

The Relationship between Retail Type and Transportation Emissions

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

This study investigates the relationship between three types of retail, Big Box, traditional and online retail, and their transportation related emissions. The study takes a comprehensive approach by examining both the consumer and freight emissions associated with each retail type. The retail environment has been evolving dramatically over the past 60 years, and this has many effects on an urban environment that are important for urban planners to understand. Although retail can influence the city in many different ways, this study isolates transportation. Using case studies in the Greater Toronto Area and the Transportation Tomorrow Survey, a scenario model is applied to compare the retail types.

The key influences examined in the scenarios that alter consumer related emissions are return rate, the number of items bought, trips where no items are bought, trip chaining and browsing before buying online. The key influences on freight transportation are the not at home delivery scenario and the number of items delivered.

The results show that as a base case, Big Box retail has the largest emissions, traditional retail the second largest and online retail the smallest emissions. Consumer transportation has a larger impact on the total emissions than freight transportation, which is the main reason Big Box retail has the largest emissions. However, the various scenarios examined demonstrate that the key influence can have a very large impact on the results, making it difficult to conclusively say Big Box retail has the largest emissions associated with it.

Conclusions that can be drawn from this study for urban planners are that for physical retail, traditional style retail tends to have smaller emissions. As well, the key influences, in particular those associated with consumer behavior, have the potential to greatly reduce emissions. Therefore, strategies to influence consumer behavior should be explored.

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Chapter 1

Introduction

The Canadian retail landscape has changed drastically over the past 60 years. One of the major changes is the development of Big Box stores, which have become very successful across North American cities. Due to its significant presence and influence on cities and consumer behavior, such as the influence on downtown vitality, walkability and accessibility (Basker et al, 2010; Haltiwanger et al, 2010), it is important to understand the broader sustainability of this type of retail. Urban transportation impacts on both the consumer and freight side are a particularly important consequence to understand. In terms of freight transportation, Big Box retail may have advantages related to economies of scale, using larger vehicles and serving fewer destinations. On the other hand, smaller, traditional retailing may employ less impactful smaller vehicles but travel more distance. In terms of people movement, generally Big Box requires greater distances travelled by consumers compared to traditional retail more distributed through the city. Even more recently, online retail has begun to emerge. Research claims that online retail reduces environmental impact from transportation by eliminating consumer travel (Cullinane, 2009). However, there has been some debate in the academic world as to the effects of online retail on transportation since there are scenarios such as not at home delivery, browsing a store before buying online, or a consumer making a trip elsewhere with the time saved, which put into question the emissions savings from eliminating consumer movement (Cullinane, 2009; Mokhtarian, 2004). The goal of this research is to evaluate different types of retail in terms of their

transportation related footprint, focusing on grams of CO₂ per item purchased for people and goods movement combined.

Before the second half of the 20th century, retail took the format of local retail, from local market stalls to “main street”, and was the only retail type available for many years. With the widespread adoption of the automobile, retail had the freedom to locate on much cheaper land further from the downtown core, and closer to major highway intersections. In these more suburban locations, retailers could build much larger stores due to the cheap land and amount of greenspace. Hence, Big Box style retail began to appear around the 1960s, and particularly boomed in popularity in the 1990s. The epitome of this growth can be seen in the growth of Walmart over the past few decades. Big Box stores are typically chain stores that locate on the suburban fringe near major highways, with large parking lots, one or two Big Box chain stores, and several medium or smaller stores (City of Hamilton, 2006).

Another technological development, the internet, introduced another type of retail in the 2000s. Online retail is the most recent form retail has taken, and is significantly different than Big Box retail because there is no physical store. Although there is a history of retail with no physical stores in the format of catalogue stores, online retail is currently the fastest growing retail type (IMRG, 2007). Online retail involves browsing and purchasing goods on the internet, and having them delivered to the door step, with no consumer travel required.

This changing retail environment presents new challenges for urban planners in the context of the major issues facing our cities. Some of these issues that are influenced by retail include smart growth, promoting intensification, downtown revitalization and transportation, including transit oriented development, active transportation, and congestion management.

Planners who want to encourage vibrant, accessible cities need to consider how retail formats influence their major goals for the growth and form of a city. Planners are faced with the need to understand the tradeoffs and impacts among their investments and decisions, typically through the lense of sustainability. This research isolates the relationship between retail format and transportation to determine the environmental impacts, and ultimately aid in more effective decision making by planners and other relevant groups.

Studying the effect of Big Box retail on transportation has been a relatively recent issue in the literature. For example, Buliung et al. (2007) used data from the Transportation Tomorrow Survey (TTS) and the Centre for the Study of Commercial Activity (CSCA) retail databases to study the effect of big box retail on consumer travel. Conversely, there has been little research done on how big box retailing affects freight movement in an urban area (Bronzini, 2008), although there are examples of supply chain optimization models used to maximize the efficiency of goods movement. There has been a significant amount of research into online retail, which compares physical retail stores to virtual ones in terms reducing transportation related emissions. However, there remains a knowledge gap concerning the broader sustainability of goods and consumer movement combined, comparing all three types of retail, traditional, big box and online.

This research aims to address this gap, with a combined consideration of retailing type and people and goods movement. A scenario model analysis will be used to compare the relationship between type of retail and the vehicle kilometers travelled for freight and consumer travel, and the equivalent gCO₂ per item for both types of transportation.

Due to the lack of knowledge on the relationship between retail type and goods movement and consumer travel, the proposed topic is an important and relevant issue. It will aid urban planners and policy makers in making key decisions related to urban intensification, smart growth, transportation investments and related policies.

1.1 Research Strategy

This thesis seeks to further our understanding of the relationship between retail type and transportation related emissions through an analysis of the CO₂ emissions for consumer and freight transportation for traditional, big box and online retailers. The questions that guide this research are as follows:

- What are the characteristics and key influences on freight and consumer transportation associated with retailing?
- What are the freight and consumer CO₂ emissions associated with different retail types?
- How do these emissions vary by the key influences?

In addition to these questions, this project explores the hypotheses that consumer transportation has the highest impact on overall retail transportation CO₂ emissions, meaning Big Box retailers would have the highest emissions, traditional retailers the second highest emissions and online retailers the lowest emissions. However, various shopping scenarios will be examined by changing key influences on the emissions, which could vary the results.

To address these research questions and hypotheses, this research project will analyze consumer travel to stores, as well as truck travel to stores or houses. Emissions in terms of

gCO₂ per item bought will be calculated and emission impacts across the retail types compared. Various shopping and shipping scenarios will be investigated.

1.2 Study Area

The area that will be considered for this research is the Greater Toronto Area. The GTA is the largest metropolis in Canada, and is an appropriate study area to obtain results that can be used by planners and policy makers across Canada. Using the GTA will provide results that can be applicable to many areas across Canada.

1.3 Document Overview

This thesis begins with a literature review on research related to retail and transportation for both consumer and freight travel. Following the literature review, a detailed description of the methodology and the data used is provided. Then the results of the research are presented followed by an analysis and discussion. The final section offers conclusions, presents limitations and recommendations for future work.

Chapter 2

Literature Review

The form that retail has taken has changed significantly over the past century, while retail continues to be a major part of a city's urban fabric. The first section of this literature review discusses these changes in the retail environment to demonstrate why it is important to study the relationship between the different retail types and their influences on a city. One of the aspects of the city that retail has a relation with is transportation, which is the focus of this research and an important aspect to consider for planners and policy makers.

How retail affects consumer transportation has been widely discussed in literature, but one aspect that does not get as much exposure is how Big Box retail affects freight transportation. Many studies (Buliung et al. 2007 and Marique et al. 2011) have shown that Big Box retail increases the emissions from consumer transportation. This intuitively makes sense since the location of Big Box retail is often far away from residential areas and encourages the use of cars. However, Bronzini (2007) identifies a research gap in terms of a lack of knowledge of how Big Box retail relates to freight transportation. Big Box retail is very efficient in terms of freight routing and likely reduces emissions related to freight transportation because of economies of scale. Not only do trucks have to make fewer stops, but they do not have to travel as far into the urban core. Understanding how consumer and freight transportation interact with each other and the overall sustainability

of transportation related to a changing retail environment is important in order to evaluate the impacts of Big Box retail.

Online retail and its effect on transportation is the next topic discussed in the literature review. There have been a significant amount of studies related to this topic, however there is yet to be a general consensus in the academic world as to how online retail has impacted transportation because it so recent and consumer behavior is very unpredictable. The various consumer behavior scenarios are outlined in the last section of the literature review, and show how much the variation in consumer behavior influences transportation.

2.1 Retail Environment

Developed before the second half of the 20th century, traditional retail has taken the form of street-oriented, small scale stores that are easily accessible for pedestrians and are often characterized by large glass display areas that enliven the streetscape. These traditional Main streets are typically located in the downtown cores of cities or towns. Small retail spaces of approximately 2,000 sq-ft compose the majority of the space in the form of boutiques and convenience shopping, and medium sized stores or minor anchors (5,000-30,000 sq-ft) can be present at the end of the streets or major intersection. Traditional main streets are compact and typically have a range of 2 to 3 blocks, creating a pedestrian friendly environment (City of Hamilton, 2006). Figure 1 is a photograph of Bloor St in downtown Toronto and is an example of a traditional, main street environment.



Figure 1: Traditional, main street environment (Bloor St, Toronto) (Source: Google)

Large scale retailers have been popular since the early 1900s, when downtown department stores, such as Eaton's, had the greatest sales volume by sector (City of Hamilton, 2006). In the post war era, the popularization of the automobile and the growth of the suburbs created an underserved market outside of the urban core, and the suburban shopping malls began to develop. These were often funded and built by the department stores, who saw a potential untapped market (Cohen, 2002). With the department stores as anchors, and easy access by car, these suburban malls began to grow. Along with them, various specialty and discount stores grew to compete with the original department stores. Around the 1980s, customers began to value prices more and to have lower brand loyalty, and the bulk of the retail market share went from department stores to the Big Box stores that had been developing (City of Hamilton, 2006). The new Big Box stores catered to consumers who wanted low prices, and the convenience of having a large variety of items in one location. Walmart represents the epitome of the growth in Big Box retail, and Basker (2005) estimates that for each new Walmart store built there is an average net reduction of 4.7 stores with fewer than 100 employees. From 1977 to 2007, Walmart opened approximately 3,000

new stores in the United States (Basker and Noel, 2009), which would mean a closure of 12,000 small stores over those 30 years. Basker et al. (2010) show a net decrease of approximately 30% in the number of retail establishments with fewer than 100 employees between 1977 and 2007. These statistics demonstrate that the Big Box retail format has been growing and taking a greater share of the retail market away from traditional retail format.

