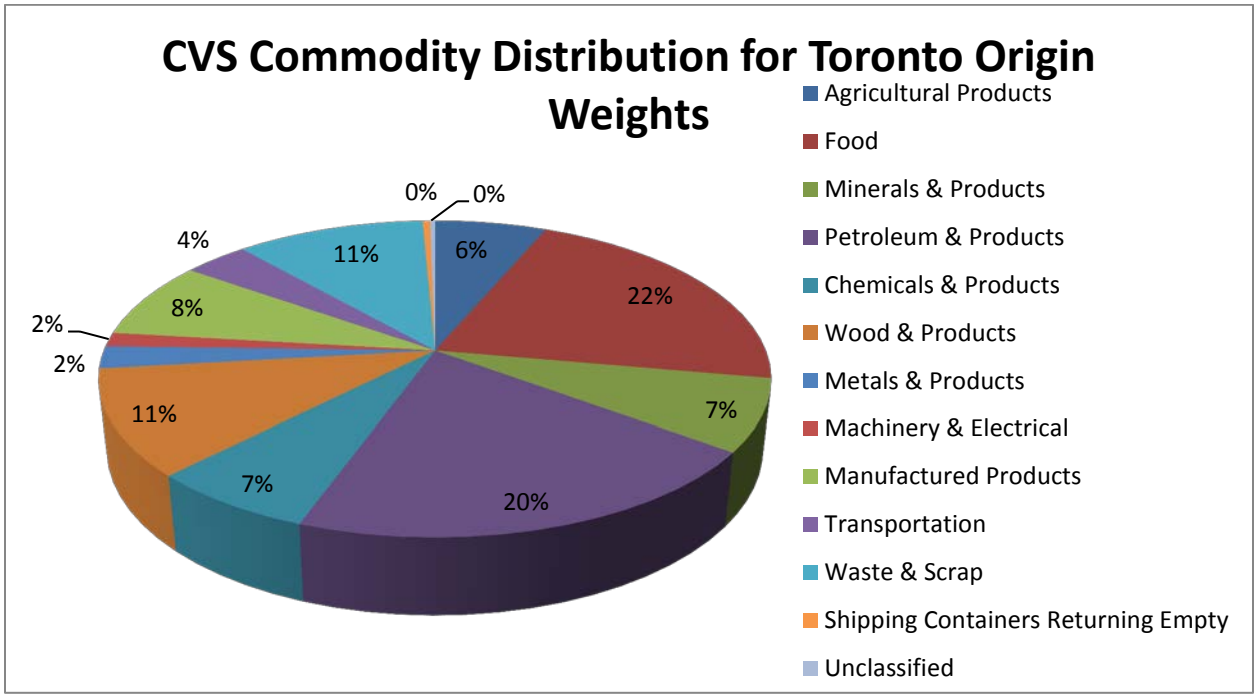


Figure 17 - CVS Commodity Distribution for Toronto Origin Weights (kg)

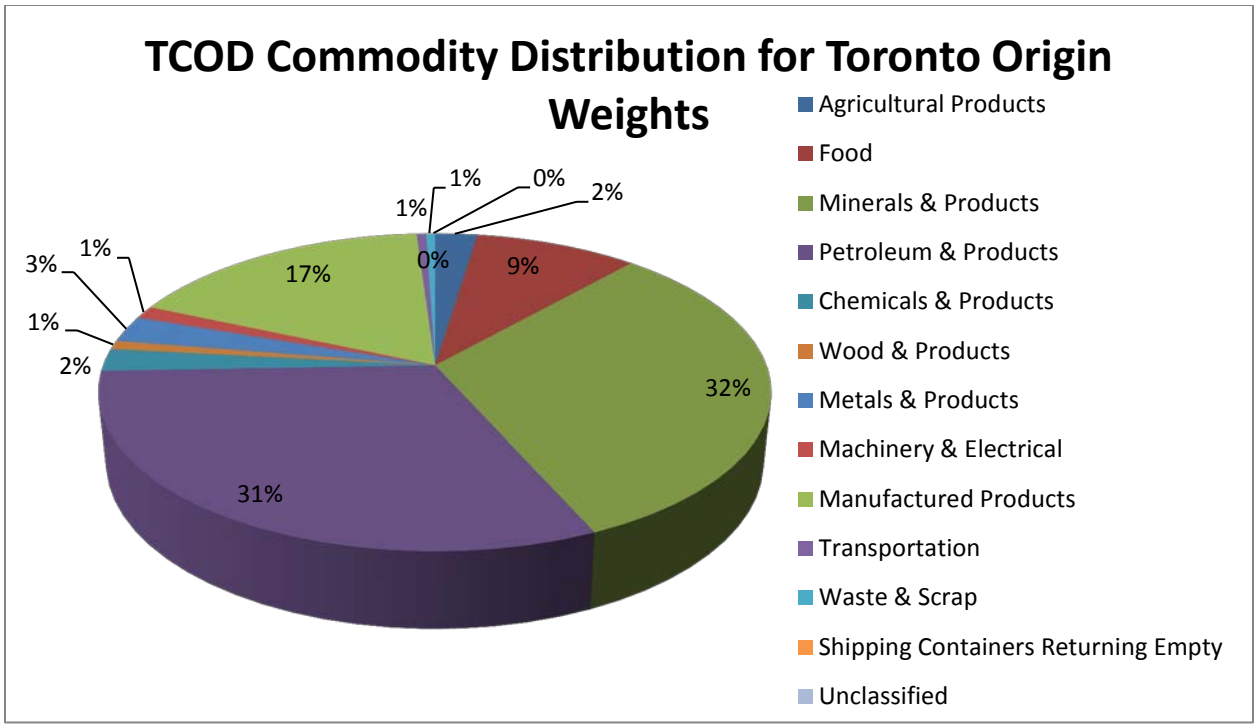


Figure 18 - TCOD Commodity Distribution for Toronto Origin Weights (kg)

The commodity distributions for the City of Mississauga origin weights appear to be fairly similar, with the exception of agricultural products which is not represented by the TCOD survey (Figures 19 and 20). More effort should be placed on agricultural products. Manufactured products are better represented on the TCOD distribution; the CVS may place more effort in this area to improve the distribution.

When compared to the GGH, the City of Mississauga commodity distributions are not comparable. This does not suggest that the distributions for Mississauga are inaccurate, but it is recommended that further investigation into the current data collection locations in the city be considered. It is also possible that the supply and demand of goods in the City of Mississauga are unique to that particular city.

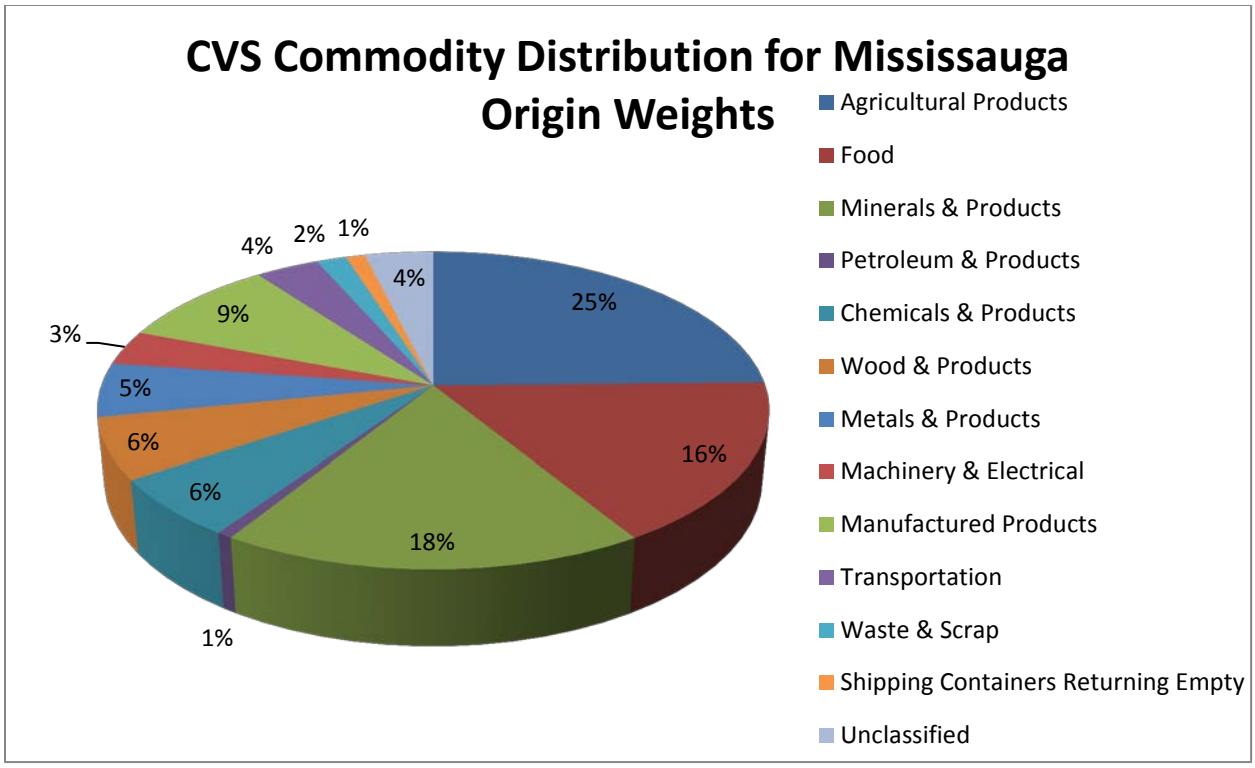


Figure 19 - CVS Commodity Distribution for Mississauga Origin Weights (kg)

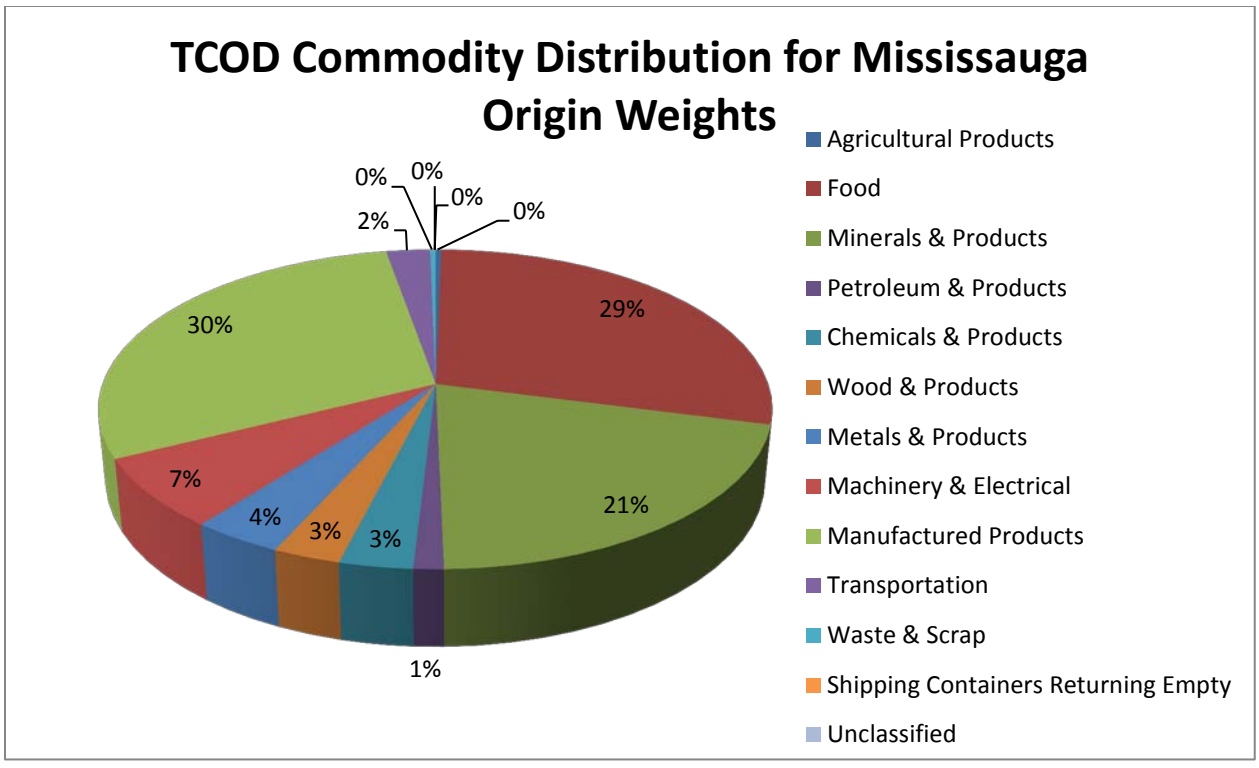


Figure 20 - TCOD Commodity Distribution for Mississauga Origin Weights (kg)

The commodity distribution for the City of Hamilton origin weights can be seen in Figures 21 and 22. Both surveys show a high amount of metal and products originating in Hamilton. This is expected as a result of Hamilton's large steel industry. The CVS distributions are more evenly distributed, while the TCOD survey distributions are heavily weighted toward three commodities; minerals and products, petroleum and products, and metals and products. The TCOD survey should put more focus on the large number of poorly represented commodity types.

The City of Hamilton does not compare well to the GGH commodity distributions. This is mostly attributed to the large percentage of metal products originating in Hamilton. Since this is analysis is a percentage distribution, the large percentage of metal directly impacts the percent distribution of other commodity types.

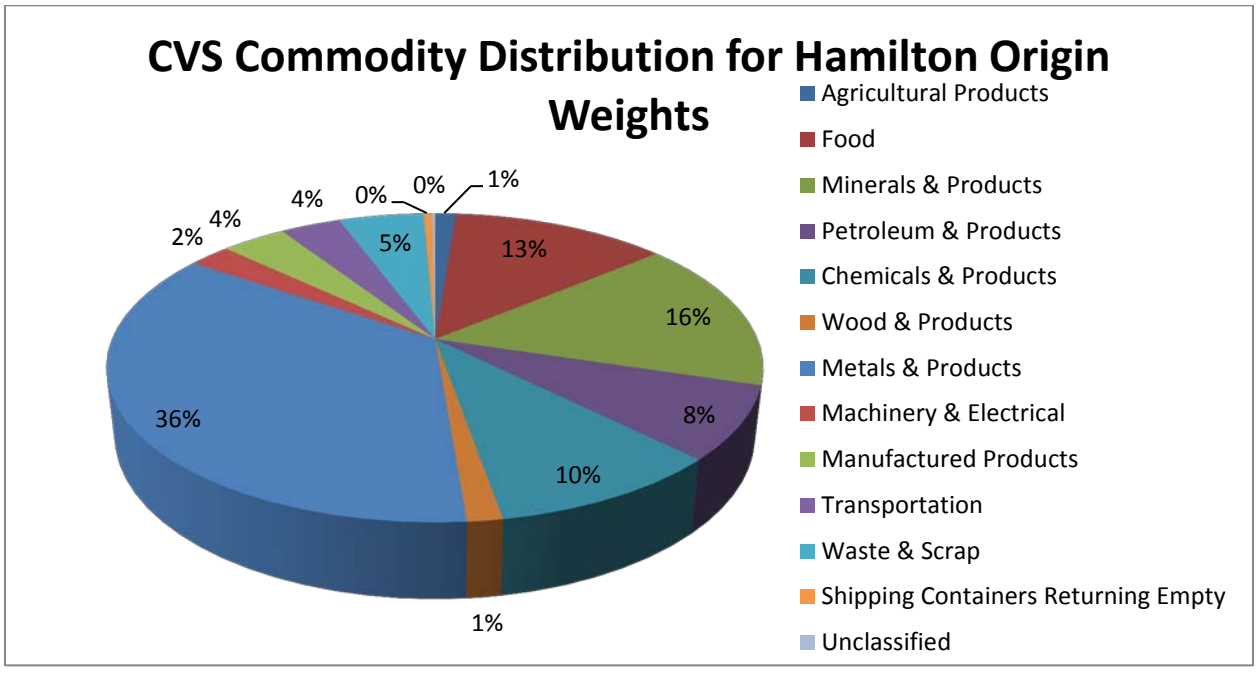


Figure 21 - CVS Commodity Distribution for Hamilton Origin Weights (kg)

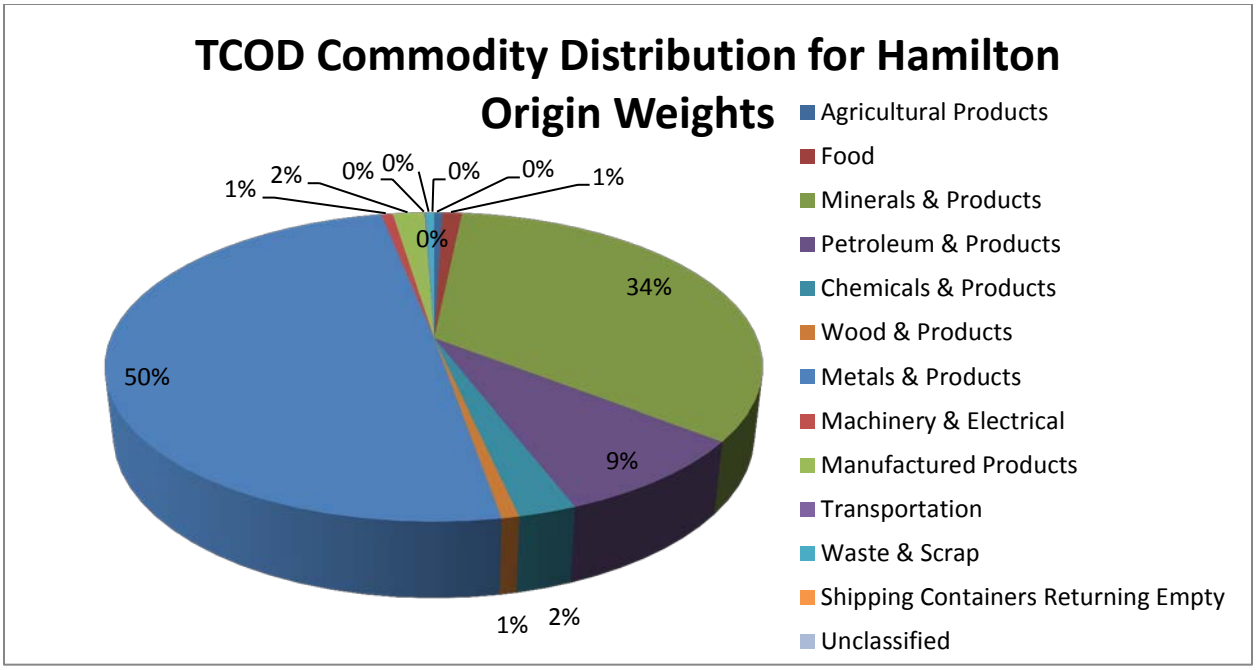


Figure 22 - TCOD Commodity Distribution for Hamilton Origin Weights (kg)

5.3.3 Destination Distributions

Commodity distributions were also evaluated for the destination weights of Toronto, Mississauga and Hamilton. The destination weight distributions for Toronto were much more similar to each other than the origin distributions. Though there is some variation, the general spread of commodities is comparable (Figures 23 and 24). The one area which shows some variation is manufactured products. The CVS could put more effort toward capturing freight transport of manufactured products arriving in Toronto.