Big Box stores often agglomerate in one location, and a group of Big Box stores is known as a Power Centre. A report produced by the City of Hamilton lists Power Centres as having the following characteristics (City of Hamilton, 2006, p.27):

- “open air configuration with substantial parking in front of each store;
- at least one major anchor store such as a discount department store or a home improvement centre;
- a number of category-specific anchor tenants each with 20,000 to 25,000 sq. ft. Gross Leasable Area (GLA) or more;
- a number of smaller stores (baby boxes) usually between 5,000 and 10,000 sq. ft. but collectively totaling only a small portion of the centre’s GLA;
- buildings situated either as standalone or attached to one another; and
- managed as a unified shopping centre”

The size of Big Box stores also varies based on the type of goods sold. Home improvement stores are one of the largest and range from 100,000 to 150,000 sq. ft. Book stores range from 25,000 to 50,000 sq.ft. whereas fashion retailers are typically the smallest at 5,000 sq. ft. or smaller (City of Hamilton, 2006). Haltiwanger et al. (2010) classify Big

Box stores as ranging in size from 50,000 to 200,000 square feet, often rectangular in shape and with ample parking for consumers driving by car. Figure 2 is a photograph of a typical power centre, with large fashion retailers and ample parking space.



Figure 2: Power Centre, Oakville On (Source: Google)

Figure 3 from Doucet et al. (2001) illustrates the increase in Big Box stores over the past few years by showing the number of new formats (i.e. Big Box format) currently open and the amount of retail floor area. The number of Big Box stores grew in the 70s, 80s and 90s, and has come to represent a very large portion of the market share. According to Doucet et al., between 1990 and 2000 the number of Big Box stores in the Greater Toronto Area has increased by 378%, and the space that they occupy has increased by 333%.

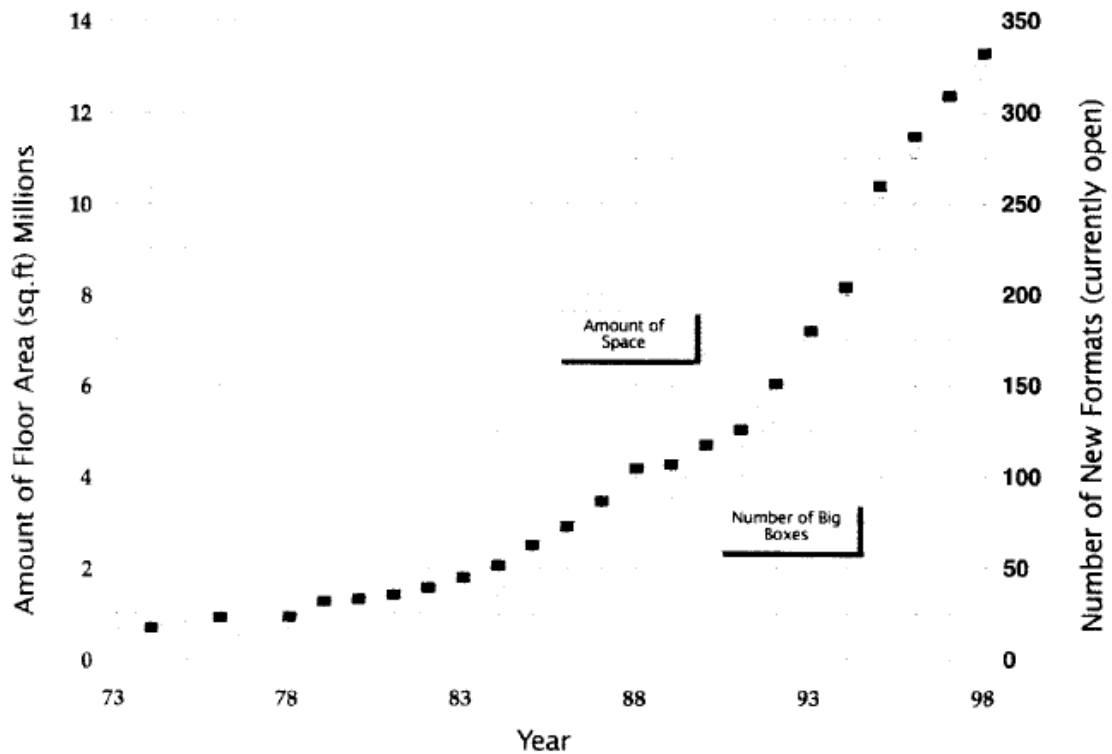


Figure 3: Growth of new retail forms in Toronto

Figure 4 (The Consumer Trends Report (2006)) shows the market share that Big Box retail held in 1989 and 1996 in the US. The graph shows that the share for each category grew during the five years, which indicates that Big Box retail was growing in the 1990s. Specialty stores had the smallest market share, with 23% in 1996, and general stores had the largest market share with 70% in 1996. Overall, the graph demonstrates the extent to which Big Box stores have taken over the retail market.

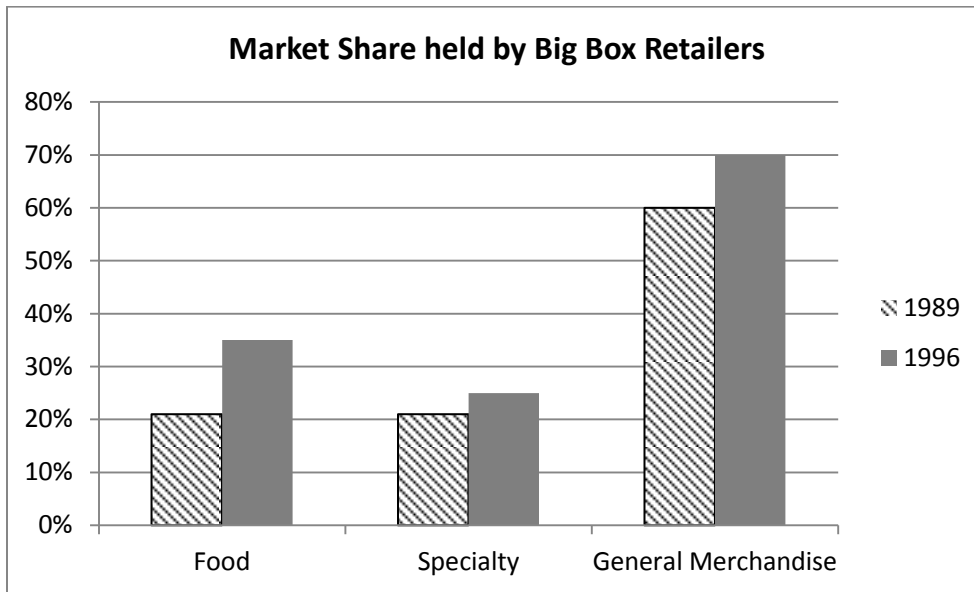


Figure 4: US Market Share held by Big Box (source: Office of Consumer Affairs, 2006)

Figure 5 from a presentation by Kennedy L. Smith (2011) also shows the growth of Big Box retail through the growth of floor area per capita in the United States. In 1960, the floor area per capita was 4 sq.ft. per capita. This value was ten times larger by 2010, where the floor area per capita was at 40 sq.ft. per capita.

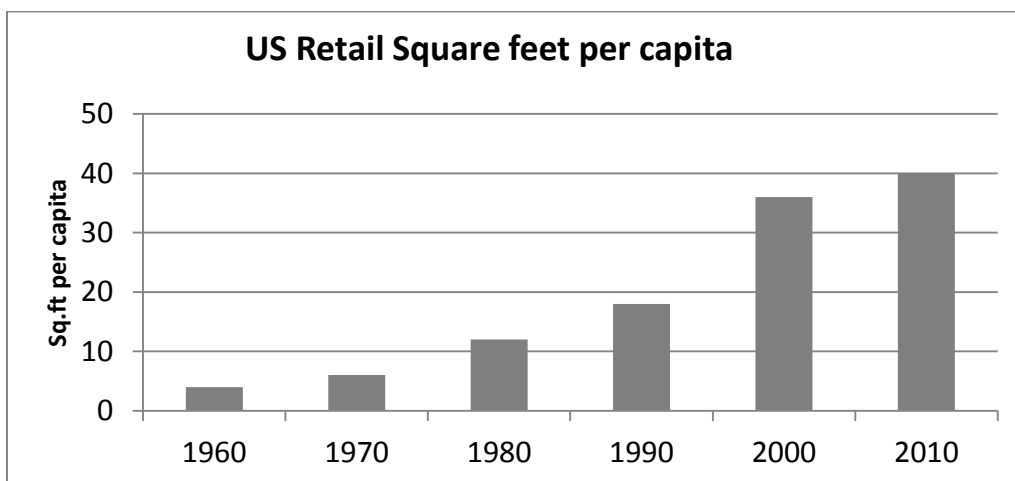


Figure 5: US Retail Square feet per capita (source: presentation by K.L. Smith)

Figure 6 from Colliers International, “The Retail Report Canada: Fall 2011 edition” shows the Canadian perspective for floor area occupied by power centres and shopping malls in 2011. The floor space growth from 2010 to 2011 was only 2.2%, which shows that Big Box stores were still growing, but at a very small rate. When considering the per capita supply growth, the growth rate is only 0.4%. Although Big Box stores are still growing and still represent a large portion of the market, they have reached a relatively stable level.

| CMA | Total Shopping Mall + Power Centre Floor Area (SF per capita) | Year over Year Growth in Shopping Mall + Power Centre Supply 2010-11 | |
|--------------------|---------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|
| | | Floor Space Growth | Per Capita Supply Growth |
| Halifax | 26.73 | 0.5% | -0.8% |
| Montreal | 14.67 | 2.2% | 1.0% |
| Ottawa - Gatineau | 18.25 | 3.3% | 5.1% |
| Toronto | 22.07 | 2.4% | 0.3% |
| Winnipeg | 15.53 | -0.3% | -1.7% |
| Saskatoon | 18.38 | 1.2% | -1.8% |
| Calgary | 24.62 | 2.6% | 1.5% |
| Edmonton | 27.92 | 2.7% | 0.9% |
| Vancouver | 13.73 | 2.3% | -0.4% |
| Victoria | 13.15 | -1.5% | -3.1% |
| Total - Above CMAs | 19.16 | 2.2% | 0.4% |

Figure 6: Shopping Mall and Power Centre Floor Area in Canada (Source: Colliers International, “The Retail Report Canada: Fall 2011 edition”)

The growth of Big Box stores during the 80s and 90s resulted in a decline of the downtowns and the closure of independent, traditional retailers. Traditional style retail has been struggling since the introduction of the suburban mall, and has been losing even more market share with the growth of Big Box retail format (Haltiwanger et al., 2010). Both planners and citizens have been striving for a revival of downtowns and encouraging