When compared to the GGH distributions, the Toronto commodity distributions are quite similar. This was also observed for the origin distributions for Toronto. This may indicate that both surveys provide good coverage of the Toronto municipal commodity movements. Since Toronto is such a large municipality with a lot of industry, it is sensible for data collection agencies to allocate more resources and times to collecting data in this area.

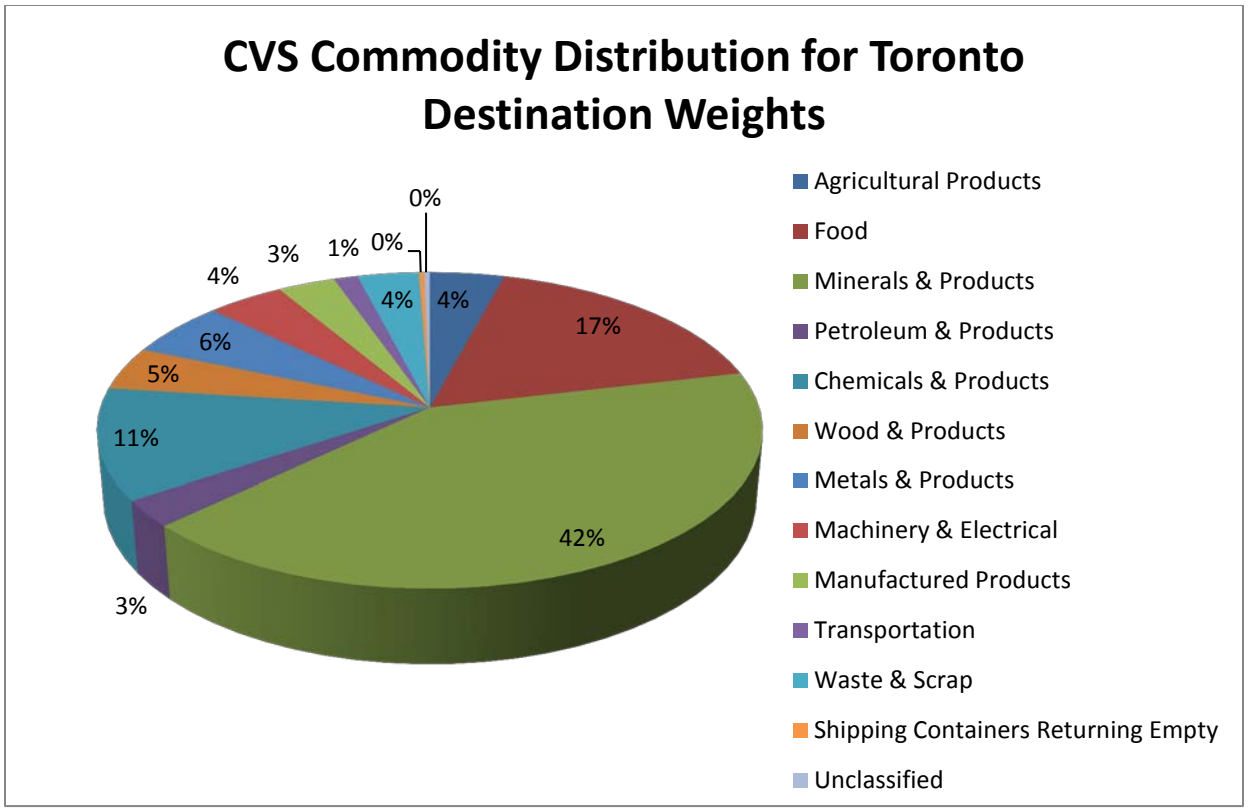


Figure 23 - CVS Commodity Distribution for Toronto Destination Weights (kg)

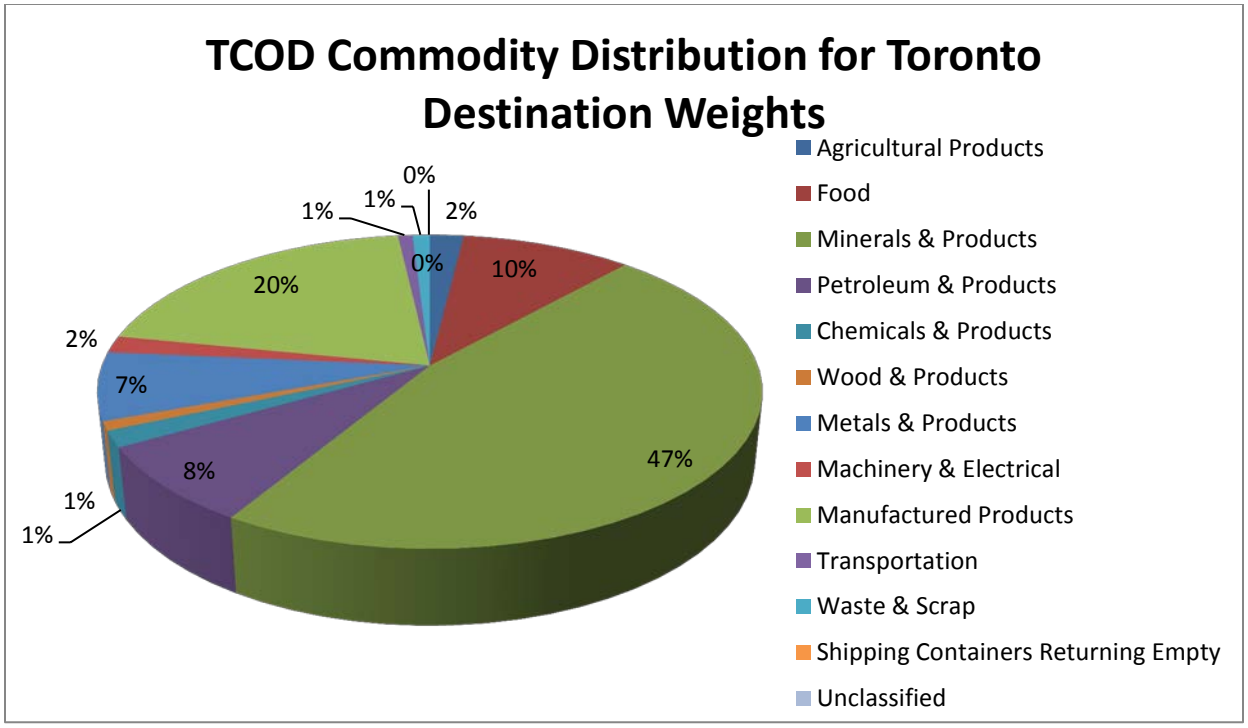


Figure 24 - TCOD Commodity Distribution for Toronto Destination Weights (kg)

The destination weight commodity distributions for Mississauga were not comparable between the CVS and TCOD surveys; coverage of a wide range of commodities was quite variable (Figures 25 and 26). Manufactured products were well represented by the TCOD survey, while minerals and products were best represented by CVS. It is unclear which survey's distribution has a better distribution. They both appear to require better coverage of multiple commodity types.

The Mississauga distributions from the CVS survey data were comparable to the GGH distributions. This does not necessarily mean that the TCOD survey methods need to be improved for this municipality, but may require further investigation to determine why the results for TCOD were so variable.

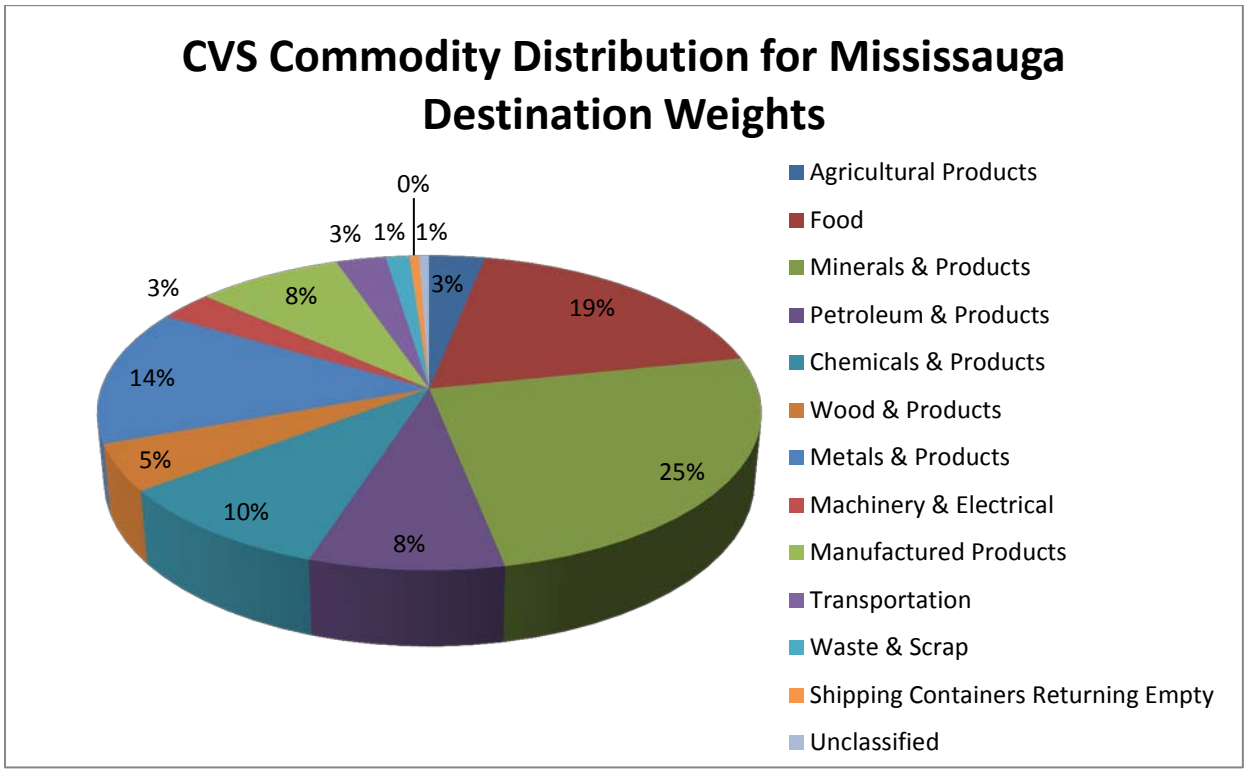


Figure 25 - CVS Commodity Distribution for Mississauga Destination Weights (kg)

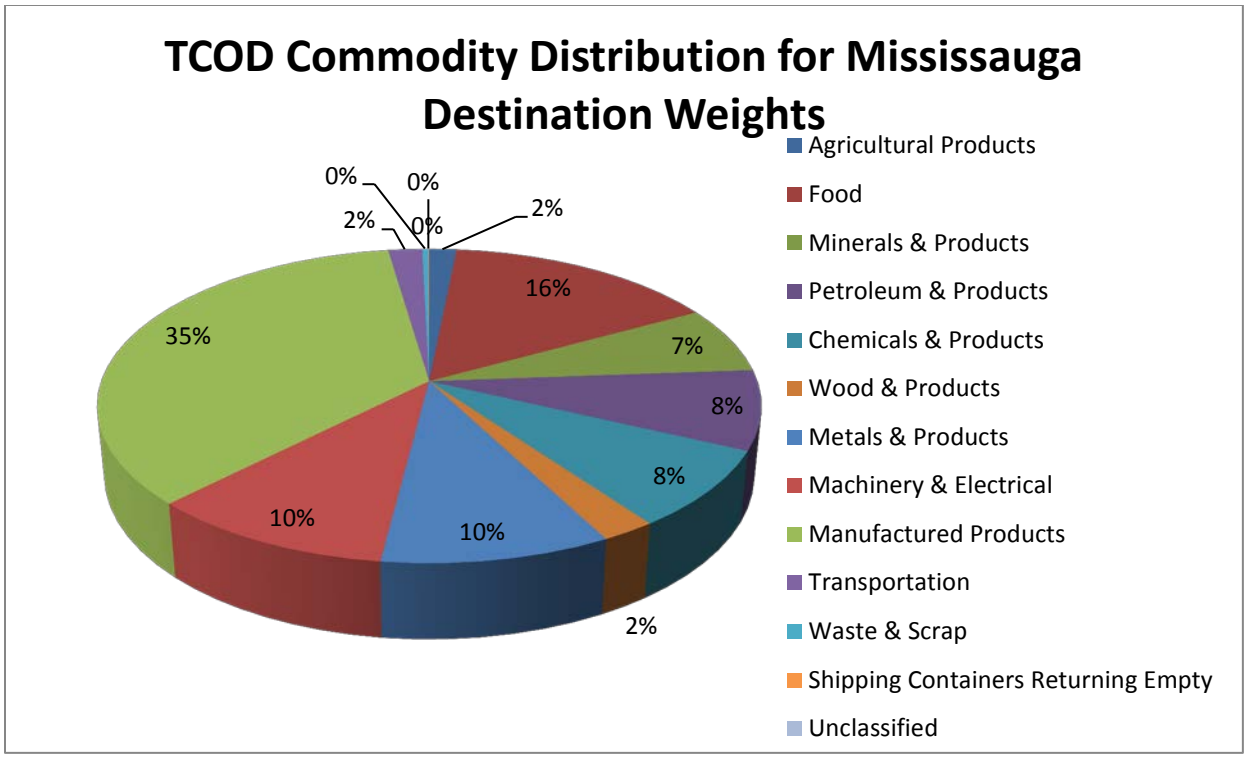


Figure 26 - TCOD Commodity Distribution for Mississauga Destination Weights (kg)

The commodity distributions for destination weights for the Municipality of Hamilton were quite variable, especially with respect to metals and products (Figures 27 and 28). Though Hamilton is known for its production of steel, this should be reflected in the origin weights, and not the destination weights. However the TCOD survey distributes 46% of the weight to metals and products. The TCOD survey should put more effort into capturing the destination weight values of the other commodities to provide a more even distribution of goods, similar to the CVS.

The CVS commodity distributions for Hamilton are somewhat similar to the GGH distributions, while the TCOD distributions are not. As discussed above, a large portion of destination weight was allocated to metals and products, which has skewed the overall distribution. Investigation into why the TCOD survey resulted in such large destination weight values for metal commodities in Hamilton.

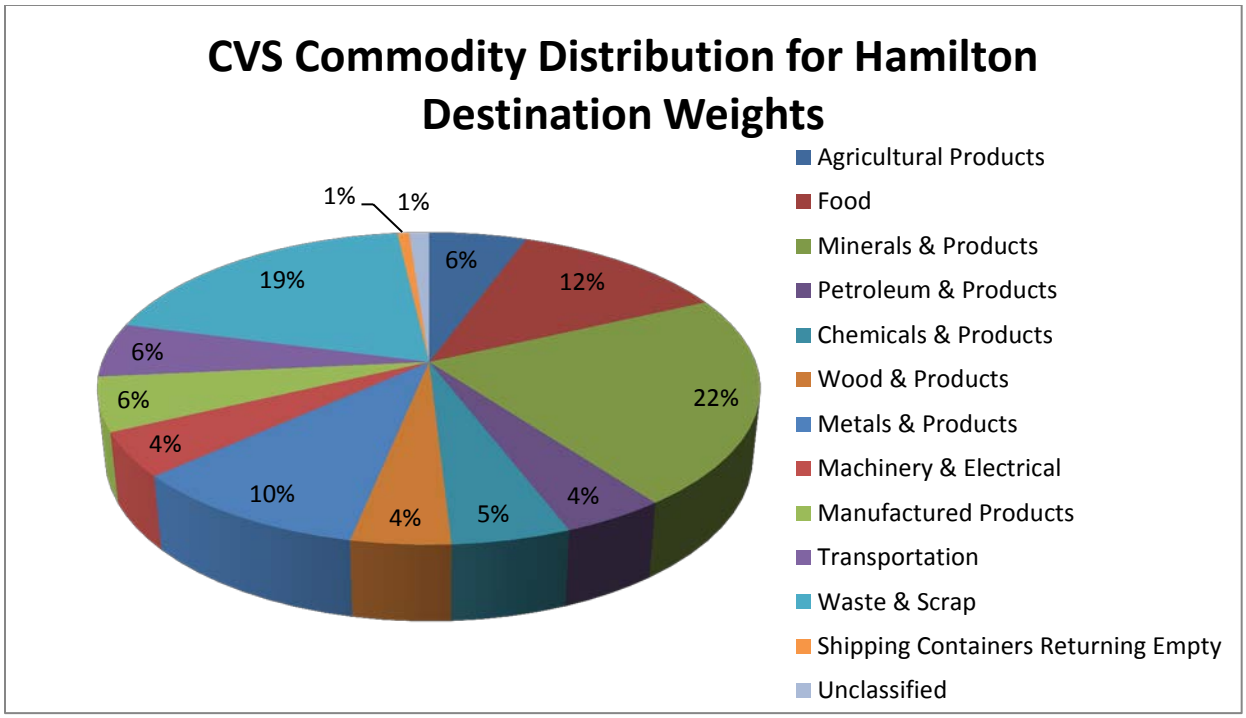


Figure 27 - CVS Commodity Distribution for Hamilton Destination Weights (kg)