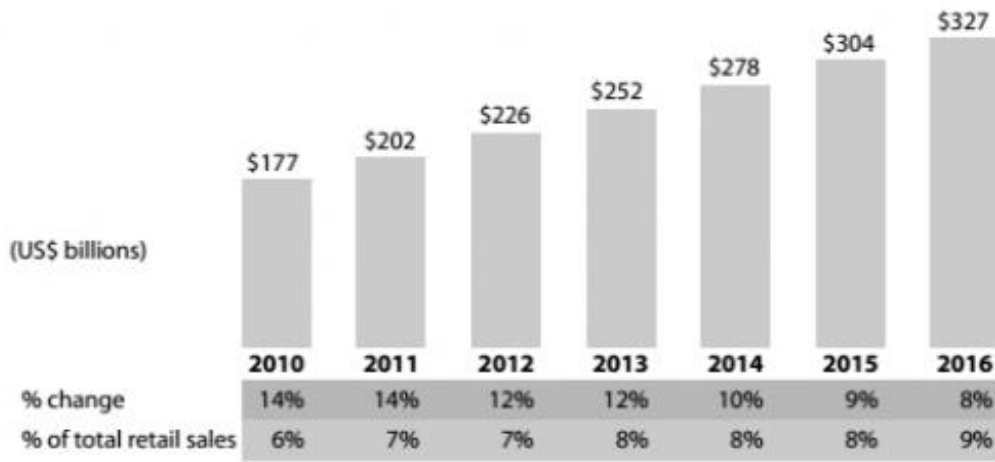
traditional style retail (City of Hamilton, 2006). Even in the suburbs there is a resurgence to revive a local Main St. This is both a reflection of the consumers' desire for a local shopping experience, as well as an increase in the willingness to pay for local products (City of Hamilton, 2006). Currently, the proportional growth of Big Box sales is not increasing significantly, while both planners and consumers are demanding the revival of downtown streets. Big Box stores, for example Walmart, have recognized the demand for the traditional retail format and have been creating different store types to accommodate this. Walmart introduced in the US in 1998 the "Walmart Neighbourhood Markets", which are approximately 38,000 sq.ft. and offer groceries, household supplies and pharmacy goods. Even more recently, Walmart introduced the "Walmart Express" format in 2011 in the US, which aims to be approximately 15,000 sq.ft. and will offer groceries and general merchandise (Walmart Stores Inc, 2012). Figure 7 shows the newest Walmart retail format, "Walmart Express", and demonstrates how it has the characteristics of a traditional retail format with a small footprint, close to the street and large display windows. As the retail environment continues to change, it is even more important to understand the consequences and impacts the different retail types may have.



Figure 7: Walmart Express Retail Format (Source: Walmart Stores Inc)

Figure 8 from Forrester Research Online Retail Forecast shows the predicted growth of the US online retail market. In 2010 the growth rate was 14%, and it is predicted to decrease slightly over the years. This is a very high growth rate when compared to the Big Box growth rate of approximately 2%. However, the percent of total retail sales that online represents is still only 6%, but is predicted to reach 9% by 2016. Online is the fastest growing retail sector, which is why it is important to understand the impacts it may have, but it still represents the smallest portion of the market share.

Figure 1 Forecast: US Online Retail Forecast, 2011 To 2016



Source: Forrester Research Online Retail Forecast, 2012 To 2016 (US)

60672

Source: Forrester Research, Inc.

Figure 8: Online Retail in the US Market

As the fastest growing retail type, online retail has the potential to have many different impacts on a city, in particular transportation impacts. However, it is still contested as to how much of the retail market online can achieve. The online shopping experience has little entertainment factor, and lacks the tactile experience of physical shopping. There may be a certain limit as to the percent of the market share online retail will achieve because it lacks these factors. As well, in terms of transportation, Cullinane (2009) argues that an online shopping purchase does not necessarily replace a trip to a bricks and mortar store, as the consumer may still want to browse through the store. Although the future usage of online retail is unclear, understanding its impact on urban transportation is important to understand as it continues to grow.

2.2 Consumer Shopping Trips

In terms of research concerning consumer transportation to retail stores, the rise in Big Box retail has generally been associated with an increase in emissions for the consumer last mile trip. One approach to establishing this relationship is comparing and describing case studies. Buliung et al. (2007), Marique et al. (2011) and Vivian (2006) used this approach. Buliung et al. (2007) used data from the Transportation Tomorrow Survey (TTS) and the Centre for the Study of Commercial Activity (CSCA) retail databases to study the effect of Big Box retail on consumer travel. Buliung used three specific case study areas in the Greater Toronto Area, where power centres were known to have appeared in the past few years. Looking at the change in trips per person over the different study years, they concluded that the increase in Big Box retail has resulted in an increase in shopping trips per person, and consequently an increase in emissions.

Marique et al. (2011) took travel information on four different neighbourhoods, two mixed-use downtown neighbourhoods and two sprawling suburbs, to compare the transportation energy consumption of consumer travel. They concluded that the suburban neighbourhoods have larger energy consumption than mixed-use neighbourhoods. In this case the purpose of trips was not isolated, so this increase in vehicle kilometers travelled cannot be directly linked to Big Box style retail. However, the method used of comparing neighbourhoods could be employed when isolating trips for shopping purposes.

Vivian (2006) conducted a study for the Institute of Transportation Engineers (ITE) that looked at five case studies of superstores and their average trip generation rate. The current ITE trip generation rate for free standing discount superstores is 3.87, but this number

is based upon of data from 1990s and the average size of store was 161,000 square feet. In the 2000s, the size of superstores often exceeded 200,000 square feet, and Vivian's study examines the different impact these larger stores have. The trip generation rate for stores greater than 200,000 square feet in size was determined by doing volume counts at each of the five locations. The conclusions of the study were that the larger superstores generated 5.50 consumer shopping trips for the p.m. peak for every 1000 sq feet of retail space. This study reflects that the larger stores do create larger traffic volumes.

Using the method of comparing case studies is advantageous because unlike a modelling approach, it is describing and analyzing real situations and is not making assumptions. Rooted in reality, the three studies above can conclusively claim that the neighbourhoods they studied with Big Box retail created more shopping trips and resulted in longer distances travelled than traditional neighbourhoods. However, there is an issue in transferability and generalization, since it is specific case studies being considered. Also, in order to compare on the neighbourhood level, information concerning consumer travel, and in the case of this research freight travel, would be needed on the neighbourhood level. Requiring this data presents a challenge because freight data on the neighbourhood level aren't readily available in Canada. Therefore, using the method of comparing case studies of neighbourhoods would be difficult when taking a combined approach examining both freight and consumer travel. However, it is a shortcoming of this approach that freight isn't considered, because truck trips are a contributor to transportation related emissions and freight travel relates to retail very differently than consumer travel. This case study of

neighbourhoods approach does not provide a comprehensive examination of the relationship between transportation and retail type.

An alternative approach to examining the relationship between retail type and consumer transportation is a micro simulation of consumer behavior. This approach is taken in studies by Schenk et al. (2007) and Leszczyc et al. (2000). Schenk uses an agent based simulation to model consumer grocery shopping behavior. Leszczyc uses a dynamic hazard model to simulate consumer shopping timing, store choice and switching behavior for grocery stores. Both models simulate which store a consumer will choose as well as how often the consumer would go there based on a very detailed, consumer by consumer level. Both models use demographic characteristics as well as store characteristics, such as variety, price and distance as input for the models. Both models are justified using survey data for consumer shopping trip behavior.

This type of method is a possible approach to modelling consumer movements for the research proposed in this thesis. A micro simulation model could be created by inputting demographic data from the census and store characteristics based on type of retail. This approach would be advantageous because it would give detailed information on consumer behavior as it relates to retail choice. However, extensive data on consumer travel behavior would be necessary to construct and implement the model, an effort that is beyond the scope of this research project.

2.3 Freight routing to retail stores

The other side of the retail transportation equation is how retail affects freight transportation. There is less research done studying the relationship between freight activity

and retail type, but there are several studies that model freight movement delivering goods to retail locations.

Both retail and supply chains have been evolving together over the past 50 years. A supply chain consists of all the processes a product goes through to go from its raw materials to a customer's home (Christopher, 2010). Traditionally the flow of goods through the supply chain consisted of extraction of raw materials, often followed by a storage buffer. Then the materials would go to manufacturers to be processed, then wholesalers and/or distributors would deliver the goods to retailers, where finally the good would end up with the customer (Rodrigue, 2006). This conventional flow is shown in Figure 9. Around the end of the 20th century, the concept of supply chain management began to evolve. This evolution coincided with the globalization of the supply chain, when many Big Box chains, such as Walmart, began manufacturing abroad (Christopher, 2010). One of the main differences in the contemporary supply chain management is maintaining communications and information flow between the different stages, as shown by the dotted line in Figure 9. Christopher (2010) describes supply chain management as a network of interdependent organizations working together to control, manage and improve the flow of goods and information from suppliers to end users.

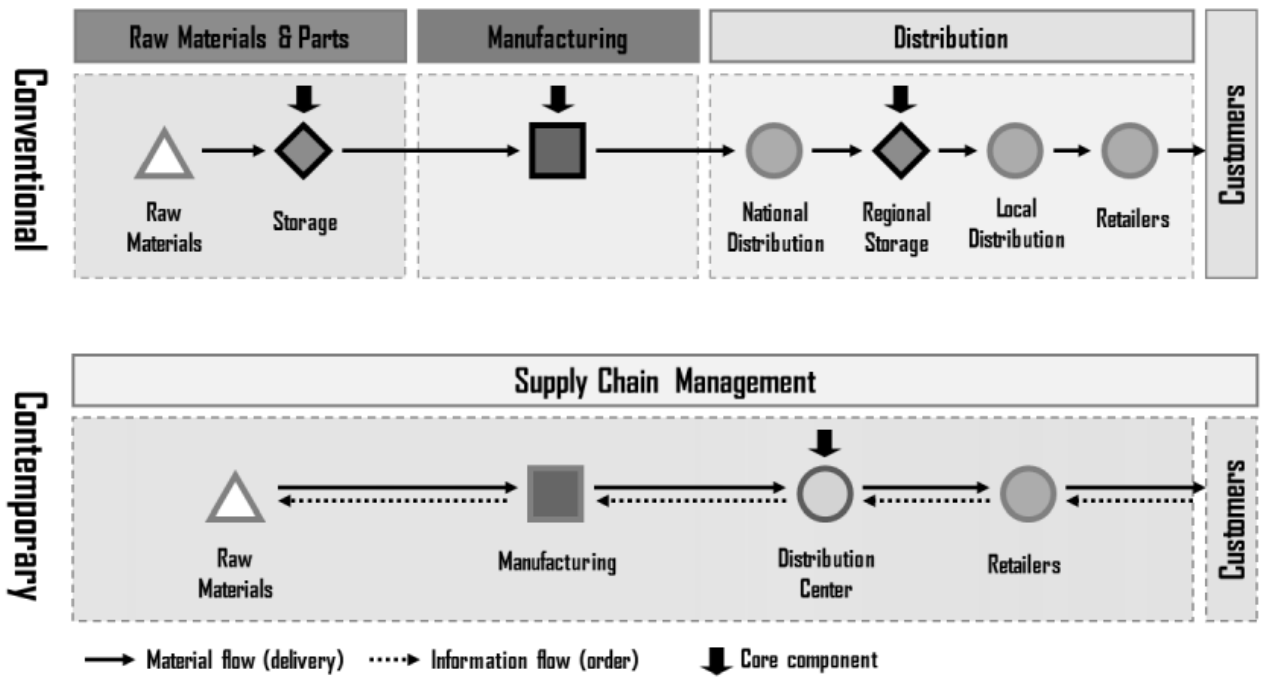


Figure 9: Conventional and contemporary arrangement of goods flow (source: Rodrigue, 2006)

Big Box stores have influenced not only the last mile of freight, from the distribution centres to the retailers, but have influenced the entire supply chain. In order to provide the low costs typical of Big Box chains, manufacturing must be less expensive and so is often done overseas, and the supply chain must be cost efficient. To achieve these goals management approaches such as Quick Response, pull-logistics and just-in-time delivery have been developed in the field of supply chain management.

Although retail influences the whole supply chain, this study concentrates only on the last part of the freight trip, from distribution centre to retailer or household. Looking at this section of the supply chain can present a challenge due to the lack of data. Freight research and models often suffer due to the lack of detailed surveys done in the freight industry (Hensher et al., 2007; Samimi et al., 2013). Trucking companies are also very protective of

their information, and are often unwilling to participate in surveys because they fear losing their competitive edge (Melnyka et al., 2012). This lack of data presents many challenges when doing research in freight travel, and presents challenges for this research project in particular. However, there is still research that explores the relationship between retail and freight travel.

Quarmby (1989) directly discusses the impacts of changing retail on freight transportation. He describes the change in retail as going from a supplier-controlled distribution towards a retailer-controlled distribution. In a supplier-controlled distribution setup, suppliers will deliver goods to local distribution centre, where they will then transport the goods to local retailers. Starting with the development of Big Box retail in the 1960s, this type of distribution is being replaced by retailer-controlled distribution, where retailers own the distribution centers, which tend to be regional as opposed to local and have a larger capacity. This type of distribution is associated with Big Box retail, with a small number of very large retail depots, using large vehicles and making few drop offs. In contrast, supplier-controlled distribution is associated with a large number of small depots, many small vehicles, and multi-drops on a local level. Quarmby (1989) provides a basic, hypothetical example to illustrate the efficiencies for freight with retailer-controlled distribution. He concludes that the big-box model using retailer-controlled distribution is more efficient, as it reduces the vehicle kilometers travelled, reduces the driver time needed to deliver goods, and increases the delivery capacity of a retailer.

One commonly used approach to modelling freight movement in a city is the four-step model, which uses origin and destination data to determine where vehicles travel. This is

a well-established method for modelling the movements of both people and goods movement. Matsumoto et al. (2006) uses this approach in a study that discusses freight modelling using a commodity flow based, four step model. The four step modelling approach is commonly used for freight movements, and consists of trip generation, trip distribution, trip assignment and modal choice. For trucks, the four step model can either be based on commodity flow or truck trips, that is, the movement of goods or the movement of trucks. Matsumoto et al. use the four step model and commodity flows to model freight movement in the Greater Tokyo Area. The research paper determines commodity flows by estimating the probability of a consumer choosing to shop at a specific location, implying that consumers drive the freight activity. This probability is determined using retail floor area, location of the store and the number of employees at the store. The data sets inputted into the model were the Tokyo Metropolitan Goods Movement Survey (goods movement between 52 zones), the Establishment and Enterprise Census data (information on firms), and Road Traffic Census (OD survey for cars, buses and trucks). When comparing the model with actual data, Matsumoto et al. concluded that his four step model did accurately relate to actual data. This type of model could be used in this research to determine the route freight vehicles take to get to the retail stores. In order to use this approach, there would need to be available data on the origins and destinations of freight traffic.

2.4 Online Retail and its Effect on Transportation

The newest form of retail, which is on the opposite side of the spectrum from Big Box retail, is online retail. Big Box retail represents one, large retail location where consumers come to the store. On the other hand, online retail represents no physical retail

location and no consumer movement, but the trucks go throughout the city to people's homes. According to a study done by the United States Census Bureau (2011), E-commerce was 4% of total retail in the USA in 2009, up from 2008 when e-commerce represented 3.6% of total retail. From 2002 to 2009 the average annual growth of e-sales has been 18.1%. Internet retail is currently the fastest growing type of retail, although it still holds the smallest share of the market (7% in 2012 (Forrester, 2012)). According to a survey by Cullinane (2009), the most popular types of goods that are purchased online are travel related purchases, films, clothes and books. In general, it is smaller items that are not too expensive. There has been a significant amount of research on the impacts of online retail on transportation, for both consumers and freight, since this type of retail is an important component to study in the changing retail environment. As the fastest growing retail format, it is important to consider online retail when examining the retail environment and its relation to transportation.

There have been several studies into online retail that involve an extensive literature review and research to describe how transportation has changed with online retail. These make logical speculations as to how online retail and transportation relate. Cullinane (2009) and Mokhtarian (2004) both use this descriptive, qualitative approach to describe the impact of online retail on transportation.

Cullinane did a conceptual analysis of the impact of e-commerce on both freight and consumer transportation. Cullinane describes some of the changes that have taken place in retail, including the change towards Big Box retail based on a literature review of several research studies. The number of shopping trips has dropped by 13%, but the distance

travelled has grown by 10% from 1995 to 2006 according to the National Travel Survey done by the Department of Transportation in the UK. Overall, this change in behavior has resulted in mileage increase of 22%. In a review of the literature on online retail, Cullinane discovers there are many different theories as to the outcomes of e-commerce, and concludes that there is no certainty that e-commerce will reduce consumer travel. On the freight side the impact is just as unclear, since e-commerce has only become popular in the 2000s and the routing techniques and delivery policies have been changing and evolving. Overall, she says that the impact of online retail is still unclear because of complex human behavior patterns and the youth of e-commerce. She does concede that in isolating the trips to a specific store and assuming those are replaced entirely by a truck, there could be beneficial impacts to transportation. However, since many shopping trips are multi-destination trips, or may still be done even with e-commerce, there is no clear effect of e-commerce on transportation.

Mokhtarian (2004) also explored how the shift to e-commerce may affect transportation patterns. She explores four different potential changes in the retail market; 1) changing the shopping mode while keeping the volume of goods and per capita consumption constant, 2) changes in the volumes of good purchased while keeping per capita consumption spending constant, 3) changing per capita spending while keeping demographics constant and 4) changing demographics. Mokhtarian's conclusions were that each scenario would have a different effect, but overall e-commerce will have no beneficial impacts on transportation.

This descriptive approach to understanding the relationship between online retail and transportation is a good step; however it provides little hard evidence with which to make

conclusions. Although this approach does not require intensive data gathering, it would be difficult to make accurate conclusions.

An alternative method would be a mixed method approach which involves literature reviews and research similar to that done by Cullinane and Mokhtarian, then using this information to create scenario models. McKinnon (2009) uses this approach to compare the carbon footprint of online shopping and conventional shopping by modelling many different scenarios. The data input to the model comes from government sources, discussions with company managers and realistic assumptions derived from the literature. The scenarios only consider small, non-food items such as books, clothing, electronics or household items. The CO₂ emissions per item purchased are compared for the conventional and online shopping.

For modelling the online shopping, McKinnon only considers the 'last mile', that is the trip from the local parcel carrier depots to the home. The four variables considered are type of freight carrier, drop density, 1st time delivery failure rate and returns. For the first variable, type of freight carrier, McKinnon concludes based on literature that the majority of couriers use traditional vans. However, he also considers the use of electric vehicles and private courier services (personal cars). His findings show that there is a significant drop in gCO₂ for electric vehicles, and an increase for private courier services. For the second variable, drop density rate, McKinnon again makes assumptions based on other literature. He assumes that on average, a van will travel a route of 50 miles and make 120 drops. However, he varies this drop rate to consider many scenarios. For example, due to drop density rates the gCO₂ for rural deliveries is almost 5 times more than for city centre deliveries according to his findings. For the third variable, 1st time delivery failure rate, McKinnon models a

scenario of 25%, 12% and 2% (again based on literature). For this scenario, McKinnon assumes the delivery van will deliver it the next day, and concludes that there is a 25% increase in gCO₂ for 25% failure rate. The final variable is the return rate, and McKinnon considers a model with 25% return rate (40% for clothing). Finally, the number of items per drop is needed in order to create a gCO₂ output. Based on an interview with a book wholesaler McKinnon uses 1.4 items per drop for books/DVDs/CDs and 2.5 items per drop for all other non-food items.

For the conventional consumer shopping model, McKinnon uses data from the National Travel Survey in the UK. From the survey, he takes data on the average non-food shopping trip distance by mode. The three variables that are changed for the scenarios are multi-purpose trips, number of products purchased and mode. Mode is given in the data, and appropriate emission factors are employed based on mode. The modes considered are car, electric car and bus, and it is concluded that taking the bus cuts gCO₂ by at least half. McKinnon realizes that the majority of shopping trips have multiple purposes, and therefore models three different scenarios; one where 50% of emissions are attributed to shopping, one with 25% and then one with 10%. These trip chaining values are based on previous research and studies of consumer behavior in the UK. When there are other purposes associated with the trip, the gCO₂ per item bought decreases. He also considers scenarios where customers browse (ie, they don't purchase anything) and return scenarios. For the number of goods purchased per trip, he initially assumes one item, and then calculates how many items would need to be purchased to match the online shopping CO₂ emissions.

The scenario model is implemented by inputting different variable values into the deterministic model to obtain different scenario results for online and conventional shopping carbon footprints. His conclusions are that online shopping has a smaller carbon footprint, unless consumers purchase more than 24 items when driving a car, or 7 items when using the bus.

To understand the relationship between retail and transportation, an alternative to modelling could be a basic description of the current situation. This approach is similar to the case study approach described above for consumer travel, but expands beyond the neighbourhood level. A study done by Rizet et al. (2012) assessing the carbon footprint and energy consumption for competing supply chains uses such a method. Rizet et al. gathered very extensive information through government databases and first hand research to describe the supply chain and consumer travel patterns related to jeans, yogurt, apples, tomatoes and furniture. Figure 10 shows some of the results of his research, and demonstrates that freight and warehouse emissions seem to be constant across retail types, while the consumer emissions are drastically smaller for the corner store. Although Rizet et al. attains conclusions on topics that this research project also aims for, their method involves extensive amounts of data that may not be available for this thesis.