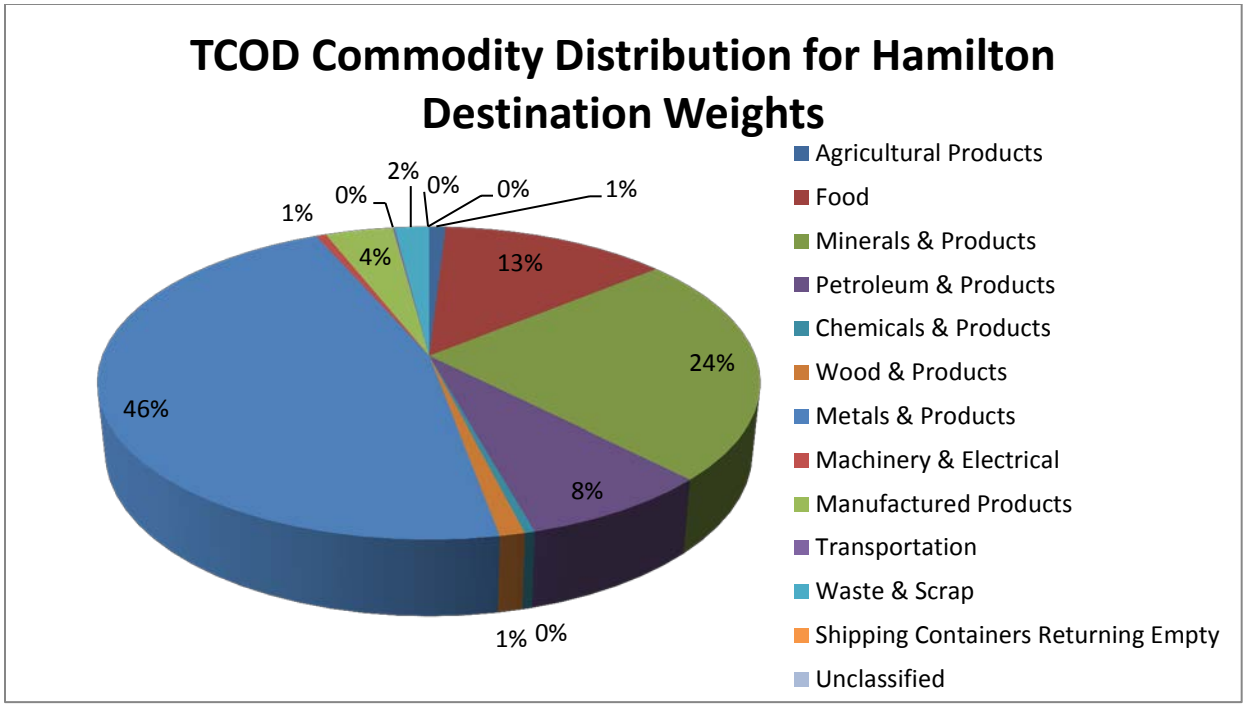


Figure 28 - TCOD Commodity Distribution for Hamilton Destination Weights (kg)

6.0 Recommendations

This spatial analysis yielded several recommendations which may improve the accuracy and effectiveness of survey data collection and comparison methods. It also provided some insight into potential freight policy considerations. Table 8 outlines the findings of this report along with the recommendations.

Table 8 - Project Recommendations

Recommendations for data collection, data comparison and freight policy considerations		
Type	**Section**	**Description**
Data Collection	4.1	CVS uses XY coordinates and TCOD uses postal codes as location fields; it would be preferred for similar fields to be used for comparison purposes.
	5.1.1	The CVS is time exhaustive and very costly, limiting the resources available to perform the survey. This is a drawback to the CVS because there is not full coverage of freight movements, especially in the outer regions of the GGH.
	5.1.2	Though it may not be feasible, adding more survey locations would capture a greater number of freight movements in the GGH.
	5.1.2	For the CVS, intra-municipal trips will not be identified if there is not a physical survey site set up in that particular location. This may explain why there are so few intra-municipal trips outside the GTA for the CVS. More survey locations are recommended.
	5.1.5	CVS data was collected in 2006 and TCOD data in 2010. There may have be different freight movement trends during each of the two years, such as impacts from the 2008 economic recession. This may impact accuracy of the comparisons. Similar dated surveys are recommended.
	5.1.5	From the density maps comparison, it is suggested that the MTO look to add survey locations to the where the CVS data is zero and TCOD data has a large weight value (mostly outer GGH regions).
	5.2	There is a high density point location just south of Guelph. This area is not a CVS location, and it is recommended that this area be considered as an additional survey location.

	5.2	The TCOD survey does not include specific point locations. Without these points, the data can only be linked to a zone or municipality. Predetermined zones may not accurately define the centers of freight activity, so it is recommended that the TCOD survey include specific point locations.
	5.3.1	The overall distribution of the commodities of the CVS and TCOD databases were somewhat similar. Similar distributions are seen for food, petroleum and products, metals and products, machinery and electrical, and agricultural products. Varying distributions are seen for the remaining categories. Transportation, waste and scrap, and shipping containers returning empty are not well captured by the TCOD survey. It is recommended that more effort be put toward these categories during data collection.
	5.3.3	Investigation into why the TCOD survey resulted in such large destination weight values for metal commodities in Hamilton is recommended.
Data Comparison	4.1	There were no common characteristics between the two surveys to link them together. Adding a common element to one of the surveys would make future study between these two surveys less challenging.
	5.1.1	The CVS survey is costly and time consuming, finding a relationship or conversion factor between the TCOD survey and the CVS would be very beneficial to the MTO as the CVS database could be populated without the expense.
	5.1.1	Havelock-Belmont-Methuen is located outside the GTA but has a high origin weight density. This may be a result of the area's mining industry and rail yard. If freight is unloaded from trains to trucks, this may account for the large number of origin weights outside the GTA.
	5.1.2	The transport of waste and scrap within a municipality was common among Toronto, Oakville and Hamilton indicating that each municipality may be responsible for a portion of their own waste disposal.
	5.1.3	Destination weight values in the outer areas of the GGH appear to be lower than the origin weight values for the same locations. This may be because municipalities with smaller populations would require less freight shipment deliveries, therefore more goods are shipped by these

		regions than are received.
	5.1.4	During the analysis a potential outlier was identified in Orillia which has large weight value of freight movements within the municipality. The commodities transported include of water, aggregate, topsoil and heavy equipment. There are several quarries in the Orillia area which may explain the large amount of aggregate shipments.
	5.1.5	Between the two surveys, there is some type of data collected for every municipality. This does not imply that all possible data for those municipalities has been collected but shows that the two surveys could be used together to fill in gaps in each of the databases.
	5.1.5	The CVS shows higher densities than TCOD for several municipalities along Highway 401 corridor possibly because the CVS has four truck inspection stations and 12 other survey locations along Highway 401. Similarly the group of municipalities in central/north GGH with high densities may have been captured by the two truck inspection stations on the Highway 400. Existing locations are effectively collecting data.
	5.2	Point density maps can be used to help determine the locations of major warehouses and truck activity centres.
	5.3.2	The CVS commodity distribution for Toronto is very similar to that of the CVS distribution for the GGH. There is consistency between the municipal and GGH area collection. In Mississauga, agricultural products are not well captured by the TCOD survey. Manufactured products are better represented on the TCOD distribution. The CVS may place more effort in this area to improve the distribution. When compared to the GGH, Mississauga commodity distributions are not comparable. This does not suggest that the distributions for Mississauga are inaccurate, but it is recommended that further investigation into the current data collection locations in the city be considered. It is also possible that the supply and demand of goods in the Mississauga are unique to that particular city. In Hamilton, the CVS commodities are more evenly distributed, while the TCOD survey distributions are heavily weighted toward three commodities; minerals and products, petroleum and products, and metals and products. The TCOD survey should put more focus on the large number of poorly represented commodity types.

	5.3.3	The CVS could put more effort toward capturing freight transport of manufactured products arriving in Toronto. In Mississauga, both surveys appear to require better coverage of multiple commodity types. The Mississauga distributions from the CVS survey data were comparable to the GGH distributions. This does not necessarily mean that the TCOD survey methods need to be improved for this municipality, but may require further investigation to determine why the results for TCOD were so variable. Though Hamilton is known for its production of steel, this should be reflected in the origin weights, and not the destination weights. However the TCOD survey distributes 46% of the weight to metals and products. The TCOD survey should put more effort into capturing the destination weight values of the other commodities to provide a more even distribution of goods, similar to the CVS.
Freight Policy	5.1.1	By identifying centres of truck activity in the GGH, the MTO can use this information for policy and planning purposes. When planning for future highway infrastructure, identification of high truck concentrations may assist in determining the highway needs in a specific area and help predict the number of trucks anticipated to use a particular section of roadway.
	5.1.1	Identification of truck activity centers could be used to evaluate or implement policies to regulate freight movements with respect to delivery times (off peak hours) and lane restrictions.
	5.2	Locating survey locations near municipality border, especially Brampton/Mississauga and Toronto/Vaughan would help capture a greater number of freight trips and may be a way to encourage more municipal coordination of freight data.

7.0 Conclusion

The CVS is a time consuming and very costly process for the MTO. Due to the restrictions of the survey, the number of data points collected is limited to the resources available. This has encouraged the MTO to consider other possibilities for freight data collection. The TCOD is a valuable resource which contains a large amount of freight data. This report has shown that the number of data points in the TCOD database far outweigh those in the CVS database. It would be beneficial to find relationship between the two surveys and use TCOD data to populate the CVS database.

This spatial analysis of the data sets revealed that there were some trends found in both the CVS and TCOD data surveys. It was seen that most of the trucks that were surveyed were either originating or ending in the Greater Toronto Area (GTA). The commodity distributions of the GGH also follow a similar trend, as does the City of Toronto. However, the TCOD survey has more data for the outer regions of the GGH than the CVS. Also, the commodity distributions for Mississauga and Hamilton were inconsistent and did not follow the GGH trend for CVS and TCOD.

Data collection methods, especially those for the CVS were examined. It was found that the current CVS locations seem to be effectively located throughout the GGH area. The point density maps reveal that many of the truck activity centers are along the provincial corridors. These locations are already well represented by CVS sites. The only recommended improvement may be to increase the total number of survey locations to improve coverage of the survey area.

This spatial analysis of the survey databases, municipality and point density maps, and commodity distribution, reveal that the coverage of the GGH provided by the two surveys overall is variable. In some cases, the CVS has more data for a particular municipality or commodity; while other times the TCOD survey has more data. This may indicate that finding a relationship which produces a statistically significant conversion factor may be challenging, however it may be possible. Though a direct correlation was not found between the CVS and TCOD surveys, recommendations for improvement of data collection methods, analysis techniques and freight policy have been provided.

Appendix A: Data Dictionaries

TCOD Data Dictionary

ID	Description
survey_year	Reference Year of the Survey
q_number	Unique Identifier
stratification_naics	North American Industrial Classification System Code
first_stage_weight	Sample Weight. Pertains to the number of companies represented by this company.
second_stage_weight	Sample weight. Pertains to the number of six month periods represented by the six month period in which this shipment was sampled.
collection_period	Identifies in which period the data was collected.
calibration_factor	Factor used to calibrate estimates based on reported revenue (not yet used).
adjusted_calibration_factor	Adjusted factor used to calibrate estimates based on reported revenue (not yet used).
shipment_instance_number	Unique identifier that is used to link to a specific shipment
edr	Flag indicating electronic data reporter
profile	Flag indicating profile record
multi_shipment	Flag indicating a mutlishipment
multi_shipment_count	Number of multishipments
multi_shipment_member	Indicates the shipment for which the mutlishipments pertain to.
document_code	Code indicating the type of shipment (domestic, international, missing, out of scope)
third_stage_weight	Sample weight. Pertains to the number of shipments represented by this shipment.
fourth_stage_weight	Sample weight. Pertains to the number of multishipments represented by this multi shipment (if applicable).
commodity_instance_number	Unique identifier that is used to link to a specific commodity within the shipment.
commodity_orig_city_name	Origin city name.
commodity_orig_prov_state_alpha_code	Origin province/state alpha code.
commodity_orig_country_uid	Origin country identifier.
commodity_orig_postal_code	Postal code of origin
commodity_orig_sgc	Standard Geographical Code of the origin location.
commodity_orig_sac	CMA of the origin of the commodity. SAC = Statistical Area Classification.
commodity_dest_city_name	Destination city name.

commodity_dest_prov_state_alpha_code	Destination province/state alpha code.
commodity_dest_country_uid	Destination country identifier.
commodity_dest_postal_code	Postal code of destination.
commodity_dest_sgc	Standard Geographical Code of the destination location.
commodity_dest_sac	CMA of the destination of the commodity. SAC = Statistical Area Classification.
commodity_border_type	Code indicating interprovincial, intraprovincial or international movement.
commodity_sctg_code	Code for the Standard Classification of Transported Goods (SCTG) commodity
commodity_name	Name provided in collection data before imputation.
commodity_hazardous_good_original	Flag indicating hazardous good from data collection.
commodity_hazardous_good_imputed	Flag indicating hazardous good after imputation.
commodity_containerized	Flag indicating containerized.
commodity_trailer_on_flat_car	Flag indicating Trailer On Flat Car (TOFC).
commodity_container_on_flat_car	Flag indicating Container On Flat Car COFC).
commodity_weight_kg	Total weight of the shipment in kilograms.
commodity_revenue	Revenue earned from shipment.
commodity_iflg_orig_sgc	Imputation flag for the field orig_sgc
commodity_iflg_dest_sgc	Imputation flag for the field dest_sgc
commodity_iflg_sctg	Imputation flag for the field sctg_code
commodity_iflg_weight	Imputation flag for the field weight_kg
commodity_iflg_revenue	Imputation flag for the field revenue
commodity_distance	Distance travelled for the shipment (derived).
commodity_tonne_km	Tonnekilometres performed (derived).

CVS Data Dictionary

CVS Data Code	**Description**
G01CTYPE1	Type of trucking company; For-Hire or Private
H04TOLON	Trip Origin Longitude
H04TOLAT	Trip Origin Latitude
CAN_US_CNAME_1	Municipality
CAN_CSDNAME_1	City
H06TDLON	Trip Destination Longitude
H06TDLAT	Trip Destination Latitude
F11COMCODE	Commodity Code: Commodities are coded to the 5-digit Standard Classification of Transported Goods (SCTG)
	Daily Weight (kg)
	Daily Trips

Appendix B: TCOD Daily Average Weights

Municipal Name	Municipal ID	Origin Based Daily Average Weight (kg)	Destination Based Daily Average Weight (kg)	Intra-Municipal Based Daily Average Weight (kg)
Vaughan	1	7239713.025	7229076.615	899360.0643
King	2	57222.52077	600150.1222	64.12921839
Mississauga	3	18123195.56	14688043.15	2061440.153
Brampton	4	9036231.684	8172829.269	1324926.865
Oakville	5	2642643.199	2539146.87	246876.0033
Hamilton	6	23056676.14	21008368.06	12845658.96
West Lincoln	7	73816.44588	73574.0629	19025.25814
Haldimand County	8	4438312.408	1583219.082	752175.2737
New Tecumseth	9	1186003.239	485483.0051	71346.55753
Springwater	10	911642.0736	457200.407	0.124273973
Bradford West Gwillimbury	11	446746.7709	3764504.925	1.481345699
Severn	12	64666.09701	547778.7103	43274.0615
Innisfil	13	392692.4745	212625.0345	0
Oro-Medonte	14	7779.945783	74429.8991	0
Barrie	15	6684767.558	6890931.744	3239114.962
Tay	16	548.0583869	64574.09914	0
Muskoka Lakes	17	79656.94778	73759.59103	0
Georgian Bay	18	1.480103014	15360.44789	0
Amaranth	19	158.6516877	19391.68635	0
East Luther Grand Valley	20	19657.26112	70695.96437	0
Mono	21	11869.10939	23115.22521	0
Melancthon	22	0	21.48696934	0
South Bruce	23	98063.10761	67270.51895	0
West Grey	24	1247206.345	127538.5791	0
Southgate	25	49234.06645	101771.4334	0
Adjala-Tosorontio	26	15462.48726	73715.0292	0
Mapleton	27	238228.8718	500717.0613	13559.24801
Wellington North	28	44430.49812	176709.5226	0
Six Nations (Part) 40	29	0	0	0
Norfolk County	30	252466.6403	752150.9104	14240.72409
Brant	31	1084180.736	968160.6393	1158.144944
New Credit (Part) 40A	32	0	0	0
Wilmot	33	278336.4995	311519.4143	6751.668763
Wellesley	34	185956.7681	193341.8096	0
Perth East	35	48217.85638	34944.94412	0

Norwich	36	310957.839	87310.16599	0
East Zorra-Tavistock	37	173295.5023	20055.48804	0
North Perth	38	168746.7732	690497.4891	0
Howick	39	1767.432506	13655.15667	0
Minto	40	102979.5353	42190.83134	0
New Credit (Part) 40A	41	0	0	0
East Garafraxa	42	293.2512462	52646.17379	0
Puslinch	43	830172.4961	1465826.307	15731.2344
Guelph	44	2429755.713	1529518.167	54050.53715
Guelph/Eramosa	45	347505.3501	170140.0644	0
Erin	46	273730.0894	237739.3409	0
Milton	47	6216320.892	4128681.574	185976.8823
Brantford	48	2712130.653	2833587.255	77442.73161
Six Nations (Part) 40	49	0	95773.21038	0
North Dumfries	50	110584.1889	146199.4992	0.211265753
Waterloo	51	1897288.709	636448.4586	345.853815
Woolwich	52	780250.8322	955881.706	20071.79147
Kitchener	53	455467.3461	1489265.162	56706.69444
Blandford-Blenheim	54	0	0	0
Cambridge	55	1314869.805	1932763.798	92067.62077
Centre Wellington	56	158041.6547	100339.441	798.8555113
Burlington	57	3013331.042	3806726.691	850542.1586
Caledon	58	3415968.079	1309600.723	161010.8354
Halton Hills	59	1926883.692	1321260.632	85340.26893
Orangeville	60	362688.858	356956.768	12461.96869
Shelburne	61	145904.8563	305681.2081	0
Blue Mountains	62	61803.32029	61019.69711	0
Clearview	63	673147.9015	96092.4388	20079.71583
Collingwood	64	270695.0599	222671.1786	0
Wasaga Beach	65	0	209.1235049	0
Tiny	66	11.454332	27466.01094	0
Grey Highlands	67	126593.3776	43135.08684	0
Essa	68	0.932054795	26771.54458	0
Mulmur	69	0	1.199243808	0
Penetanguishene	70	125812.081	54461.83452	0
Christian Island 30A	71	0	0	0
Midland	72	548094.3031	114009.7541	0
Quinte West	73	547748.1443	387414.6697	0
Stirling-Rawdon	74	49754.11021	5435.292091	0
Marmora and Lake	75	20583.64074	91134.24843	0
Brighton	76	403.5037127	106359.0948	0