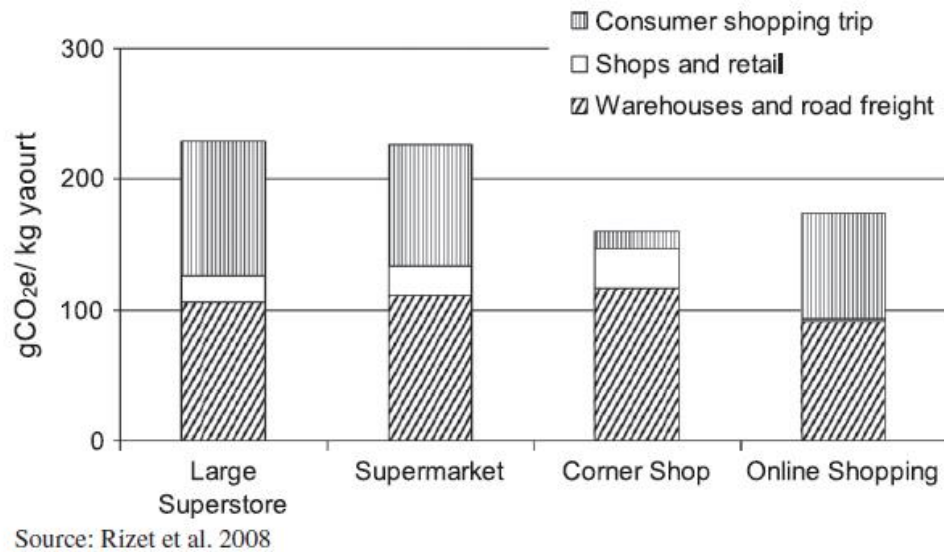


Figure 10: Emissions of yogurt supply chains in the Paris region (Source: Rizet et. al., 2008)

This section has described various research on the relationship between retail and transportation, and since the retail system has been changing dramatically over the past few decades it is important to continue to study this relationship. For Big Box retail, there have been many studies showing that it can increase consumer travel, but few studies showing its effect on freight transportation. Research into e-commerce can also be applied to studying the effects of retail on transportation, and there have been many studies looking at the effects of e-commerce. However, overall there has been little consensus in the academic world about how e-commerce truly influences and interacts with transportation, since there are many complex issues associate with the studies.

The method that will be used to approach this problem in this research is based on the one introduced by Mckinnon (2009). This approach is chosen over the others described in the literature review for several different reasons. One of the main reasons is the lack of detailed data available. The descriptive, case study approach done by Builing (2007) and Marique

(2011) described scenarios for specific neighbourhoods. However, neither of these studies considered the freight side, and freight data at the neighbourhood level is not available for my research and would be very labour intensive to gather.

The consumer behavior models done by Schenk (2007) and Leszcyc (2000) could have been used to model the consumer side, but once again very detailed data would have been necessary. To create and justify a model of my own would require extensive shopping travel information that does not exist, and transferring their model into my study area would present issues of accuracy and transferability. It would also be a challenge to incorporate online shopping behavior into these models.

For the freight travel behavior, the four-step model was discussed as a method done by Wisetjindawat et al. (2006). To implement the four-step model, I would need to know the origins and destinations for freight movements on a detailed level. This information on freight movement is not readily available in Ontario, making the four-step model a difficult approach to the research question.

The research project conducted by Rizet et al. (2012) came to conclusions very similar to ones I am trying to achieve in my research project. However, their method was creating a very detailed description of the supply chain and consumer travel behavior based on very extensive data. Gathering this amount of data for my research project would very labour intensive and, overall, an impractical method.

McKinnon's (2009) method involved finding averages and gathering enough case study information to draw conclusions. For the consumer side, he used average shopping trip distances, which is information that is available in Ontario. Gathering enough information to

assume averages is a more practical task than creating detailed models or gathering detailed travel information on a specific neighbourhood. Although his method does not consider online retail, it can be adapted to take that form of retail into account. McKinnon's method is the best choice because it does not require as much data and can be used for the both the consumer and freight modelling.

2.5 Scenarios

Retail trips are complex to model or predict because there are many different options that can happen during a retail trip that change key influences. These options can include a shopping trip without purchasing anything, a-not-at home delivery for online retail, or the need to return a good. McKinnon dealt with these different retail options in his research, employing a scenario-based approach as described in the previous section. These different options have also been explored in other scenario based research, as this section describes.

2.5.1 Return Rate

If a consumer decides to return a good purchased from either a traditional, or Big Box store, the result is an extra trip made to the store by the consumer. For online retail, the impact of returning goods varies depending on the policy of the company, but the most popular method is requiring the consumer to put the returned good into the mail. For example, Amazon includes a Return Mailing Label which the customer can then use to mail the goods back to Amazon (Amazon, 2013). This would only result in a small extra trip from the consumer, likely as part of a trip chain. No extra freight distance would be travelled as the post truck would be traveling its route either way (Cullinane, 2009). Nairn (2003) claims that 6-10% of goods purchased in physical stores are returned. For online retail, Nairn (2003)

states a return rate of 30% for non-food items, while Fernie et al. (2004) claims a return rate of 25%. McKinnon (2009) used an online return rate of 25% for non-clothe items, and 40% for clothe items.

2.5.2 Items Bought per Trip

The research for this thesis involves considering the emissions on a per item basis, which means that the frequency of shopping trips and the number of items bought on these trips are important factors to consider.

Cullinane also states that for 43% of all shopping trips in the UK the total cost of goods purchased is less than £10. This reflects that on average the number of items bought per trip is relatively low. As well, in general there are more items bought at Big Box stores compared to traditional, small stores, which would reduce the emissions per item for shopping trips to Big Box stores. This is also reflected in the fact that trips to the local, traditional store are often more frequent than trips to the large Big Box stores. Sorensen (2009) uses data from all retail types across the world, and concludes that for physical stores, 16% of the time consumers only purchase one item. The mean number of items purchased is 12 items, but the median number of items purchased is 5 items (Sorensen, 2009). The difference in the average and median reflect a skewed data set, where consumers are doing bulk purchases that bring the average up.

In terms of online retail, the number of items dropped per delivery is the equivalent number as number of items purchased at a store. Based on interviews with a book wholesaler, McKinnon (2009) uses 1.4 items per drop for books/DVDs/CDs and 2.5 items per drop for all other non-food items. Grand & Toy's online division states that they make

between 50 to 60 drops per delivery route, and the average distance between deliveries is 1.2 km (Transport Canada, 2012). Cullinane (2009) points out that when shopping online, consumers often buy from multiple companies and this means extra courier trips from each company and an increase in emissions per item dropped. A study by Haider et al. (2009) investigated the number of items dropped per stop for courier companies in Canada. The results of his study are shown in Table 1, and demonstrate that 79.4% of the time only one item is dropped.

| | Number of Packages | | |
|-----|--------------------|-------|-----------|
| | 1 | 2-4 | 5 or more |
| Apr | 78.3% | 14.3% | 7.3% |
| Jun | 81.4% | 12.5% | 6.0% |
| Sep | 78.4% | 14.6% | 7.0% |
| Dec | 79.4% | 14.3% | 6.3% |
| | 79.4% | 14.0% | 6.7% |

Table 1: Items delivered per drop, online retail (source: Haider et al., 2009)

2.5.3 No Items Purchased

Cullinane (2009) says that the third most popular item bought in a retail shopping trip is ‘nothing’, representing 16% of all shopping trips. Mckinnon (2009) uses 10% of trips as the average percent where is nothing is purchased, but also considers 20% (typical for clothes) and 33.3% (typical for furniture). The shopping trip where no items are bought is important to consider, as it would increase the average emissions per item bought. Therefore an important scenario to consider in the analysis is the case where no item is purchased.

2.5.4 Trip Chaining

Trip chaining is another scenario that must be considered when calculating the emissions per item. Many trips made that include purchasing an item have other purposes or tasks involved in them. Therefore, not all the emissions for the trip can be attributed to shopping, as a trip to accomplish the other goals may have been done anyways. To account for trip chaining, McKinnon (2009) creates three scenarios, one where 50% of emissions are attributed to shopping, one with 25% and then one with 10%. By taking trip chaining into consideration, the emissions per item will decrease.

2.5.5 Browsing Before Buying Online

Many online shoppers visit a physical store to see the product they wish to purchase before buying it online. McKinnon(2009) estimates that up to one in every five online shoppers will visit the store to see the product before buying online. This scenario would mean that a consumer trip occurs for online shopping, which would increase the emissions associated with online shopping.

2.5.6 Not at Home Delivery

Not at Home Delivery is a very common issue in online retail, since courier trucks mostly deliver during working hours while the majority of people are away at work. When “Not at Home Delivery” occurs, the courier company usually attempts to deliver again the next day (McKinnon, 2009). If two failed deliveries occur the consumer must drive to a depot to pick up their goods. McKinnon (2009) uses delivery failure rates of 25%, 12% and 2% based on his literature research. Interaction Media in Retail Group (IMRG) (2007)

reports 11% of deliveries fail on the first attempt and 2% of deliveries fail altogether. McKinnon and Tallman (2003) report a delivery failure rate of 20%. Agatz et al (2008) discuss one possible solution to reducing Not at Home Deliveries, which is using time slots. For example, Peapod, an online grocer, allows consumers to book a 2 or 3.5 hour time slot 5 days a week for when their orders will be delivered. Using time slots increases customer service, but can also result in reducing the drop density since there will be fewer households to service at one time and less flexibility in choosing the optimal route. Other solutions include having lockers that customers must go to themselves to pick up an order, a solution that Amazon has started to implement (The Economist, 2012). A company called Kinek has set up a system where retailers will hold packages and receive a small payment from the consumer when they go to pick it up (The Economist, 2012). These types of systems avoid the problem of Not at Home Delivery, but mean that the consumer must make a trip. If the consumer has to make a shopping trip, it could negate the possible beneficial impact online retail has on transportation related emissions.

The Not at Home Delivery scenario is very important when considering transportation related emissions, as it will either increase the freight emissions or require the consumer to make a trip. Therefore, delivery failure rate is important to consider in this research.

2.6 Summary

The literature demonstrates how the retail environment has been changing in recent decades, which includes the rise of the Big Box stores through the 1980s and 1990s, which overtook traditional style retail. More recently, the Big Box style retail has plateaued in terms

of its growth (Colliers, 2011), and Big Box chains have even started the reintroduction of traditional style retail for their stores. At the turn of the century, online retail started to grow at a very significant rate, but has yet to represent a large portion of the market share. These three types of retail, traditional, Big Box and online, each have a different influence on transportation. The literature suggests that Big Box significantly increases consumer related transportation and has the largest impact on the consumer side, although it is more efficient for freight transportation. Traditional style retail means a smaller distance travelled for consumers, but has more negative affect on the freight side.

There are mixed opinions on how online retail affects transportation, but in an ideal scenario, the general consensus seems to be that online has fewer transportation related emissions than brick and mortar retail. Since consumer behavior is highly variable and complex, there are many different shopping trip scenarios that have been considered in the literature, and must be addressed in this research project. Due to the changing retail environment, and the lack of literature considering all three types of retail for both the consumer and freight transportation, this project is a relevant addition to the research related to retail activity and transportation emissions.

Chapter 3

Methodology

The primary objective of this research project is to further our understanding of the relationship between retail type and transportation emissions. The literature review introduced a variety of methods that have been used to understand how retail effects transportation. For this research project, a scenario model based on the method used by McKinnon (2009) will be used to compare freight and consumer travel for various retail types. The scenario model approach will be employed based on data from the Transportation Tomorrow Survey (TTS), industry case studies and assumptions based on literature. A scenario model explores results for various assumptions and a range of behaviors, and is used due to a lack of detailed data. Consumer distances travelled for shopping trips will be determined using the TTS data for various Traffic Zones (TZ), then the freight distance travelled to stores or consumer households will be determined by examining case studies. For each retail classification, the consumer and freight distances will output information on average kilometers per item. Using emission factors, the gCO₂ per item is determined. For each retail type, the average gCO₂ per item for consumers and freight will be the final output and will be used to compare traditional, Big Box and online retail. Using a per item approach will eliminate the need to define a time frame, which would present difficulties in modelling. An item would include any shopping item bought because the available data does not distinguish between type of shopping items bought.

The methodology section of this report begins by summarizing the general methodological approach for the research. This is followed by a description of the study

location and how the Traffic Zones from the TTS data are selected for consumer distance information. The third section goes into detail about how the consumer distance is determined, while the fourth section describes how the freight distance is determined. The final section discusses how the average distances will be converted to gCO₂.

3.1 Methodological Approach

Figure 11 shows a conceptual map of the scenario model. For the consumer distances, the TTS will be used to gain data on the average consumer shopping trip distances and the destination TZ. For the freight distances, case studies will be conducted to gain information on freight route distance and the number of drops per route. Retail type will have an impact on both consumer shopping trip distance and freight route distance. For example, if the retail type is a Big Box store in the suburbs, it will likely increase consumer shopping trip distance and decrease freight route distance. Using the three variables circled in the hashed line in Figure 11 (consumer shopping trip distance, freight route distance and drops per route), the CO₂ emissions per item will be calculated. These CO₂ emissions will be classified into the different types of retail, big box, traditional and online. The destination TZs will be used to help classify into retail type.

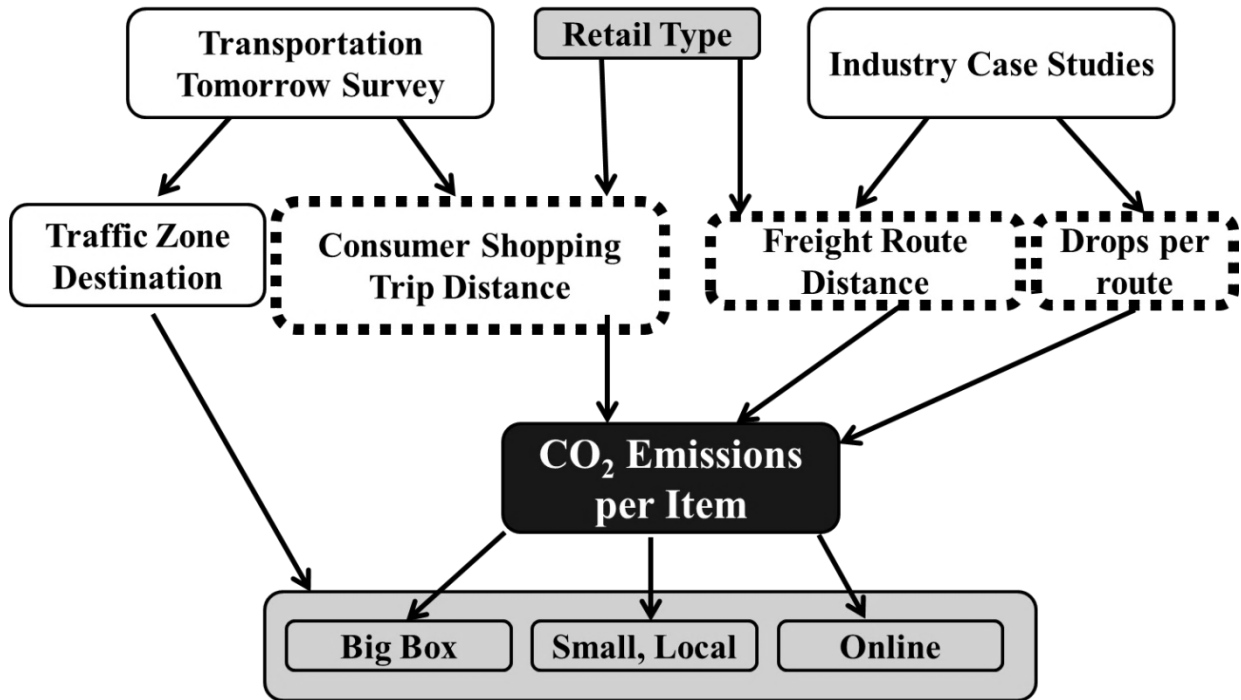


Figure 11: Concept Map of Model

The three variables circled in the hashed line will vary and change depending on the scenario being modelled. There will be four scenario components that will influence the average consumer shopping trip distance. The first is the return rate, whether the consumer makes an extra trip to return an item. The second is the scenario where consumers travel to the store, but do not purchase any item. The third is trip chaining, which will deal with the scenario where consumers are shopping as part of a journey with other destinations and purposes. The fourth scenario is browsing a store before purchasing something online, which would create a consumer travel component for online retail.

Two scenario components that influence freight route distance and drops per route will be considered. The first is the not-at-home delivery scenario, when the online shopping delivery vehicles try to drop off an item when no one is home. This may result in the trip

having to be repeated the next day, or the consumer having to drive to the depot. The vehicle type will also be considered, which would take into account vehicle size as well as whether the vehicle is hybrid-electric or diesel. The final variable that will be explored is the number of items dropped on a delivery route.

Table 2 summarizes the scenarios that will be explored and how the scenarios will affect the resulting CO₂ emissions. The table also presents the percent change that will be applied to the CO₂ emissions for various scenarios. These percent changes are based upon the information discussed in the literature review.

| Scenario | Effect on CO₂ emissions | Percent change for CO₂ emissions |
|---------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------|
| Key Influences on Consumer Emissions | | |
| Return Rate | Physical Stores: Increases Consumer Online Stores: Increases Freight | Physical Stores: 5% to 10% Online Stores: 25% to 35% |
| Items Bought | Decreases Consumer | Range 0 to 20 |
| No Items Bought | Increases Consumer | Range 10% to 30% |
| Trip Chaining | Decreases Consumer | Physical Stores: 10% to 50% |
| Browsing Before Buying Online | Online Stores: Increase Consumer | Online Stores: 0% to 25% |
| Key Influences on Freight Emissions | | |
| Not at Home Delivery | Increases Freight | Online Stores: 2% to 25% |
| Items delivered | Decreases Freight | Very large range (10s to 10,000) |

Table 2: Scenarios

The majority of the key influences directly affect the average distance travelled to the store, while the number of items bought and delivered affects the number of items per trip.

For example, if the return rate is 5% for Big Box and traditional retail, it means that 5% of consumers make an extra trip to the store to return a good. This directly increases the distance travelled by 5%. When considering trip chaining, if two destination locations are visited in one trip, only 50% of the distance travelled can be attributed to shopping. Again, the distance travelled is directly reduced by 50%. When considering multiple influences into one combined scenario, the percentages are compounded based on the emissions from the original distance travelled. Equation 1 demonstrates that the CO₂ emissions per item are a function of distance travelled, emission factors, modal choice, number of items and the key influences are a percentage adjustment factor.

$$kgCO_2 \text{ per item} = \sum_0^n \sum_0^m (\bar{d}_m * e_m * p_m * \beta_n) / \text{number of items} \quad \text{eq. 1}$$

Where:

n represents the number of influences

m represents the number of modes

\bar{d}_m represents the average distance for mode m

e_m represents the emissions factor for mode m

p_m represents the proportion of modal share for mode m

β represents the percentage change due to influence n

By varying the trip related variables based on the scenario components described above, a comprehensive understanding of the relationship between retail type and transportation related emissions can be gained. It is important to consider the different scenario components, since shopping trips can be complex and can vary significantly from person to person based on their consumption choices. Unlike the commute to work, where

there is typically a trip in the morning and the afternoon with defined start and end points, more scenarios must be considered when looking at shopping trip patterns.

3.2 Location and Traffic Zone Selection

The study location for this research is the Greater Toronto Area because it represents a Canadian metropolitan area, and has a mix of all three types of retail within the area. Having a mix of the retail types and available transportation data makes the area suitable for this analysis. For the consumer model, average shopping trip lengths based on the Transportation Tomorrow Survey (TTS) are used. The TTS is a survey done in the Greater Golden Horseshoe Area that gathers information on household travel behavior. The most recent TTS was done in 2006, where 150,000 households were randomly selected for an interview, representing approximately 5% of the population. The survey process involved a telephone interview as well as On-line Direct Data Entry (Data Management Group, 2012).

The data taken from the TTS for this study includes trip length, purpose and destination. Destination is an important factor, since it is used to compare the big box and traditional retail travel activity. Since there is no consumer movement for online retail, it does not need to be considered in the consumer model. The destination in the TTS data is divided into different Traffic Zones (TZs), and each TZ is classified in this research into different retail types. The TZs for the 2006 TTS survey are shown in Figure 12. They are geographical divisions of the survey area, and in the urban areas are divided on a very fine level.



Figure 12: TTS Traffic Zones, 2006

To get a good representation of average shopping trip distances, 20 TZs under Big Box classification, and 20 TZs under traditional retail classification are identified. The zones are chosen based on the criteria discussed in the literature review. For Big Box retail, there is substantial parking in the front, at least one major Big Box chain store, a mix of other large/ medium sized stores, and stores that are standalone (City of Hamilton, 2006). For example, the Crossroads power centre was a chosen zone, and an aerial view is provided in Figure 13. The image shows a large open parking lot, a few major Big Box outlets that are labeled (Staples, Canadian Tire, Future Shop, Superstore), and a variety of midsized retailers. This zone has the characteristics of Big Box retail as described by the literature; therefore it

was chosen as one of the twenty zones for that class of retail. The twenty zones were identified in an effort to provide coverage across the GTA are listed in Table 3, and a map is shown in Figure 15.



Figure 13: Crossroads Power Centre (source: Google maps)

| Power Centres | Street 1 | Street 2 | Area | TZ |
|----------------------|-----------------|-------------------|-------------|-----------|
| 1 | Weston Rd | Highway 401 | North York | 135 |
| 2 | Dufferin St | Wilson | North York | 423 |
| 3 | Dufferin St | Steeles Ave | North York | 393 |
| 4 | Eglinton Ave E | Victoria Park Ave | Scarborough | 529/526 |
| 5 | Kennedy Rd | Highway 401 | Scarborough | 487 |
| 6 | Eglinton Ave E | Laird Drive | East York | 220 |
| 7 | Islington Ave | Queensway | Etobicoke | 299 |
| 8 | Tenth Line | Argentia | Brampton | 3617 |
| 9 | Keele St | St Clair Ave W | Toronto | 146 |
| 10 | Leslie St | York Mills Rd | North York | 231 |
| 11 | Morningside | Sheppard | Pickering | 577/576 |
| 12 | Brittania | Marvis | Mississauga | 3607/3608 |
| 13 | Bouvaird | Main | Brampton | 3425/3370 |
| 14 | Chrysler | Queen | Brampton | 3421/3331 |
| 15 | Brock | Pickering Pkwy | Pickering | 1045 |
| 16 | Hays | Trafalgar | Oakville | 4035/4034 |
| 17 | Wycroft | Burloak | Oakville | 4002 |
| 18 | Thickson | Victoria St E | Oshawa | 1155 |
| 19 | Silver Linden | High Tech Rd | Markham | 2250 |
| 20 | Dundas | Winston Churchill | Mississauga | 4024 |

Table 3: Big Box Traffic Zones

For the traditional retail class, the zones consist of several small stores that have window displays, are street-oriented and cater to a pedestrian friendly environment (City of Hamilton, 2006). For example, the intersection of Lakeshore and George St in Oakville (Figure 14) is a zone chosen to represent traditional retail. The image shows that there are a number of small stores with large, street-oriented window fronts, and the overall the street is pedestrian friendly. Since the area meets the criteria of traditional retail as per the literature it is selected as one of the 20 zones to represent traditional retail. The 20 zones chosen to represent traditional retail are shown in Table 4, and the map in Figure 15.