Cramahe	77	6274.654739	19167.65125	0
Hamilton	78	21508.64314	16771.7679	0
Port Hope	79	102086.7307	238997.0298	160.9115911
Alnwick/Haldimand	80	11711.58824	21553.53036	0
Oshawa	81	1446673.649	1497456.477	21679.44749
Clarington	82	3326775.955	533456.1624	45223.20103
Scugog	83	897481.0925	270274.5521	0
Uxbridge	84	1927226.468	2472211.652	1304807.322
Whitchurch-Stouffville	85	73635.62933	2529737.771	25102.3598
Newmarket	86	66512.7455	695732.2271	4089.020711
Erie	87	0	0	0
Wainfleet	88	96449.46888	621866.9885	0
Pelham	89	9571.406769	67622.74968	0
Welland	90	198775.4467	740508.3384	116198.4419
Niagara Falls	91	385259.8346	942636.8921	11352.61902
Port Colborne	92	2796346.37	1371417.367	1245897.365
Fort Erie	93	67922.51831	480235.9637	0.969336932
Pickering	94	844119.4546	1333518.372	594.5015878
Toronto	95	36264604.87	45420946.03	17581867.8
Niagara-on-the-Lake	96	31883.15997	19514.6535	1144.353281
Lincoln	97	871083.1419	1134142.108	43402.51203
Grimsby	98	37248.65488	865193.253	3634.05276
Thorold	99	657284.7143	1069782.285	193104.6405
St. Catharines	100	407090.4384	664271.1141	265095.6838
Richmond Hill	101	235845.6158	1018861.261	23.05798532
Aurora	102	85621.42836	620280.9257	1237.94678
Markham	103	842318.963	2344024.582	27528.35936
Whitby	104	1791104.058	986853.2169	106250.97
Ajax	105	1347452.151	1248511.423	87987.24172
Cobourg	106	189096.5924	306655.0349	200.8225228
Galway-Cavendish and Harvey	107	83622.51161	67079.82874	0
Kawartha Lakes	108	269895.1395	635892.6642	8631.580921
Bracebridge	109	280666.6165	269221.0069	0
Highlands East	110	1.864109479	4.270053534	0
Minden Hills	111	13598.53241	31.74330085	0
Brock	112	1324.720358	69963.95511	0
Georgina	113	1459.717852	324344.0347	31.26054795
Ramara	114	5591395.211	99747.46453	34732.53545
Orillia	115	5729693.615	5039338.56	4890773.984
Gravenhurst	116	12884.69933	28408.0867	0
East Gwillimbury	117	22799.46544	704264.5125	0

Chippewas of Georgina Island First Nation	118	0	0	0
Mnjikaning First Nation 32 (Rama First Nation 32)	119	0	0	0
Mississaugas of Scugog Island	120	0	0	0
Alderville First Nation	121	0	0	0
Otonabee-South Monaghan	122	5480584.459	1331391.83	15208.91303
Douro-Dummer	123	56620.27531	76409.4426	10340.32396
Havelock-Belmont-Methuen	124	373225.0499	120305.5407	1292.246323
North Kawartha	125	16525.49909	149247.9289	0
Cavan-Millbrook-North Monaghan	126	32087.19102	18553.56726	0
Peterborough	127	48223.97783	5417823.265	7.978388849
Smith-Ennismore-Lakefield	128	10057.11504	4792.061779	0
Hiawatha First Nation	129	0	0	0
Curve Lake First Nation 35	130	0	0	0
Trent Hills	131	1244.939737	24530.41202	0
Asphodel-Norwood	132	146357.9241	3.560449205	0
Wollaston	133	0	0	0
Faraday	134	0	0	0

Appendix C: CVS Daily Average Weights

Municipal Name	Municipal ID	Origin Based Daily Average Weight (kg)	Destination Based Daily Average Weight (kg)	Intra-Municipal Based Daily Average Weight (kg)
Vaughan	1	4276504.559	7945856.088	10895.07
King	2	0	199698.698	0
Mississauga	3	13126111.16	13470675.08	45291.91
Brampton	4	10913788.71	10625407.7	0
Oakville	5	4923628.073	3408549.445	520494.019
Hamilton	6	14408461.87	12495990.25	430574.586
West Lincoln	7	28249.27	205642.026	11345.397
Haldimand County	8	1918479.735	491755.849	0
New Tecumseth	9	169325.462	597616.48	0
Springwater	10	155411.661	165749.013	0
Bradford West Gwillimbury	11	169934.185	1213577.544	0
Severn	12	0	88476.544	0
Innisfil	13	38211.706	882695.475	0
Oro-Medonte	14	31136	82656.239	0
Barrie	15	177151.917	3369819.281	0
Tay	16	0	128654.244	0
Muskoka Lakes	17	0	0	0
Georgian Bay	18	0	0	0
Amaranth	19	0	0	0
East Luther Grand Valley	20	0	0	0
Mono	21	1117.116	7308.36	0
Melancthon	22	0	0	0
South Bruce	23	0	0	0
West Grey	24	0	0	0
Southgate	25	0	0	0
Adjala-Tosorontio	26	0	55175.097	0
Mapleton	27	14321.295	20913.158	0
Wellington North	28	256094.961	231315.928	0
Six Nations (Part) 40	29	0	0	0
Norfolk County	30	0	0	0
Brant	31	684362.361	357223.328	0
New Credit (Part) 40A	32	0	0	0
Wilmot	33	680305.591	524145.894	0
Wellesley	34	17610.353	120112.392	0

Perth East	35	0	0	0
Norwich	36	0	0	0
East Zorra-Tavistock	37	0	0	0
North Perth	38	0	0	0
Howick	39	0	0	0
Minto	40	15965.404	15952	0
New Credit (Part) 40A	41	0	0	0
East Garafraxa	42	0	0	0
Puslinch	43	6279725.349	923642.904	0
Guelph	44	3656071.284	1954178.71	0
Guelph/Eramosa	45	216737.231	53597.502	0
Erin	46	946693.999	0	0
Milton	47	7729096.435	3311364.816	25186.812
Brantford	48	2187555.355	1883618.5	0
Six Nations (Part) 40	49	0	147080.193	0
North Dumfries	50	967442.857	1097292.387	0
Waterloo	51	211646.617	424241.843	185.367
Woolwich	52	367555.775	242935.82	0
Kitchener	53	2993221.293	2788379.359	33466.681
Blandford-Blenheim	54	0	0	0
Cambridge	55	5076953.388	3755364.902	0
Centre Wellington	56	259489.116	111718.525	0
Burlington	57	4446801.153	3845597.172	458.304
Caledon	58	2172367.081	874784.233	280151.08
Halton Hills	59	1960744.473	838985.678	0
Orangeville	60	295152.461	126322.179	0
Shelburne	61	8518.267	56967.92	0
Blue Mountains	62	0	0	0
Clearview	63	224909.98	189810.873	0
Collingwood	64	62205.471	310856.736	0
Wasaga Beach	65	17562.519	93728.912	0
Tiny	66	0	0	0
Grey Highlands	67	0	0	0
Essa	68	105056	398480.521	0
Mulmur	69	0	0	0
Penetanguishene	70	21586.695	31484.124	0
Christian Island 30A	71	0	0	0
Midland	72	106433.428	233666.127	0
Quinte West	73	0	0	0
Stirling-Rawdon	74	0	0	0

Marmora and Lake	75	0	0	0
Brighton	76	102781.062	73761.253	0
Cramahe	77	159277.63	66292.812	0
Hamilton	78	140323.353	41.607	0
Port Hope	79	162367.974	198195.152	0
Alnwick/Haldimand	80	0	64109.043	0
Oshawa	81	547903.437	2371297.015	0
Clarington	82	1694181.7	1567736.168	276753.847
Scugog	83	0	71216.856	0
Uxbridge	84	149333.446	103804.246	0
Whitchurch-Stouffville	85	159960.054	425060.102	0
Newmarket	86	221427.225	704448.933	0
Erie	87	0	0	0
Wainfleet	88	169213.497	103789.125	0
Pelham	89	9404.26	93412.965	0
Welland	90	303293.444	1075170.359	0
Niagara Falls	91	1242835.399	1839894.432	0
Port Colborne	92	1102481.674	456383.784	0
Fort Erie	93	362092.902	665231.364	0
Pickering	94	369163.108	678709.463	0
Toronto	95	19195314.86	23633128.29	791463.73
Niagara-on-the-Lake	96	220503.908	394289.842	0
Lincoln	97	84320.098	478679.855	0
Grimsby	98	63647.659	524221.54	0
Thorold	99	812582.672	837681.312	0
St. Catharines	100	1669545.27	2480662.93	0
Richmond Hill	101	325534.929	869753.721	0
Aurora	102	140911.716	420840.973	0
Markham	103	512485.404	3057756.146	0
Whitby	104	1804645.461	2189837.13	0
Ajax	105	370435.782	708365.753	0
Cobourg	106	558382.005	494464.38	0
Galway-Cavendish and Harvey	107	18260	1449	0
Kawartha Lakes	108	329088.392	442622.235	0
Bracebridge	109	0	0	0
Highlands East	110	0	0	0
Minden Hills	111	0	0	0
Brock	112	84411.042	8886.417	0
Georgina	113	256023.475	95684.513	0

Ramara	114	0	2145.936	0
Orillia	115	26960.328	527762.233	0
Gravenhurst	116	0	0	0
East Gwillimbury	117	124418.564	412948.557	0
Chippewas of Georgina Island First Nation	118	0	0	0
Mnjikaning First Nation 32 (Rama First Nation 32)	119	0	0	0
Mississaugas of Scugog Island	120	0	0	0
Alderville First Nation	121	0	0	0
Otonabee-South Monaghan	122	63220.426	13494.955	0
Douro-Dummer	123	122337.54	0	0
Havelock-Belmont-Methuen	124	4623581.139	124287.232	0
North Kawartha	125	0	26070.131	0
Cavan-Millbrook-North Monaghan	126	192241.846	523527.976	0
Peterborough	127	805735.702	2354392.867	0
Smith-Ennismore-Lakefield	128	47277.816	20852.46	0
Hiawatha First Nation	129	0	0	0
Curve Lake First Nation 35	130	0	0	0
Trent Hills	131	4835.698	139800.486	0
Asphodel-Norwood	132	391736.2	322948.121	80911.2
Wollaston	133	0	0	0
Faraday	134	0	0	0

Appendix D: Commercial Vehicle Survey Locations

Collection Site	Longitude	Latitude	Highway/Road
AllistonEastEB	-79.842183	44.144269	IndustrialPkwy
AllistonEastWB	-79.842685	44.146161	IndustrialPkwy
AllistonWestEB	-79.859763	44.141926	IndustrialPkwy
AllistonWestWB	-79.860642	44.143458	IndustrialPkwy
AmbassadorBridgeEB	-83.074586	42.311373	Hwy3HuronChurchRd
AmbassadorBridgeWB	-83.073322	42.31181	Hwy3HuronChurchRd
BarrieSB	-79.727326	44.428328	Hwy26
BismarckNB	-79.499242	43.057509	NiagaraRd20
BismarckSB	-79.504666	43.057949	NiagaraRd20
BlueWaterBridgeEB	-82.421993	42.997426	Hwy402
BlueWaterBridgeWB	-82.419979	42.999487	Hwy402
BowLakeNB	-77.954536	44.997046	Hwy28
BowLakeSB	-77.957784	45.000951	Hwy28
BowmanvilleWB	-78.64616	43.902676	Hwy401
BramaleaCNTerminalNB	-79.683537	43.740548	IntermodalDr
BramaleaCNTerminalSB	-79.685246	43.739534	IntermodalDr
BurwashNB	-80.804312	46.340139	Hwy69
BurwashSB	-80.811586	46.339259	Hwy69
CanfieldEB	-79.732237	42.97721	Hwy3
CanfieldWB	-79.734488	42.981327	Hwy3
CasselmanWB	-75.005718	45.324618	Hwy417
ChambersCornersNB	-79.365238	42.90335	Hwy3
ChambersCornersSB	-79.369715	42.903356	Hwy3
ChaudieresBridgeNB	-75.713851	45.416443	FleetSt
ChaudieresBridgeSB	-75.715026	45.415824	FleetSt
CochraneEB	-81.043078	49.05777	Hwy11
CochraneWB	-81.043078	49.059978	Hwy11
CookstownWB	-79.67476	44.196802	Hwy89
CorbyvilleNB	-77.386484	44.199098	Hwy37
CorbyvilleSB	-77.388533	44.200178	Hwy37
CornwallBridgeNB	-74.738639	44.998474	Hwy138
CornwallBridgeSB	-74.742504	44.99817	Hwy138
CurryHillEB	-74.360258	45.201708	Hwy401
DoverCentreNB	-82.358329	42.550984	Hwy40
DoverCentreSB	-82.371271	42.544403	Hwy40
DrydenEB	-92.785837	49.785212	Hwy17

DrydenWB	-92.785837	49.787874	Hwy17
DuffsCornersWB	-80.037122	43.193574	WilsonSt
ElfridaEastEB	-79.768709	43.171239	HamiltonRd20
ElfridaEastWB	-79.767486	43.172895	HamiltonRd20
ElfridaNorthNB	-79.773425	43.17678	HamiltonRd20
ElfridaNorthSB	-79.77539	43.177034	HamiltonRd20
FortErieWB	-78.947369	42.913624	QEW
FortFrancesBridgeNB	-93.400291	48.608519	ChurchSt
FortFrancesBridgeSB	-93.402384	48.609073	ChurchSt
FranktownNB	-76.050064	45.009511	Hwy15
FranktownSB	-76.06079	45.007995	Hwy15
FruitlandWB	-79.713146	43.235765	QEW
GananoqueEB	-76.077053	44.358456	Hwy401
GananoqueWB	-76.079792	44.361197	Hwy401
GaslineWB	-79.112596	42.895682	Hwy3
GeorgetownEastEB	-79.905216	43.661769	RiverRd
GeorgetownEastWB	-79.908162	43.664407	RiverRd
GeorgetownNorthNB	-79.963939	43.663086	Hwy7
GeorgetownNorthSB	-79.9678	43.66029	Hwy7
GeorgetownSouthEB	-79.875335	43.647813	Hwy7
GeorgetownSouthWB	-79.875928	43.649196	Hwy7
GeorgetownWestNB	-79.896621	43.610699	TrafalgarRd
GlenTayEB	-76.326568	44.87985	Hwy7
GlenTayWB	-76.330029	44.883703	Hwy7
GravenhurstNB	-79.346695	44.887891	Hwy11
GravenhurstSB	-79.350668	44.886132	Hwy11
GuelphSB	-80.309086	43.614787	Hwy6
HaleyStationEB	-76.779219	45.57044	Hwy17
HaleyStationWB	-76.777983	45.573901	Hwy17
HawkesburyBridgeNB	-74.601112	45.61458	JohnSt
HawkesburyBridgeSB	-74.603663	45.616721	JohnSt
HearstEB	-83.710246	49.69215	Hwy11
HearstWB	-83.709798	49.697372	Hwy11
HeydenNB	-84.322262	46.663491	Hwy17
HeydenSB	-84.327249	46.661781	Hwy17
KemptvilleNorthSB	-75.62727	45.037805	Hwy416
KemptvilleSouthNB	-75.623607	45.022003	Hwy416
KennedyEastWB	-79.278632	43.775824	Hwy401
KennedyWestEB	-79.289325	43.772191	Hwy401
KingNorthNB	-79.567855	43.937932	Hwy400
KingSouthSB	-79.557509	43.873665	Hwy400

LancasterWB	-74.486276	45.145035	Hwy401
LangfordEB	-80.103191	43.173579	WilsonSt
MacDonaldCartierBridgeNB	-75.695629	45.432366	KingEdwardAve
MacDonaldCartierBridgeSB	-75.69704	45.431459	KingEdwardAve
MallorytownEB	-75.831682	44.508267	Hwy401
MallorytownWB	-75.859745	44.488591	Hwy401
MiltonCPTerminalEB	-79.823494	43.558708	TrafalgarRd
MiltonCPTerminalWB	-79.824498	43.559481	TrafalgarRd
MountHopeNB	-79.894718	43.195013	Hwy6
MountHopeSB	-79.898058	43.196087	Hwy6
NewLiskeardNB	-79.672059	47.577186	Hwy11
NewLiskeardSB	-79.678267	47.577082	Hwy11
NorthBayWB	-79.492403	46.33202	Hwy17
NorthshoreEB	-82.586389	46.212237	Hwy17
NorthshoreWB	-82.586389	46.215757	Hwy17
OakvilleEB	-79.712739	43.432678	QEW
OakvilleWB	-79.714802	43.4342	QEW
PeaceBridgeEB	-78.907273	42.906476	QEW
PeaceBridgeWB	-78.906788	42.907777	QEW
PearsonSilverDartSouthNB	-79.624055	43.687742	SilverDartDr
PearsonSilverDartSouthSB	-79.626235	43.688924	SilverDartDr
PearsonVistaNorthEB	-79.642796	43.700612	SilverDartDr
PearsonVistaNorthWB	-79.643293	43.700949	SilverDartDr
PearsonVistaSouthNB	-79.641597	43.698508	SilverDartDr
PearsonVistaSouthSB	-79.641755	43.698332	SilverDartDr
PetersCornersWB	-80.100451	43.294595	Hwy8
PigeonRiverBorderNB	-89.583219	48.001765	Hwy61
PigeonRiverBorderSB	-89.586201	48.002905	Hwy61
PrescottBridgeNB	-75.457521	44.736248	Hwy16
PrescottBridgeSB	-75.461839	44.734715	Hwy16
PutnamEB	-80.967739	42.970494	Hwy401
PutnamWB	-80.968278	42.973652	Hwy401
QueenstonBridgeEB	-79.045301	43.152723	Hwy405
QueenstonBridgeWB	-79.044894	43.153363	Hwy405
RedRockEB	-88.329838	48.967513	Hwy17
RedRockWB	-88.334872	48.967513	Hwy17
RentonEB	-80.245384	42.851514	Hwy3
RentonWB	-80.24731	42.857693	Hwy3
SarniaEB	-82.182219	42.988084	Hwy402
SarniaWB	-82.181807	42.995016	Hwy402