Figure 14: Lakeshore and George St (Source: Google maps)

| Main Streets | Street 1 | Street 2 | Area | TZ |
|---------------------|-----------------|------------------|---------------------------|-----------|
| 1 | Unionville | Carlton | Union Ville, Markham | 2409 |
| 2 | Yonge | Richmond | Richmond Hill | 2211/2241 |
| 3 | Yonge | Olive | Finch Station, Willowdale | 443/450 |
| 4 | Simcoe | King | Oshawa | 1208 |
| 5 | Brant | Lakeshore | Burlington | 4060 |
| 6 | George | Lakeshore | Oakville | 4016 |
| 7 | Lakeshore W | Primrose | Mimico | 286/287 |
| 8 | Dufferine | Eglington | York | 161 |
| 9 | Yonge | St-Clair | Deer Park | 203/204 |
| 10 | Queen | Hambly | The Beaches | 253/254 |
| 11 | Bloor | Bartlett | Bloor Village | 103/104 |
| 12 | Main | Queen | Brampton | 3348/3351 |
| 13 | Queen | Mill | Streetsville | 3836 |
| 14 | Bloor | Bathurst/Spadina | The Annex | 72/73 |
| 15 | Brock | Dundas | Whitby | 1141/1143 |
| 16 | Lakeshore E | Briarwood | Port Credit | 3642 |
| 17 | Haddington | Avenue | Nortown | 194/195 |
| 18 | Danforth | Cedarvale | Woodbine | 251 |
| 19 | Carlton | Parliament | Cabbage Town | 19/23 |
| 20 | Bloor | Cliveden | The Kingsway | 314/316 |

Table 4: Traditional Retail Traffic Zones

These 40 Traffic Zones (20 for Big Box retail and 20 for traditional retail) are chosen based on their meeting the criteria for each retail type as discussed in the literature review and are representatively spread across the Greater Toronto Area. A map of the 40 zones is shown in Figure 15, where the black zones are traditional retail and the white zones are Big Box retail.



Figure 15: Retail Traffic Zones

Based the visual examination of the GTA to find the 40 retail traffic zones, the sample selected represents a large portion of the population. Within the City of Toronto, there are many long, traditional, main st, therefore within the City of Toronto the zones

selected represent a small portion. However, the traditional outside the City of Toronto and the Big Box power centres selected reflect a good portion of the population. Therefore, the selection of 40 traffic zones is a good sample size to draw accurate conclusions from.

It should also be noted that there are several retail zones in the GTA that do not fit into the criteria used to identify traditional and Big Box zones. The criteria, based on literature, were selected in order to find zones that distinctly could be classified into one of the two retail types. However, there are many retail areas that are a blend of both traditional and Big Boxes, as well as areas that have strip development or large malls, which were not considered in this thesis.

3.3 Determining Consumer Distances Travelled

Consumer distances travelled for shopping trips are obtained using shopping trip distances to the 40 select shopping related TZs. To extract this data, the Internet Data Retrieval System from the University of Toronto Data Management Group is used (Data Management Group, 2012). A detailed description of the query run is in Appendix A.

This data query returned a list of shopping trip distances to each zone, and the number of trips for each distance. As mentioned previously, the TTS data represents 5% of the population, and the data queries return an adjusted number to reflect the whole population of the GTHA. Therefore the number of trips for each distance does not represent actual survey response, but an inflated number to represent all the households in the Greater Hamilton and Toronto Area (GTHA). It should also be noted that outliers were present, and since the TTS is only a 5% representation, outliers had a significant influence on the results. Therefore, the outliers were removed from the data query results. Based on the distances returned from the

TTS, and the general size of the GTA, the outliers were distances above 60km with a large jump in distance from the previous trips.

Another query was run to determine the modal split of shopping trips to each destination shopping Traffic Zone. This was done by adding a third filter with the Field Name “Primary Travel Mode of Trip”. Multiple queries were run with different input codes for this filter. The runs included Auto Driver (D) as one run to represent drivers, the next run was Transit excluding GO rail (B) and Joint GO rail and local transit (J) as bus transit emitters. Another run was GO rail only (G) to represent rail transit shopping. The joint local and GO rail trips are interpreted as bus transit emitters in order to use a more conservative, worst-case scenario. Finally Cycle (C), Auto passenger (P) and Walk (W) are modeled to represent shoppers who did not make any emissions during their shopping trip. Subsequently, for auto trips all the emissions are attributed to the driver, while the passenger is attributed zero emissions in order to avoid double counting. Although passengers aren’t attributed to making emissions, it is important to note that they can affect the number of items purchased for that one trip. When considering the number of items purchased, a key influence on emissions per item, auto trips with a passenger are more likely to have a larger number of items purchased. Figure 16 is a flowchart visually showing the methodology for determining consumer shopping distances and related emissions. The methodology just described corresponds to step 1 on the flowchart.

The goal of this research is to make an overall comparison of the three types of retail, traditional, Big Box and online. Therefore, an average distance travelled to traditional and Big Box retail is needed. First the average trip distances for each mode of transportation must

be converted to gCO₂ emitted, since the conversion is different for the four travel mode types. The conversion method will be discussed later on in the methodology, and represents step 2 in Figure 16. Using percentage modal split for each Traffic Zone, the emissions from auto-drivers, bus transit users and train transit users are used to find a weighted average of the emissions per shopping trip to each Traffic Zone. This represents step 3 in Figure 16. These individual Traffic Zone distances are examined and discussed, and then the last step is to calculate an overall average for Traditional and Big Box retail by calculating a weighted average using the number of trips and emissions for each individual Traffic Zone for each classification. This represents step 4 in Figure 16.

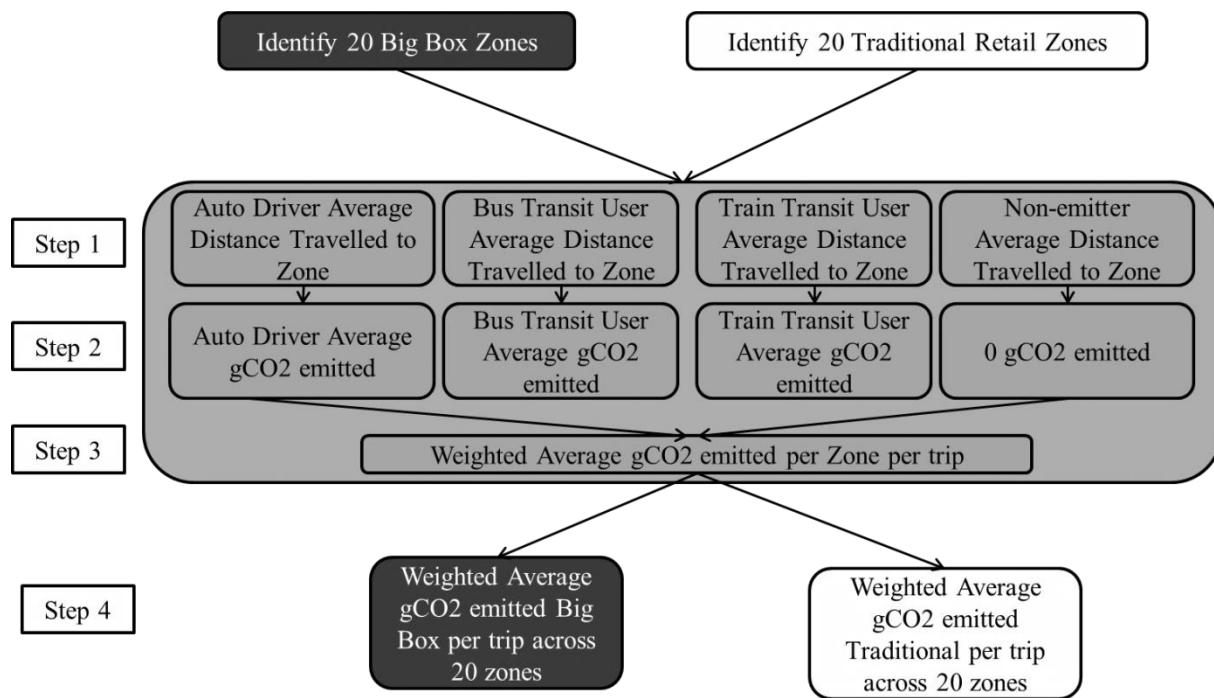


Figure 16: Methodology for Consumer Emissions

This methodology for determining consumer distances travelled and the related emissions will determine a basic average gCO₂ emitted for a trip to Big Box retail and

traditional retail outlets. Once this average is determined, various scenarios can be applied to the gCO₂ calculated, as described previously in Table 2, and calculated as described in equation 1. This will adjust the gCO₂ and provide a more comprehensive understanding of the differences between emissions for Big Box and traditional retailers.

3.4 Determining Freight Distances Travelled

For the freight model, case studies in the GTA are examined and relevant literature consulted. The model assumes that freight related trips start at a distribution centre (DC) or warehouse, with the specific details for the last mile trip of the freight distribution differing based on retail format and operations. The model information that is needed includes average delivery route distances and the number of items per drop, in order to obtain the kilometers per item. Information on type of vehicles is also implemented into the model. Using the average route distance information, combined with the average number of items per vehicle, the CO₂ emissions per item can be modelled for big box, tradition and online retail.

For the average route distance and drops per route for online retailers, case studies for retailers in the GTA are used to obtain the necessary data. The first case is based on data from Transport Canada's (2012) EcoFreight Project relating to distance and drop density for Grand and Toys online retail. This case study will be used to obtain route distances for trucks delivering for online retailers.

For Big Box and traditional retail, a case study for a retailer that has store locations across the GTA in both retail formats will be used. The retailer wished to remain anonymous, but data on route distance, the weight of goods delivered and the number of drops per route were provided for this research. This data set is used to calculate route distances and the

number of items dropped per route for Big Box and traditional retailers. Then equation 1 will again be applied to calculate the gCO₂ per item, but only diesel trucks of various sizes will be considered as the modal choice.