SaultSteMarieBridgeNB	-84.356005	46.509732	Hwy17B
SaultSteMarieBridgeSB	-84.359042	46.509755	Hwy17B
ShakespeareEB	-80.777171	43.367658	Hwy7
ThousandIslandsBridgeNB	-75.976285	44.366286	Hwy137
ThousandIslandsBridgeSB	-75.981214	44.366286	Hwy137
ThunderBayHwy102EB	-89.296538	48.469317	Hwy102
ThunderBayHwy102WB	-89.293589	48.471273	Hwy102
ThunderBayHwy11EB	-89.451484	48.379649	Hwy17
ThunderBayHwy11WB	-89.451484	48.382133	Hwy17
TillsonburgEB	-80.752667	42.837581	Hwy3
TillsonburgWB	-80.755797	42.841817	Hwy3
TrafalgarEB	-79.846333	43.555131	Hwy401
TrafalgarWB	-79.847986	43.556057	Hwy401
TurnersCornersEB	-79.220595	43.071347	NiagaraRd20
TurnersCornersWB	-79.223316	43.073667	NiagaraRd20
VaughanCPTerminalNB	-79.664237	43.811494	RutherfordRd
VaughanCPTerminalSB	-79.665338	43.811467	RutherfordRd
VictoriaNB	-79.896456	43.789109	Hwy10
VictoriaSB	-79.902484	43.785563	Hwy10
WasiNB	-79.356506	46.179542	Hwy11
WasiSB	-79.361467	46.179542	Hwy11
WellandCanalEB	-79.214008	42.89834	Hwy3
WhitbyEB	-78.893629	43.87137	Hwy401
WindsorEastEB	-82.813513	42.238141	Hwy401
WindsorTunnelEB	-83.041768	42.323633	GoyeauSt
WindsorTunnelWB	-83.039299	42.32398	GoyeauSt
WindsorWestWB	-82.905569	42.243285	Hwy401
WindsorDetroitFerryEB	-83.103496	42.265311	SprucewoodAve
WindsorDetroitFerryWB	-83.103355	42.266673	SprucewoodAve
WinonaEB	-79.653776	43.218891	QEW

Appendix E: Original Scope of Project

To: Ministry of Transportation of Ontario **February 1, 2013**

From: Ryerson University – Civil Engineering Department

Subject: Masters of Engineering – Transportation Planning Project

---

Fadwa Behnam, Mohammad Bari and Heather Nottbeck will be working on the "Data" oriented project for the winter semester starting January 2013 and ending in June of 2013 under the supervision of Dr. Chow. All three candidates have experience in Traffic Operation, Road Safety, Transportation Planning and Highway Design.

Recently, MTO Systems Analysis and Forecasting Office (SAFO) presented a case to Dr. Chow regarding the need to validate both TCOD data with CVS data. This includes performing a study to show the benefits and disadvantages of using TCOD to validate future usage. One of the challenges that will be faced is that TCOD data is presented in tons per trip while CVS data is in vehicles per trip. Other challenges include: using nodal origins and destination in congestion with zonal origins and destinations. In addition, there will be a minimal error since the data presented by TCOD and CVS was not collected in the same year.

One of the opportunities with this project is to identify factors to relate the TCOD commodity tonnage with the CVS vehicles. There are very few sources of data for this kind of conversion – many freight models in the U.S., for example, resort to non-validated conversion rates determined from the Vehicle Inventory Use Survey, which has been discontinued since 2002. With the "before" and "after" data present here, we can estimate factors and goodness of fit measures that may be useful to many other freight planning agencies in North America, particularly places in Canada that only have TCOD data and no locally collected CV OD data (which would give a strong argument for its continued funding).

As part of the data fusion process, we will identify factors relating the two sets of data at a common zonal level (from GGH model) by using multiple linear regressions. We will find OD outliers in the data and statistically weak relationships between particular commodities to CV-class pairs that may require more data collection effort in the future. We will also test a range of

commodity aggregation levels to provide MTO with a trade-off analysis of commodity detail versus significance of the conversion to CV-classes.

If time permits, we would also like to compare our findings with other sources for converting commodities to CVs such as the VIUS data used in the U.S., and examine how we can link the commodity types to assigned trucks on the urban network in TransCAD.

SCOPE OF WORK

- Research valid methods to combine and relate data in tons by commodity type to vehicle class units
- Identify duplication of data, outliers, and further data needs
- Compare the TCOD and CVS to determine if they can be used together while still keeping their own identities – this entails creating a fusion model that relates one data set (the TCOD) to the other (CVS) by estimating and evaluating factors of conversion between different commodity type groupings to different CV classes.
- Both EMME and TRANSCAD will be used to create a common zone level for OD matrix comparison; the GGH model zone system will be exported from EMME and imported into TransCAD. Both TCOD and CVS data will be aggregated to the GGH zone system.
- Extrapolate data and validate using other data such as CUS

DELIVERABLES

- List of advantages and disadvantages of both TCOD and CVS databases
- TCOD and CVS data aggregated to GGH model zones, by commodity type (2-3 different levels of grouping will be considered, e.g. all 2-digit SCTG, 20 groups, or 10 groups) and by CV class (the set of classes used by MTO)
- A set of conversion factors between the two databases, estimated with multiple linear regression, to demonstrate the value of the TCOD database, if such relationship exists
- A list of OD outliers and information of particular commodity-group to CV-class pairs that would benefit from additional data collection
- A trade-off analysis between commodity grouping aggregation with statistical significance of commodity to CV relationship

- Final Presentation, delivered to MTO SAFO

PRELIMINARY SCHEDULEFOR MEETING AND MILESTONES

Meetings will be monthly, or as required, and the specific dates will be determined as the project progresses. They can be by teleconference or in person, depending on the clients' availability.

PROJECT TEAM

The Project team has three members that are currently pursuing their masters in engineering under the supervision of Dr. Chow. Fadwa Behnam is an Engineer-in-Training since June 2011 after graduating from the Civil Engineering program at Ryerson University. She has experience in various areas such as project management, traffic engineering, road safety and transportation planning. Fadwa is currently working for the city of Mississauga while pursuing her Master of Engineering part time with Dr. Chow.

Although the work will be shared between the two team members, Fadwa will mainly be responsible for researching ways to combine TCOD data with CVS data and to also create a model using TRANCAD.

Mohammad Bari is an Engineer – in – Training as of August 2012 and has recently graduated from Ryerson University with Bachelor of Engineering in Civil Engineering. He has experience in various transportation engineering topics including transportation planning, traffic operation and management and highway design. Currently Mohammad is doing his Master of Engineering under Dr. Chow.

Mohammad will mainly be responsible for layering the data entered by Fadwa using EMME so that both data bases can be used together to create a model.

Heather Nottbeck is a professional engineer who graduated from Ryerson University in 2009 with a Bachelor of Engineering in Civil Engineering. She currently works for the Ministry of Transportation in the Highway Engineering department and is pursuing her Master of Engineering part-time. She has experience in transportation planning, highway engineering, traffic operations and management, road safety and project management.

Heather will mainly be responsible for analyzing the model created by Fadwa and Mohammad and investigating the advantages and disadvantages of both models as well as identifying any improvements that can be made.

Lastly, we want to thank you for your time and we look forward to starting this new and exciting project. We can be reached at fbehnam@ryerson.ca, mohammad.s.bari@ryerson.ca and hnottbec@ryerson.ca.

Best Regards,

Fadwa Behnam, E.I.T.

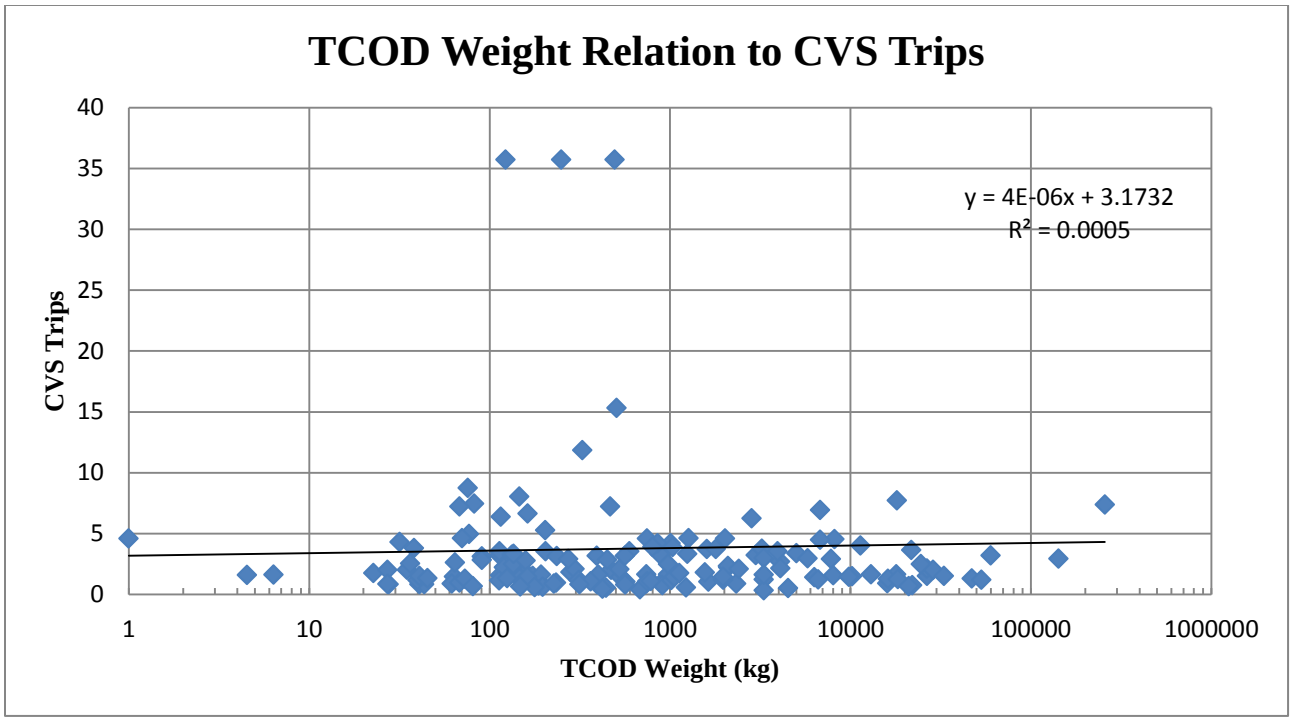
Mohammad Bari, E.I.T.

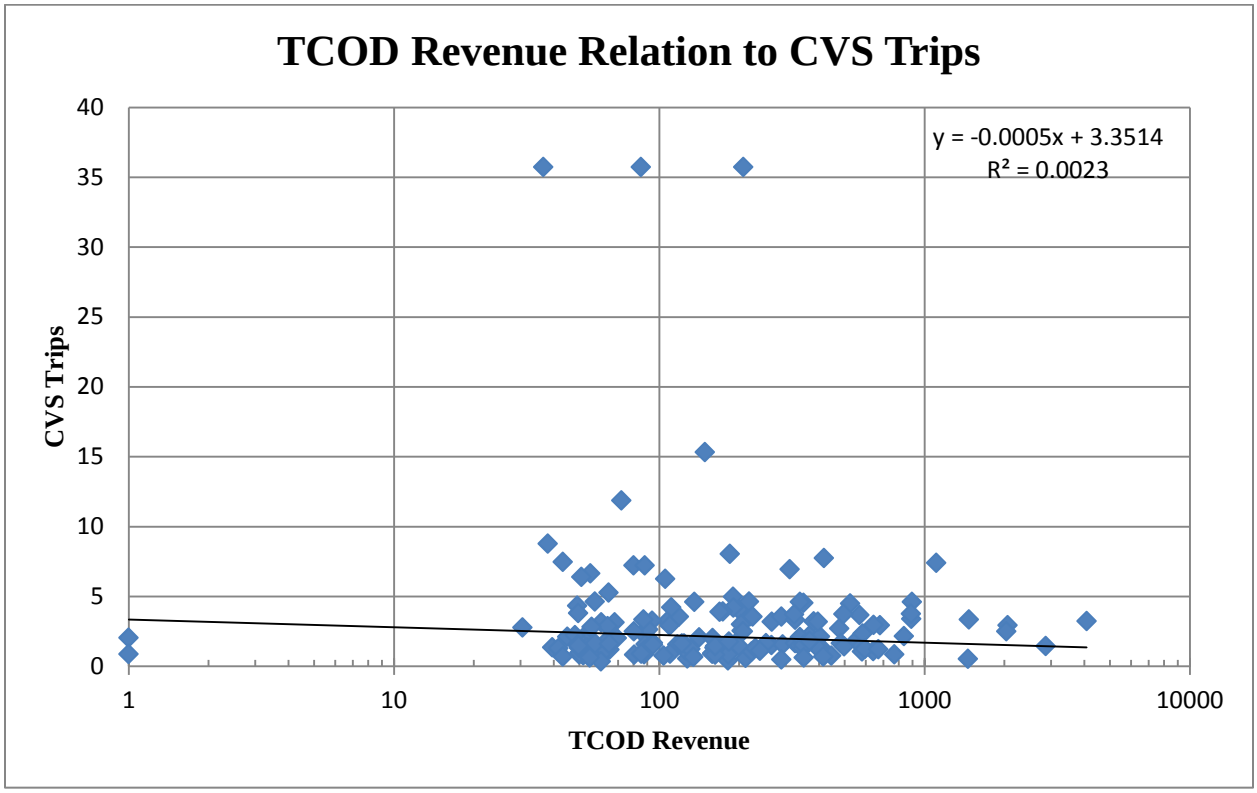
Heather Nottbeck, P. Eng.

Appendix F: Meeting Minutes

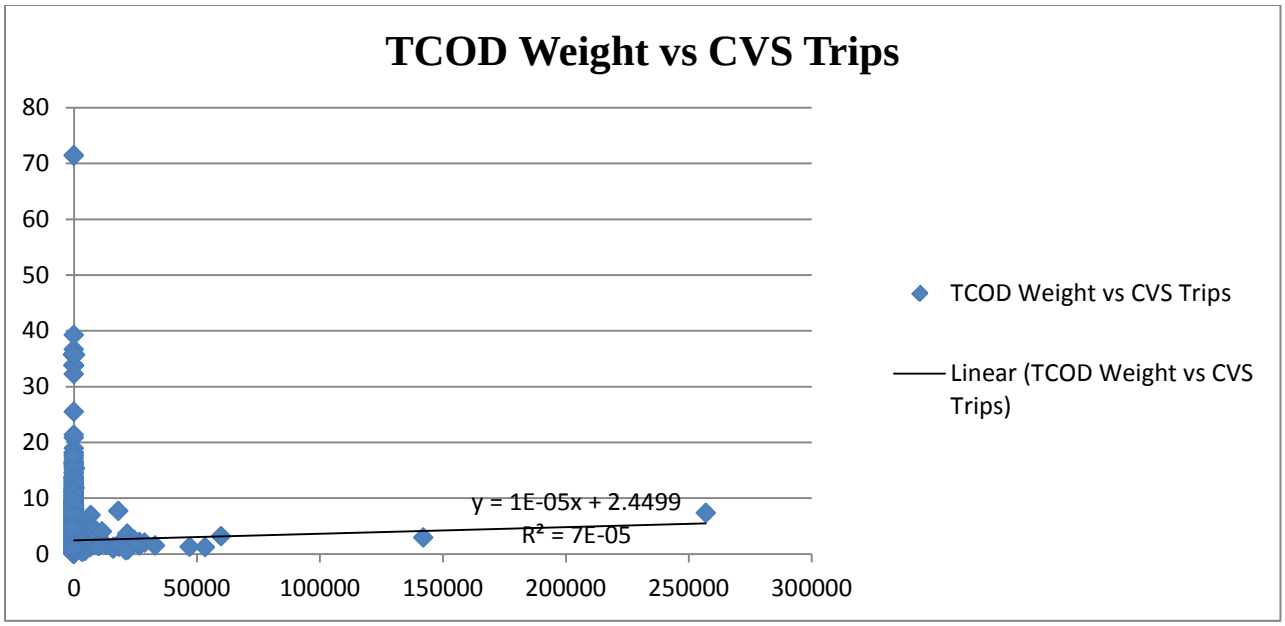
Progress Meeting Minutes- May 16th, 2013

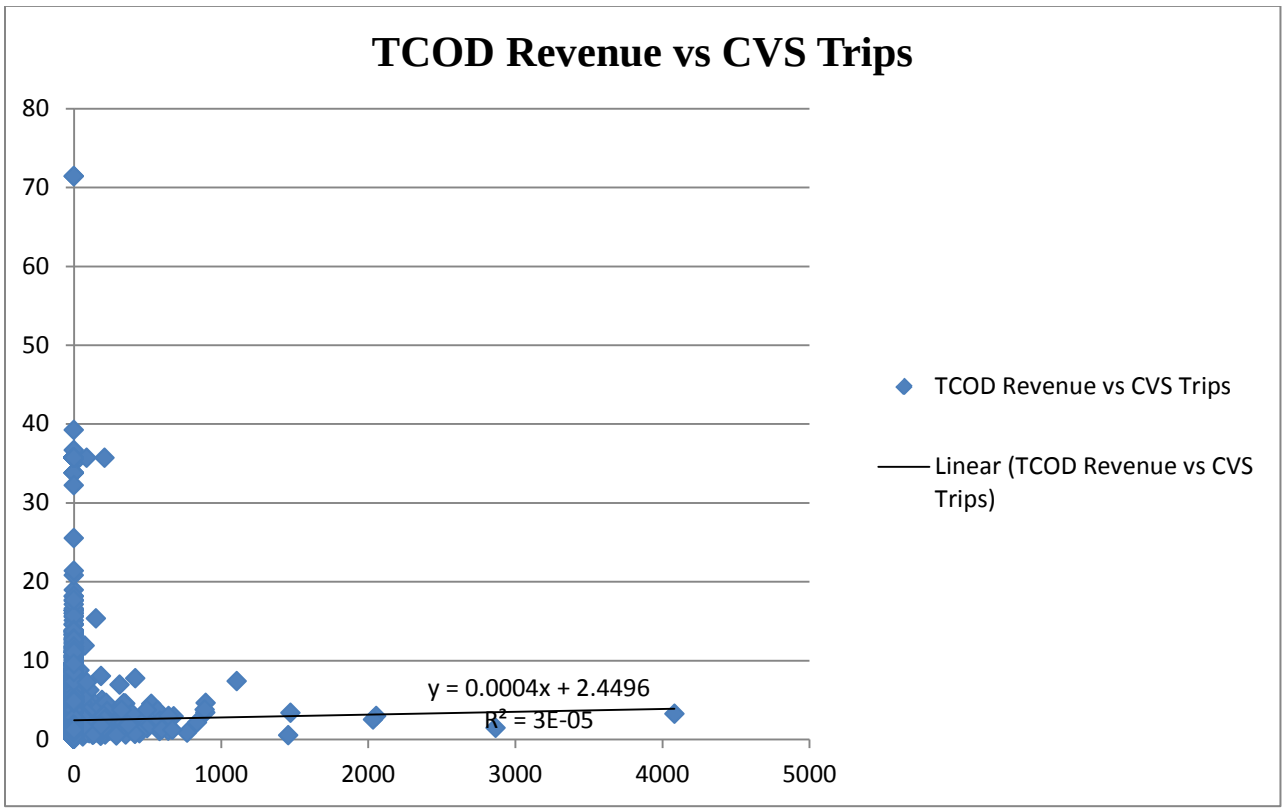
- First the summary of what was completed to date was presented to MTO:
  - After obtaining data from MTO, the TCOD data was grouped into zones using postal codes and the CVS data with longitude and latitude. To determine the geographical location of the postal codes and the longitudes and latitudes, GIS software was utilized to assist with the task.
  - For the TCOD data, each data point had an origin and destination postal code. To determine geographical location of these postal codes, a postal code map that displayed the location was obtained. This map was then overlaid onto the zonal map, which then allowed us to determine which postal code belonged to which zone. With this new map, a table was created that displayed the postal codes with the related zones. This was then used to replace the postal codes within the TCOD database with the corresponding zone numbers. Once this was completed, OD matrix was created to display weight and revenue values.
  - In the case of the CVS database, the origins and destinations were sorted by longitudes and latitudes instead of postal zones; however the procedure to organize the data was similar to the TCOD data. A map was created where one layer had zonal information and another layer had the longitude and latitude information. Using this map a table was created that displayed the longitude and latitudes with their corresponding zones. With this table, all data points now have an origin and a destination zone with the corresponding weight revenue and trip length.
  - To further group and analyze data points, all data points with same origin and destination zone were grouped using Microsoft Access. Also, the CVS OD table and the TCOD OD table were combined and data points are analyzed, using regression and frequency histograms.
- MTO suggested that the data can also be aggregated into Municipalities to see if the overall trends can be seen at a first glance rather than looking for zones within a municipality to find overall trends.
  - The trends below were presented to MTO for the regression analysis completed:



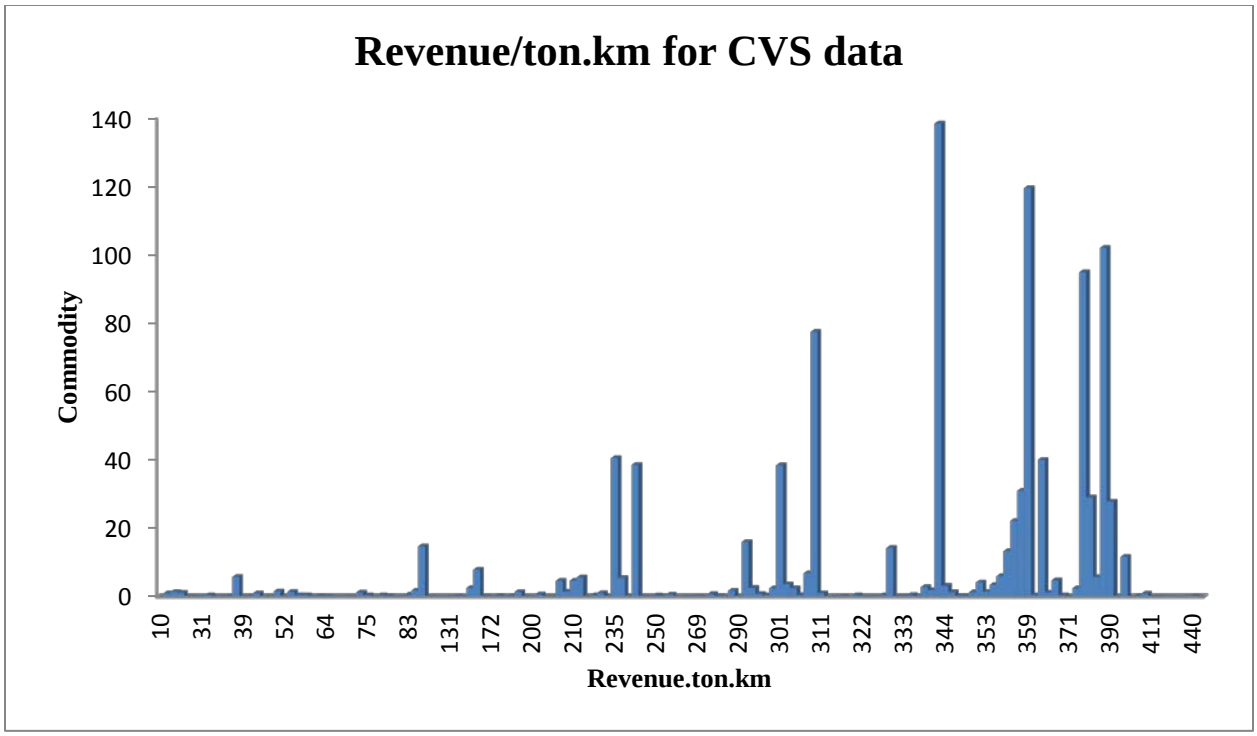


- A linear regression was also obtained for all the data points from CVS and TCOD data as shown in the two graphs below; however, no strong relationship is found.

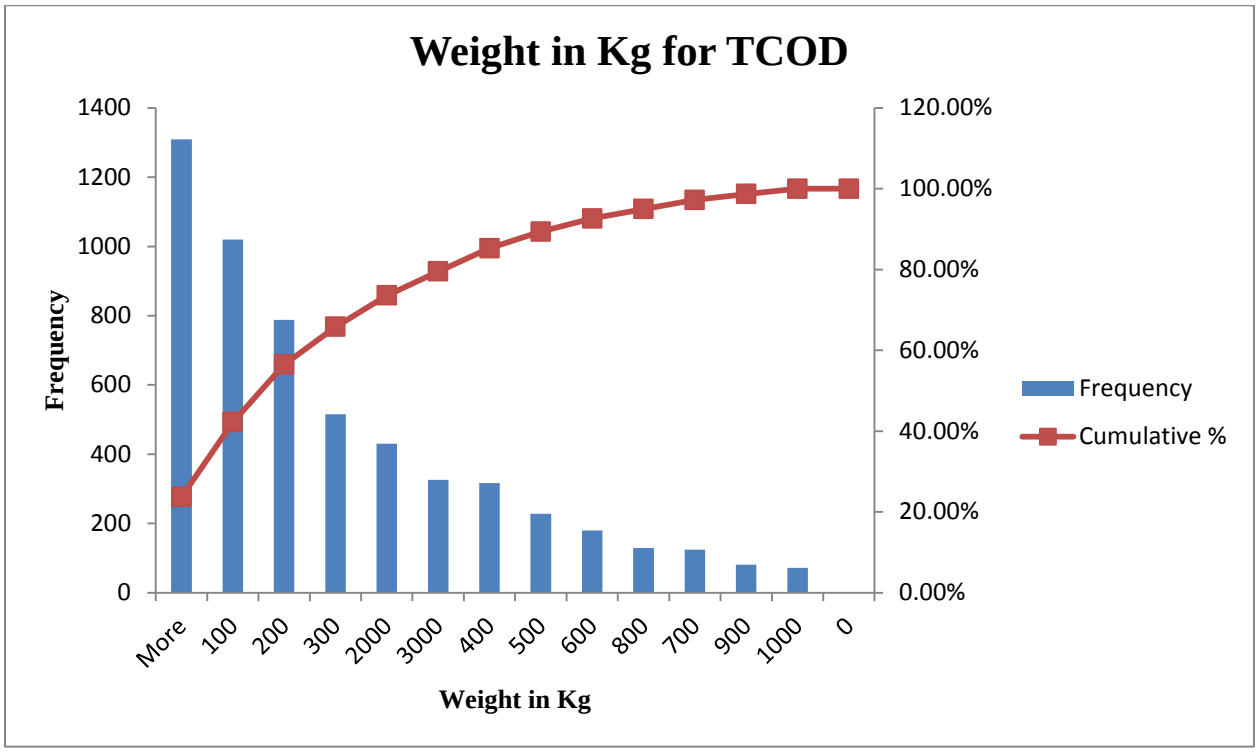




- Below is a sample histogram of Revenue/ ton. Km grouped by commodity type based on the dictionary provided.



- A Sample histogram of Weight in Kg for TCOD data is shown below:

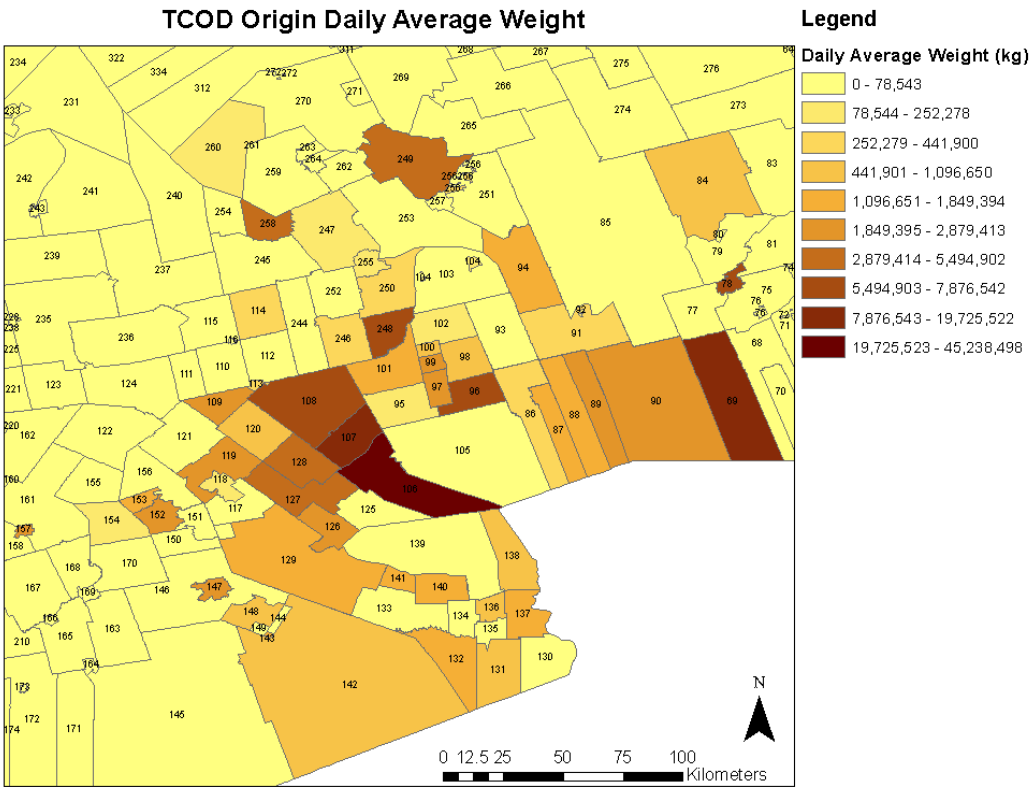


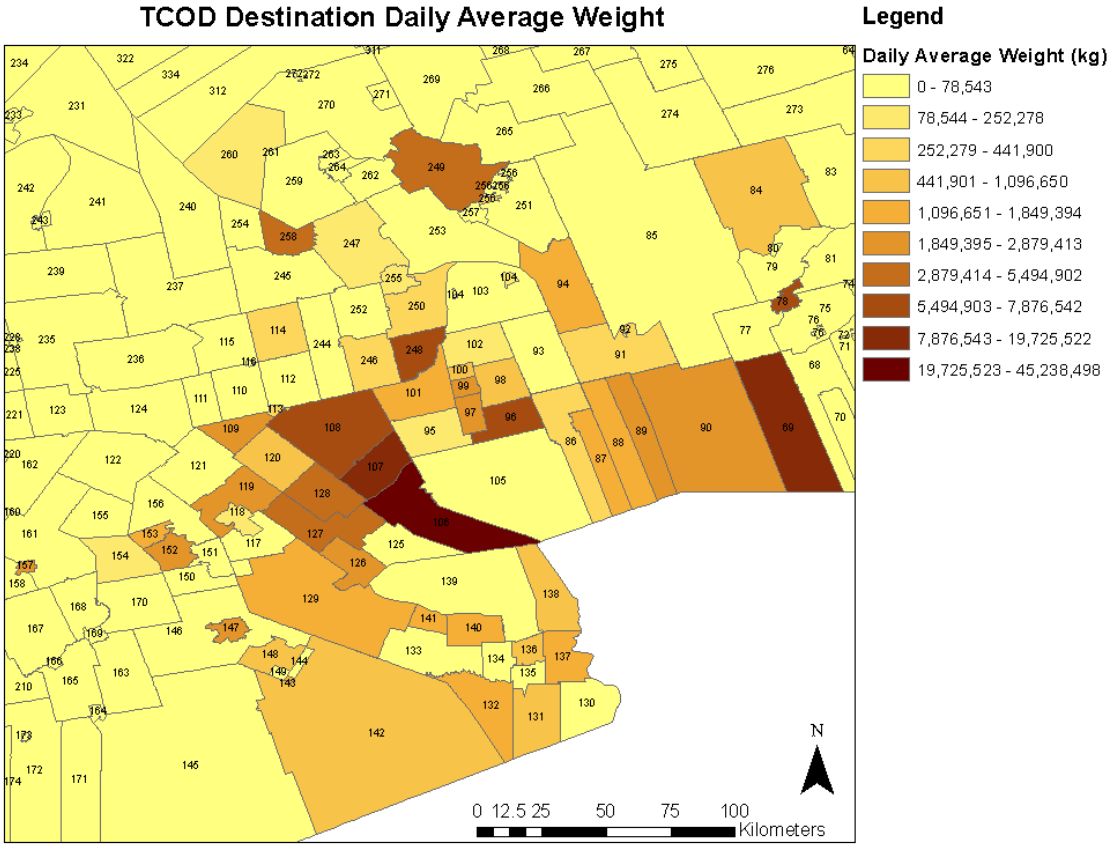
MTO suggested the following:

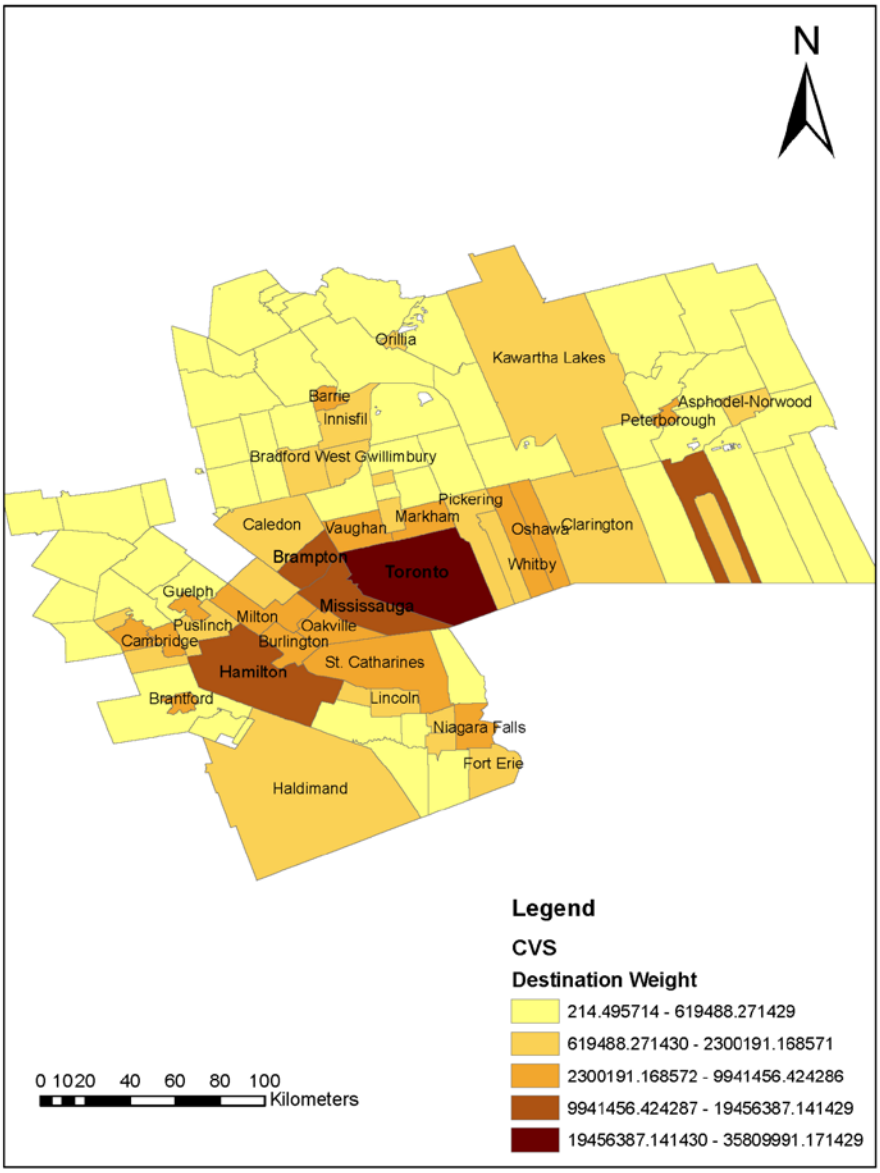
- Compare each database at a higher level before going into specifics
- When looking at a higher level look at municipalities and see what zones are in each municipality
    - Look at inter and intra zonal trip for the municipalities
- Revenue
    - CVS revenue is value of commodity
    - TCOD revenue is cost of delivering good therefore not applicable to us
- Use the weight of the commodity to compare the two
    - Scale the weights to percentage to allow for a better comparison
- TCOD is about 50 to 70 percent of CVS however TCOD is 200% of CVS GTA area
- Compare the maps of TCOD and CVS
    - Look at the dot density of the postal code based production and attraction
- For the CVS database filter out the trucks that have empty trips
- **Need to understand each database before comparing**

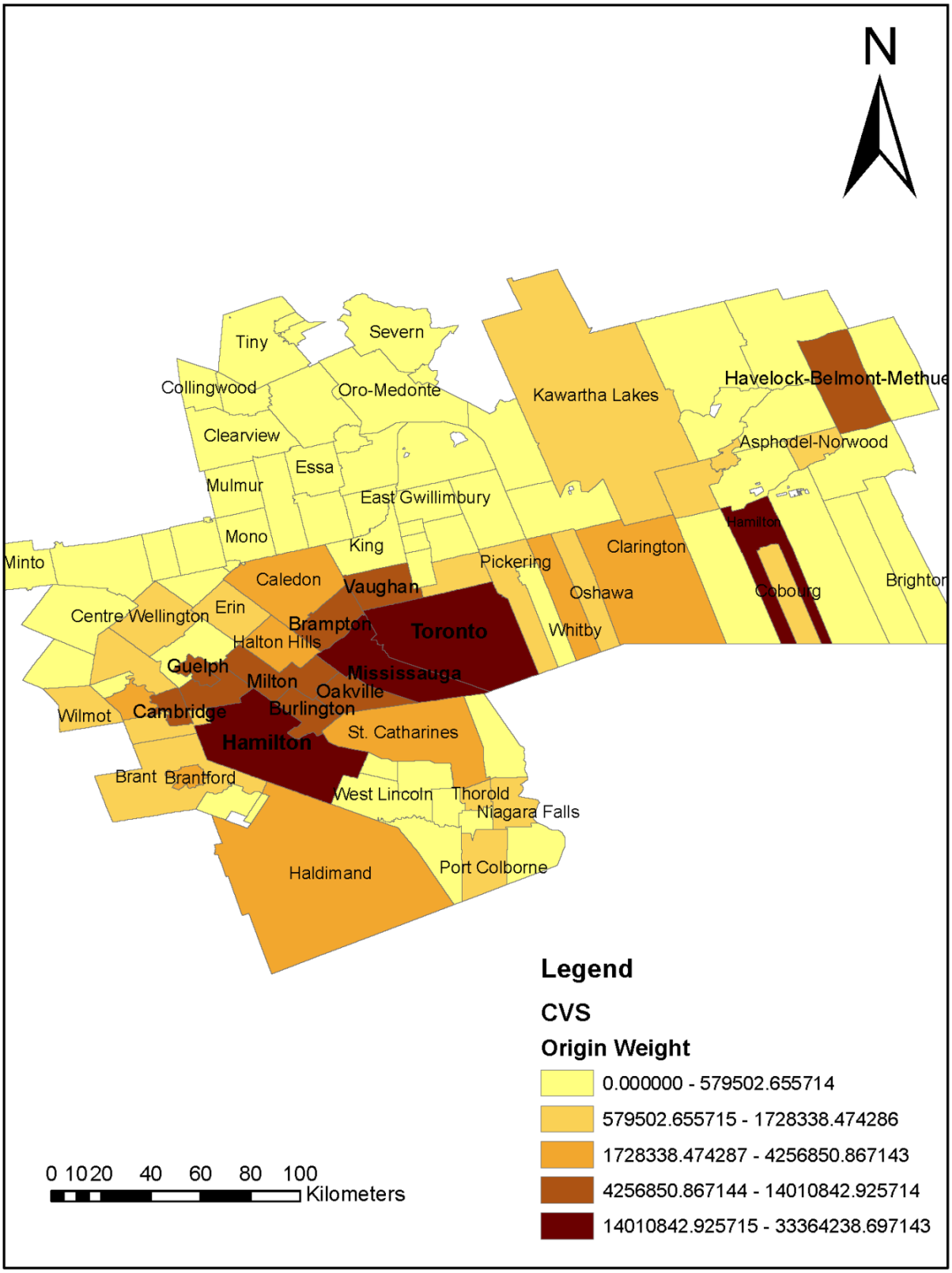
May 31st ,2013 Meeting Minutes

- As discussed in the previous meeting overall trends (using the density maps from ARC GIS) were presented to MTO. This was done for the Origins and destinations of both TCOD and CVS.
- The municipality maps has been retrieved from the Ryerson web site and density maps were also presented to MTO
- The survey area for each survey could be different, therefore they captured different types of trucks for each region
- Since the CVS the only covers Ontario it would have a better grasp of what travels through Ontario, compared to the TCOD which is nationwide survey
- Depending of the time of year each survey is conducted, would dictate how many trucks would get surveyed
- MTO mentioned that the shape file provided might have holes in it, thus new file will be sent shortly. Another analysis must be completed using the new files.
- EMME files for traffic assignment will be sent by MTO.




TCOD Destination Daily Average Weight
Legend
Daily Average Weight (kg)
0 - 78,543
78,544 - 252,278
252,279 - 441,900
441,901 - 1,096,650
1,096,651 - 1,849,394
1,849,395 - 2,879,413
2,879,414 - 5,494,902
5,494,903 - 7,876,542
7,876,543 - 19,725,522
19,725,523 - 45,238,498
N
0 12.5 25 50 75 100
Kilometers


N
Orillia
Kawartha Lakes
Barrie
Innisfil
Asphodel-Norwood
Peterborough
Bradford West Gwillimbury
Pickering
Caledon
Vaughan
Markham
Oshawa
Clarington
Brampton
Toronto
Whitby
Guelph
Mississauga
Milton
Puslinch
Oakville
Cambridge
Burlington
St. Catharines
Hamilton
Brantford
Lincoln
Niagara Falls
Fort Erie
Haldimand
Legend
CVS
Destination Weight
214.495714 - 619488.271429
619488.271430 - 2300191.168571
2300191.168572 - 9941456.424286
9941456.424287 - 19456387.141429
19456387.141430 - 35809991.171429
0 10 20 40 60 80 100
Kilometers


N
Tiny
Severn
Collingwood
Oro-Medonte
Kawartha Lakes
Havelock-Belmont-Methue
Clearview
Asphodel-Norwood
Essa
Mulmur
East Gwillimbury
Hamilton
Mono
King
Clarington
Minto
Pickering
Caledon
Vaughan
Oshawa
Brighton
Erin
Cobourg
Centre Wellington
Brampton
Toronto
Whitby
Halton Hills
Guelph
Milton
Mississauga
Oakville
Wilmot
Cambridge
Burlington
St. Catharines
Hamilton
Brant
Brantford
West Lincoln
Thorold
Niagara Falls
Haldimand
Port Colborne
Legend
CVS
Origin Weight
0.000000 - 579502.655714
579502.655715 - 1728338.474286
1728338.474287 - 4256850.867143
4256850.867144 - 14010842.925714
14010842.925715 - 33364238.697143
0 10 20 40 60 80 100
Kilometers

		Daily Average Weight (kg)			
Municipality	**ID**	**CVS Origin**	**CVS Destination**	**TCOD Origin**	**TCOD Destination**
Adjala-Tosorontio	245	13,582.18	178,047.84	-	-
Ajax	88	450,650.71	901,232.29	1,376,259.92	1,222,995.73
Alnwick/Haldimand	72	3,982.92	78,648.27	-	-
Amaranth	111	193.80	-	-	-
Asphodel-Norwood	75	1,632,519.15	1,316,198.66	-	-
Aurora	100	140,983.08	452,362.69	85,439.15	669,467.48
Barrie	256	295,939.99	4,407,704.11	27,429.67	314,744.05
Bradford West Gwillimbury	249	191,244.58	1,705,463.80	667,206.90	4,527,270.71
Brampton	108	14,010,842.93	15,394,014.44	9,971,027.10	7,876,542.27
Brant	147	925,240.61	445,885.30	2,667,649.40	2,799,485.67
Brantford	148	2,545,084.98	3,066,422.42	439,592.14	603,856.82
Brighton	67	108,895.86	102,731.13	-	-
Brock	95	113,146.18	96,739.23	4.14	101,479.92
Burlington	127	6,786,811.03	5,404,116.72	2,995,419.59	3,827,219.37
Caledon	109	3,140,612.26	1,133,998.49	4,272,339.15	2,016,153.18
Cambridge	152	7,209,333.63	5,513,073.64	2,093,293.21	2,439,711.07
Campbellford/Seymour,Percy,Hastings	74	48,396.67	257,591.64	-	-
Cavan-Millbrook-North Monaghan	78	950,279.54	573,648.72	5,437,202.36	6,584,336.99
Centre Wellington	122	688,336.28	157,952.62	146,304.11	78,542.71
Clarington	91	2,767,269.74	2,300,191.17	3,166,946.93	426,534.74
Clearview	246	286,376.50	301,551.99	666,677.73	307,217.97
Cobourg	71	759,807.11	853,818.75	-	-
Collingwood	255	63,988.29	556,822.65	128,174.36	216,634.36
Cramahe	68	213,122.09	124,165.21	-	-
Curve Lake First Nation 35	81	-	322.33	-	-
Douro-Dummer	82	122,401.69	176,445.25	-	-
East Garafraxa	110	-	-	-	-
East Gwillimbury	103	162,386.53	469,402.59	5,633.37	1,520.47
East Luther Grand Valley	112	8,609.80	13,814.20	-	-
Erin	121	1,425,091.49	-	-	-
Essa	253	145,685.49	537,249.95	-	-
Fort Erie	131	442,685.18	961,909.83	111,529.48	1,096,649.59
Galway-Cavendish and Harvey	85	27,581.94	19,211.60	-	-
Georgina	104	350,011.63	101,262.42	1,428.47	225,273.89
Grimsby	142	165,952.79	798,207.22	37,136.00	865,197.64
Guelph	119	5,741,982.10	3,281,093.80	2,626,923.21	1,941,244.60

Guelph/Eramosa	120	285,605.27	56,698.53	260,321.15	687,674.05
Haldimand	143	2,643,905.46	858,884.74	5,078,762.52	1,849,393.70
Halton Hills	129	2,818,416.89	1,753,721.71	1,952,071.62	1,430,782.77
Hamilton	69	19,594,177.55	19,226,430.68	22,100,088.77	19,725,522.05
Havelock-Belmont-Methuen	83	5,639,901.71	250,998.82	-	-
Innisfil	251	311,674.92	1,437,976.55	-	-
Kawartha Lakes	86	733,267.25	752,537.21	89,991.34	358,806.03
King	102	29,623.57	335,144.13	5,181.51	115,795.42
Kitchener	153	4,256,850.87	3,959,768.48	418,756.88	1,213,245.37
Lincoln	141	223,295.08	1,090,420.10	1,631,044.14	1,395,128.47
Mapleton	123	282,876.82	291,330.20	-	-
Markham	97	700,309.42	3,950,784.78	914,071.18	2,285,599.95
Midland	265	107,465.71	358,362.29	-	-
Milton	128	11,763,183.40	4,550,214.49	6,126,302.44	3,502,014.99
Minto	124	31,084.50	74,970.18	-	-
Mississauga	107	18,917,629.45	19,456,387.14	17,964,683.32	13,813,394.88
Mono	113	1,116.53	7,323.94	147,173.53	347,951.40
Mulmur	115	-	12,362.40	-	-
New Tecumseth	247	251,306.02	776,288.50	51,499.21	252,278.33
Newmarket	101	223,794.62	1,047,096.59	95,971.21	1,207,995.40
Niagara Falls	138	1,728,338.47	2,872,925.45	388,272.99	898,452.16
Niagara-on-the-Lake	139	309,539.16	554,630.57	-	-
North Dumfries	151	1,444,311.05	1,454,801.94	-	2,356.05
North Kawartha	84	-	26,142.08	600,099.67	652,118.49
Oakville	126	6,536,558.29	4,762,632.54	2,662,419.92	2,525,642.71
Orangeville	114	450,392.61	150,518.54	373,377.10	429,802.88
Orillia	258	51,415.38	1,013,406.95	5,713,942.85	5,494,901.56
Oro-Medonte	254	62,661.05	198,330.76	-	-
Oshawa	90	929,473.55	3,890,099.20	623,561.23	2,246,781.64
Otonabee-South Monaghan	76	401,318.59	106,697.22	-	-
Pelham	135	52,042.53	153,269.96	-	-
Penetanguishene	264	43,610.43	40,995.23	111,040.63	54,261.29
Peterborough	79	1,286,437.69	4,648,875.52	10,398.71	30,526.90
Pickering	87	660,957.10	842,002.27	1,095,363.75	1,755,435.53
Port Colborne	132	1,342,851.20	551,367.51	2,884,602.96	1,548,263.75
Port Hope and Hope	70	372,310.99	361,001.95	73,451.95	60,380.11
Puslinch	118	8,331,295.12	1,172,208.22	44,990.16	213,738.27
Ramara	252	-	79,551.97	-	-
Richmond Hill	98	529,750.72	1,271,579.00	242,734.36	1,004,799.29
Scugog	92	217,822.72	155,386.87	69,907.75	249,438.79
Severn	250	47,057.14	156,245.70	5,690,884.96	441,899.67

Shelburne	117	144,921.83	167,490.62	-	-
Six Nations (Part) 40	145	66,112.43	214.50	-	-
Smith-Ennismore-Lakefield	80	80,648.09	41,707.21	3.23	45,330.96
Springwater	248	212,507.17	263,728.27	8,500,916.60	6,973,595.04
St. Catharines	140	2,228,755.27	3,404,781.07	410,546.60	1,523,180.44
Tay	263	-	128,717.28	-	-
Thorold	137	1,118,825.09	1,161,799.11	783,338.96	1,233,270.22
Tiny	260	34,740.63	3,704.32	548,100.11	141,310.77
Toronto	106	33,364,238.70	35,809,991.17	36,376,661.73	45,238,497.67
Uxbridge	94	385,638.72	139,287.87	2,316,447.92	1,661,012.99
Vaughan	96	6,598,740.72	9,941,456.42	6,488,827.95	7,016,162.49
Wainfleet	133	171,859.27	106,203.76	-	-
Wasaga Beach	259	73,582.80	93,860.19	-	-
Waterloo	154	332,510.36	895,133.18	19,295.45	168,511.84
Welland	136	579,502.66	1,321,672.17	162,436.41	642,950.16
Wellesley	156	85,165.62	120,143.72	-	-
Wellington North	125	382,891.87	321,135.89	-	-
West Lincoln	134	73,186.84	548,861.39	-	-
Whitby	89	2,579,225.13	3,385,156.76	2,525,661.10	2,588,023.86
Whitchurch-Stouffville	99	240,750.72	619,488.27	352,766.44	2,879,412.63
Wilmot	155	824,078.37	606,691.54	-	-
Woolwich	157	712,700.67	370,343.95	3,285,654.05	2,067,520.22
Total		195,843,240	195,843,240	176,115,240	176,115,240

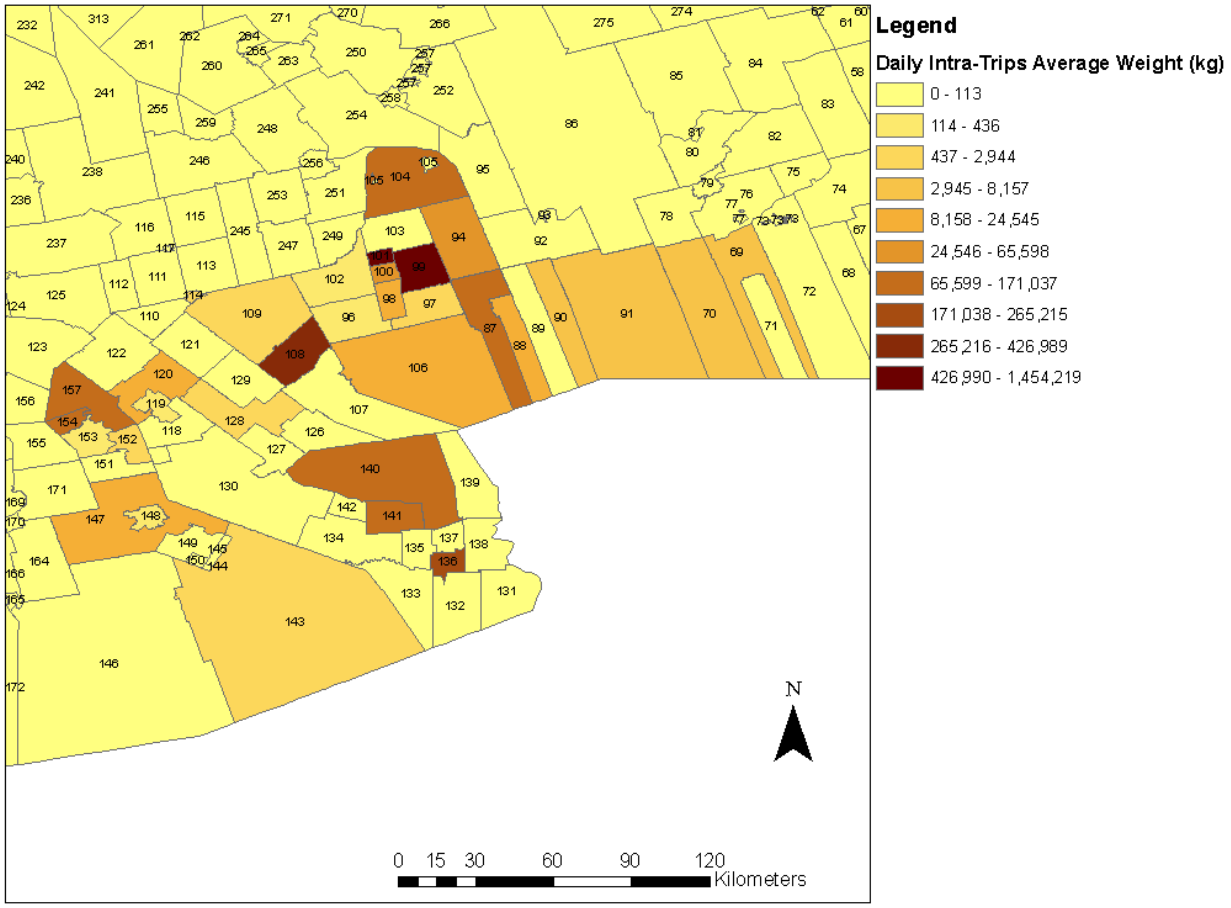
Municipality	ID	Origin Difference	Destination Difference
Adjala-Tosorontio	245	-13,582.18	-178,047.84
Ajax	88	925,609.21	321,763.44
Alnwick/Haldimand	72	-3,982.92	-78,648.27
Amaranth	111	-193.80	0.00
Asphodel-Norwood	75	-1,632,519.15	-1,316,198.66
Aurora	100	-55,543.93	217,104.79
Barrie	256	-268,510.31	-4,092,960.06
Bradford West Gwillimbury	249	475,962.33	2,821,806.91
Brampton	108	-4,039,815.83	-7,517,472.16
Brant	147	1,742,408.79	2,353,600.37
Brantford	148	-2,105,492.84	-2,462,565.60
Brighton	67	-108,895.86	-102,731.13
Brock	95	-113,142.05	4,740.68
Burlington	127	-3,791,391.44	-1,576,897.35
Caledon	109	1,131,726.89	882,154.69

Cambridge	152	-5,116,040.43	-3,073,362.57
Campbellford/Seymour,Percy,Hastings	74	-48,396.67	-257,591.64
Cavan-Millbrook-North Monaghan	78	4,486,922.81	6,010,688.26
Centre Wellington	122	-542,032.17	-79,409.91
Clarington	91	399,677.19	-1,873,656.43
Clearview	246	380,301.23	5,665.98
Cobourg	71	-759,807.11	-853,818.75
Collingwood	255	64,186.06	-340,188.29
Cramahe	68	-213,122.09	-124,165.21
Curve Lake First Nation 35	81	0.00	-322.33
Douro-Dummer	82	-122,401.69	-176,445.25
East Garafraxa	110	0.00	0.00
East Gwillimbury	103	-156,753.16	-467,882.13
East Luther Grand Valley	112	-8,609.80	-13,814.20
Erin	121	-1,425,091.49	0.00
Essa	253	-145,685.49	-537,249.95
Fort Erie	131	-331,155.70	134,739.76
Galway-Cavendish and Harvey	85	-27,581.94	-19,211.60
Georgina	104	-348,583.16	124,011.47
Grimsby	142	-128,816.79	66,990.43
Guelph	119	-3,115,058.89	-1,339,849.20
Guelph/Eramosa	120	-25,284.12	630,975.53
Haldimand	143	2,434,857.06	990,508.96
Halton Hills	129	-866,345.28	-322,938.94
Hamilton	69	2,505,911.21	499,091.37
Havelock-Belmont-Methuen	83	-5,639,901.71	-250,998.82
Innisfil	251	-311,674.92	-1,437,976.55
Kawartha Lakes	86	-643,275.91	-393,731.18
King	102	-24,442.06	-219,348.70
Kitchener	153	-3,838,093.99	-2,746,523.11
Lincoln	141	1,407,749.06	304,708.36
Mapleton	123	-282,876.82	-291,330.20
Markham	97	213,761.76	-1,665,184.83
Midland	265	-107,465.71	-358,362.29
Milton	128	-5,636,880.96	-1,048,199.51
Minto	124	-31,084.50	-74,970.18
Mississauga	107	-952,946.13	-5,642,992.26
Mono	113	146,057.00	340,627.45
Mulmur	115	0.00	-12,362.40
New Tecumseth	247	-199,806.82	-524,010.17

Newmarket	101	-127,823.41	160,898.81
Niagara Falls	138	-1,340,065.49	-1,974,473.29
Niagara-on-the-Lake	139	-309,539.16	-554,630.57
North Dumfries	151	-1,444,311.05	-1,452,445.89
North Kawartha	84	600,099.67	625,976.41
Oakville	126	-3,874,138.38	-2,236,989.83
Orangeville	114	-77,015.52	279,284.34
Orillia	258	5,662,527.47	4,481,494.61
Oro-Medonte	254	-62,661.05	-198,330.76
Oshawa	90	-305,912.32	-1,643,317.55
Otonabee-South Monaghan	76	-401,318.59	-106,697.22
Pelham	135	-52,042.53	-153,269.96
Penetanguishene	264	67,430.20	13,266.06
Peterborough	79	-1,276,038.97	-4,618,348.61
Pickering	87	434,406.65	913,433.27
Port Colborne	132	1,541,751.76	996,896.24
Port Hope and Hope	70	-298,859.04	-300,621.84
Puslinch	118	-8,286,304.95	-958,469.94
Ramara	252	0.00	-79,551.97
Richmond Hill	98	-287,016.36	-266,779.72
Scugog	92	-147,914.97	94,051.93
Severn	250	5,643,827.82	285,653.97
Shelburne	117	-144,921.83	-167,490.62
Six Nations (Part) 40	145	-66,112.43	-214.50
Smith-Ennismore-Lakefield	80	-80,644.86	3,623.75
Springwater	248	8,288,409.43	6,709,866.77
St. Catharines	140	-1,818,208.67	-1,881,600.63
Tay	263	0.00	-128,717.28
Thorold	137	-335,486.13	71,471.11
Tiny	260	513,359.48	137,606.45
Toronto	106	3,012,423.03	9,428,506.50
Uxbridge	94	1,930,809.19	1,521,725.11
Vaughan	96	-109,912.78	-2,925,293.93
Wainfleet	133	-171,859.27	-106,203.76
Wasaga Beach	259	-73,582.80	-93,860.19
Waterloo	154	-313,214.91	-726,621.34
Welland	136	-417,066.24	-678,722.01
Wellesley	156	-85,165.62	-120,143.72
Wellington North	125	-382,891.87	-321,135.89
West Lincoln	134	-73,186.84	-548,861.39

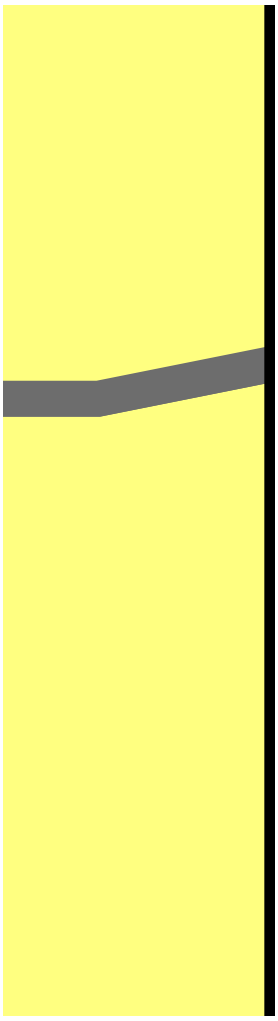
Whitby	89	-53,564.04	-797,132.90
Whitchurch-Stouffville	99	112,015.72	2,259,924.36
Wilmot	155	-824,078.37	-606,691.54
Woolwich	157	2,572,953.38	1,697,176.27

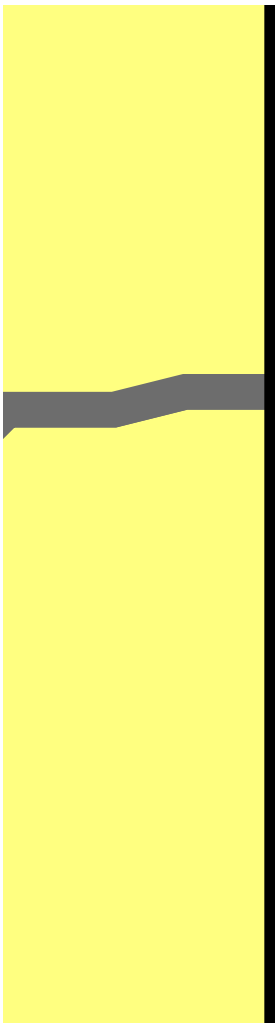
TCOD Intra-Trips Daily Average Weight



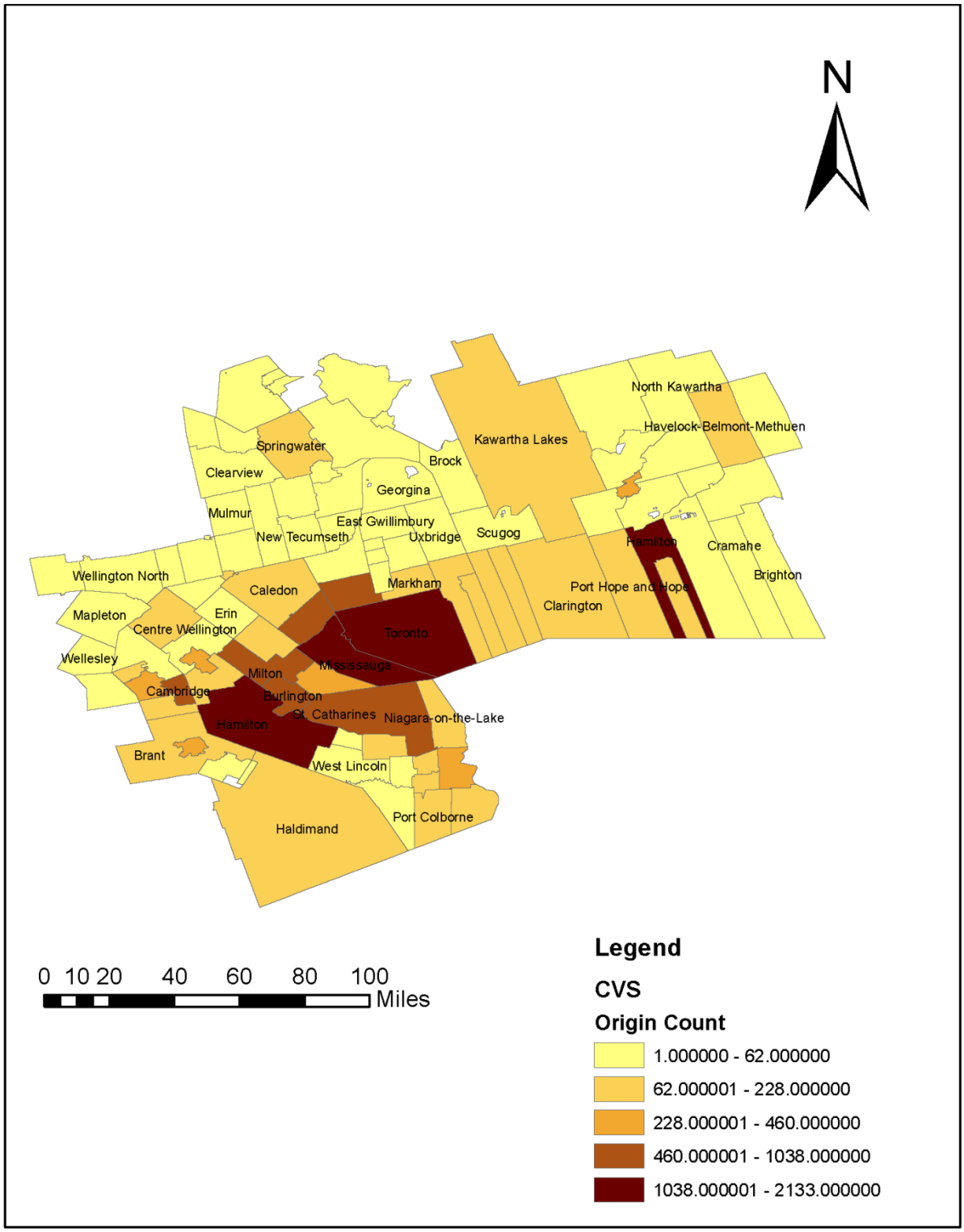
Municipality	ID	Daily Intra-Trips Average Weight (kg)
Whitchurch-Stouffville	99	1,454,219.30
Newmarket	101	1,026,685.70
Brampton	108	426,988.62
Welland	136	265,214.83
Lincoln	141	171,037.10
Waterloo	154	150,139.45
St. Catharines	140	128,724.63
Woolwich	157	110,013.33
Georgina	104	103,490.87
Pickering	87	101,309.84
Aurora	100	65,597.82
Uxbridge	94	36,854.29
Toronto	106	24,545.09
Brant	147	23,290.92
Ajax	88	14,857.08
Richmond Hill	98	12,197.83
Guelph/Eramosa	120	11,689.84
Port Hope and Hope	70	8,157.04
Clarington	91	4,437.72
Oshawa	90	4,229.01
Hamilton	69	3,527.11
Cambridge	152	2,943.90
Haldimand	143	1,416.17
Orangeville	114	1,410.69
Markham	97	1,390.67
Milton	128	1,374.44
Caledon	109	965.46
Brantford	148	436.25
King	102	292.16
Guelph	119	188.67
Vaughan	96	179.47
Kitchener	153	138.13
Grimsby	142	113.34
New Tecumseth	247	31.26
Oakville	126	31.06
Port Colborne	132	27.29
North Kawartha	84	19.57
Burlington	127	15.43

Niagara Falls	138	13.52
Thorold	137	10.00
Fort Erie	131	8.70
Centre Wellington	122	3.10
Cavan-Millbrook-North Monaghan	78	2.32
Clearview	246	1.74
Mississauga	107	0.61
Halton Hills	129	0.59
Whitby	89	0.40

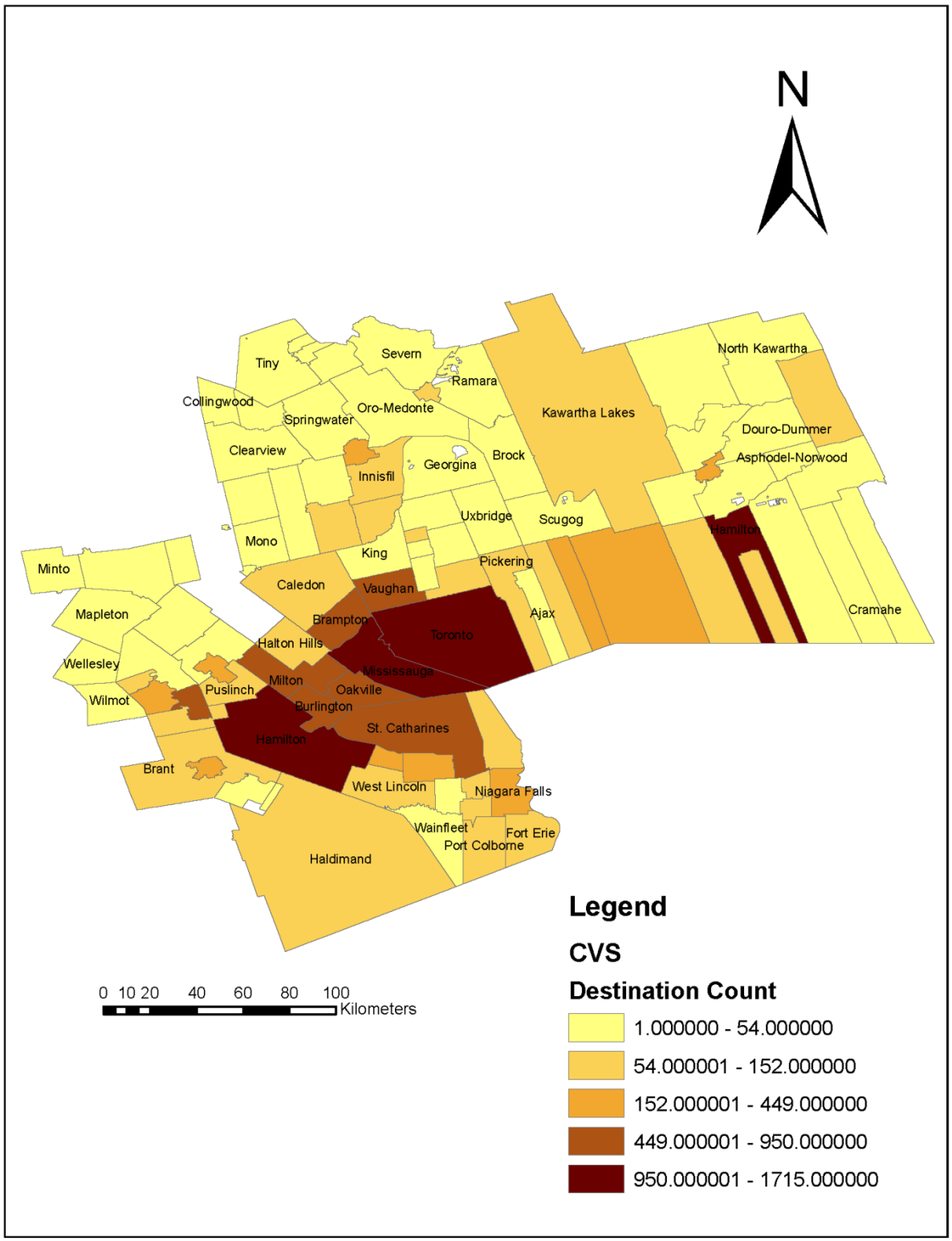




CVS Number of Origin Trips



CVS Number of Destination Trips



References List

Earth Tech (2008). 2006-2007 Commercial Vehicle Survey Field Operations Report. Earth Tech Canada Inc. August 2008.

Statistics Canada (2013). Trucking Commodity Origin and Destination Survey (TCOD). Retrieved from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=2741&Item_Id=122313

MOI (2013). Places to Grow: The Greater Golden Horseshoe. Ontario Ministry of Infrastructure. Retrieved from: https://www.placestogrow.ca/index.php?option=com_content&task=view&id=270&Itemid=84

OTA (2011). MTO 2011-2012 Commercial Vehicle Survey. Retrieved from Ontario Trucking Association: http://www.ontruck.org/imispublic/Operations2/AM/ContentManagerNet/ContentDisplay.aspx?Section=Operations2&ContentID=9909

OTA (2013). MTO Commercial Vehicle Survey Underway Across Province at Truck Inspection Stations. Retrieved from Ontario Trucking Association: http://ontruck.org/imispublic/Home/AM/ContentManagerNet/HTMLDisplay.aspx?Section=Home&ContentID=12674

Tardif, R (2011) Continental Gateway and Trade Corridors: MTO Commercial Vehicle Forecasting Framework, March 2011

Tardif, R. (2012). Border Survey: Trade and Traffic Data Session Presentation. Retrieved from: http://www.thetbwg.org/meetings/201211/presentations/d13tardiff_bordersurvey.pdf