Determining gCO₂ emissions

The comparison between traditional, Big Box and online retail is focused on examining the gCO₂ emitted per item consumed. To determine this number, the average trip distances per item determined in the previous sections must be converted into emissions (gCO₂ emitted per item).

The emissions factors are based on a reference tool published by the Green House Gas Protocol (2012). The emissions factors taken from this publication are based on data from the United States. Table 5: CO₂ emissions factors (GHG Protocol, 2012) shows the CO₂ emissions factors used to convert the distances into gCO₂ emitted.

| Mode | CO₂ | | |
|-------------------------------------------|-----------------------|-----------|--------------|
| Bus - Local Bus | 0.0665 | Kilogram/ | Passenger km |
| Train - National Rail | 0.1150 | Kilogram/ | Passenger km |
| Passenger Car - Gasoline | 0.2433 | Kilogram/ | Km |
| Heavy Duty Vehicle - Rigid - Diesel | 0.7167 | Kilogram/ | Km |
| Heavy Duty Vehicle - Articulated - Diesel | 1.0690 | Kilogram/ | Km |
| Light Goods Vehicle - Diesel | 0.3893 | Kilogram/ | Km |

Table 5: CO₂ emissions factors (GHG Protocol, 2012)

As for the fuel types used, Table 6 shows the fleet makeup of Canadian vehicles (Statistics Canada, 2009). The table shows that for trucks, the vast majority run on diesel fuel.

| | Total, all vehicles | Vehicles up to 4.5 tonnes | Trucks 4.5 tonnes to 14.9 tonnes | Trucks 15 tonnes and over |
|------------------------|---------------------|---------------------------|----------------------------------|---------------------------|
| Gasoline | 94% | 97% | 26% | 2% |
| Diesel | 6% | 3% | 72% | 98% |
| Other fuel type | 0% | 0% | 1% | N/A |

Table 6: Canadian Fleet Makeup (Statistics Canada, 2009)

These various conversion factors will be used to determine the transportation emissions for freight and consumers for each types of retail.

The next chapter will present the results and discuss the various scenarios explored, as well as discuss the overall implications of the results.

Chapter 4

Results and Discussion

This chapter presents the results for the average emissions for consumers and freight for retail activity, as well as how this average changes from key influences in different scenarios. First the characteristics and emissions for consumer shopping trips will be discussed, then the characteristics and emissions for the freight trips. This will be followed by a consideration of both the consumer and freight emissions combined into a total. Next various key influences will be studied and varied to create different scenarios. These key influences include return rate, consumers not purchasing anything, trip chaining, not-at-home delivery, type of truck, browsing before buying online and number of items delivered. The last section will present the broader applicability and impact of the results.

4.1 Average Emissions for Consumer Shopping Trips

The average CO₂ emissions for consumer shopping trips were calculated by using the TTS trip length data to the specified 40 TZs and the modal choice data. Figure 17 displays the results for the kg CO₂ per item from the consumer trip activity. This is a base case scenario, and includes the trip to the store and back assuming only one item it purchased. For Big Box retail, the consumers emitted 2.61 kg CO₂ per item bought. For traditional retail, the consumers emitted 1.87 kg CO₂ per item bought. For online retail there are no emissions associated with the consumer since there is no consumer movement. These results demonstrate that on the consumer side, Big Box retail has the largest environmental impact, traditional retail has a slightly smaller impact, and online has no impact on the consumer side.

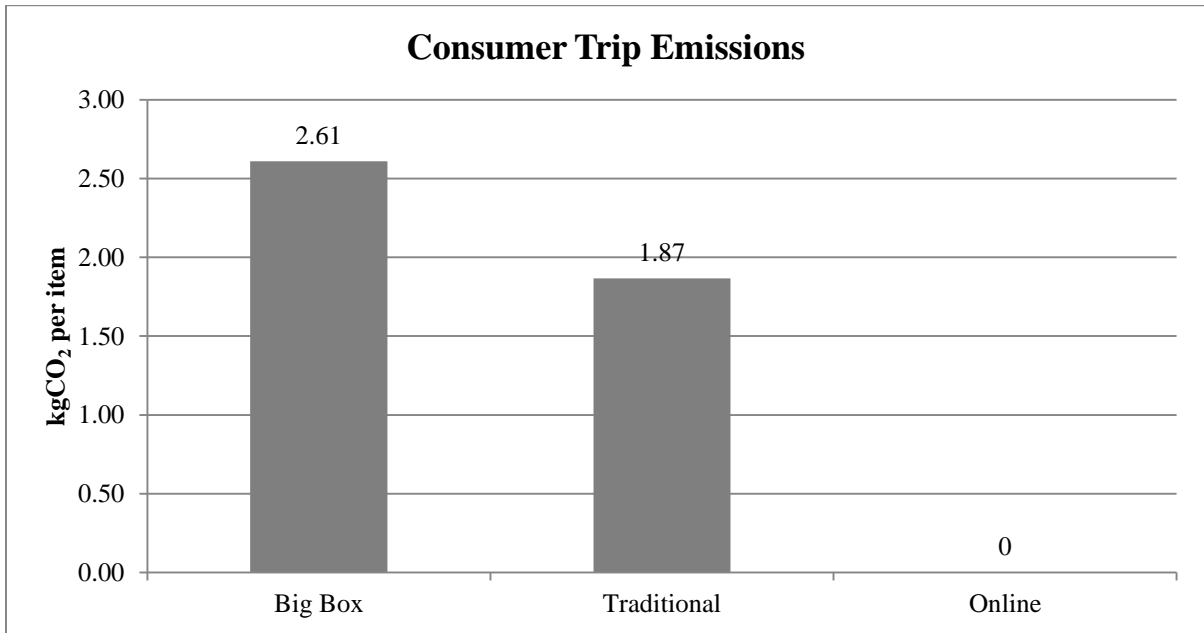


Figure 17: CO₂ emissions for consumer shopping trips

These emissions were calculated based on the distance travelled by each mode, the emissions associated with that mode, and the percent of trips each mode represented. The one-way shopping distances travelled, by mode are shown in Figure 18. The average distance travelled by car to a Big Box retail zone is 7.1 km, while the average distance travelled by car to a traditional retail zone is 5.3 km. This shows that consumers who drive to go shopping are travelling further to get to a Big Box retail centre than to a traditional Main St. These results can also be seen in the distances travelled by car passengers. Although it seems like consumers are travelling a far distance by GO rail, this mode represents a very insignificant portion of the modal split, as will be discussed later. For local transit users, consumers are travelling 6.6 km to Big Box retail centres and 7.9 km to traditional retail centres. This reflects how traditional retail centres have more people travelling by public transit and are

more accessible, allowing people to travel from further distances. For consumers who choose to walk for their shopping trips, for both types of retail the average distance travelled is approximately 1 km. The walking distance is similar for each retail type, since if consumers are located at a further distance than they are willing to walk they will choose alternative modes. For cycling, consumers travel on average 3.4 km to traditional retail zones, and only 1.2 km to Big Box retail zones. This once again reflects the accessibility of traditional zones which usually have a better cycling path network and allow consumers to cycle more easily from further distances. The cycling distance is also indicative of the type and amount of goods purchased at traditional retailers versus Big Box retailers. Often at Big Box stores, consumers purchase more goods as well as larger, bulkier items which are difficult to transport on a bicycle.

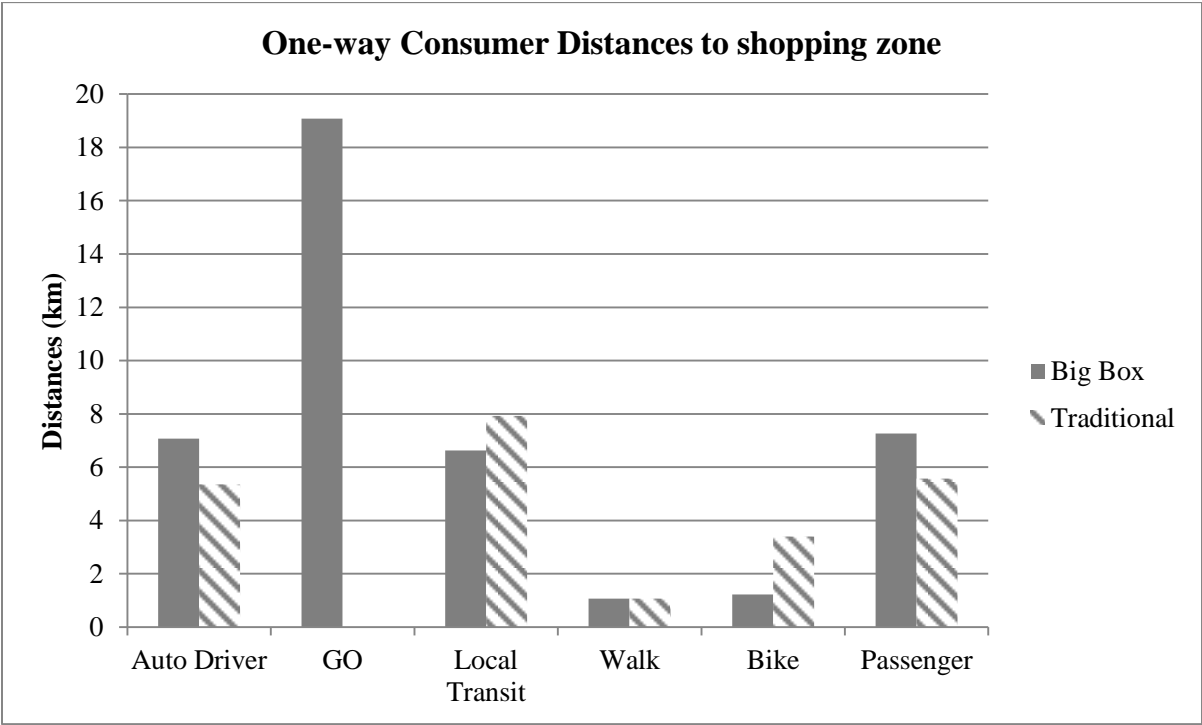


Figure 18: Consumer distances travelled to shopping zones

The modal split for consumer shopping trips is shown in Figure 19. Trips by car represent the majority of shopping trips to both retail types. For Big Box retail zones, 75% were made by drivers, and for traditional retail zones, 66% were made by drivers. Although Big Box zones have a higher percentage of people driving, auto drivers still represent a very large modal share for both types of retail. Auto passenger is the second highest mode for both retail types, representing 22% of trips to Big Box zones and 14% of trips to traditional retail zones. The third largest mode for both types of retail is local public transit, which is 2% of trips to Big Box zones and 14% of trips to traditional retail zones. Public transit is the mode with the largest difference between the two retail types, which illustrates how Big Box retail is often inaccessible by public transit. For Big Box retail zones, the other modal types represent less than 1% of the modal split and have an insignificant impact on the environmental footprint. For traditional retail zones, active transportation is slightly more present, with 2% of trips done by walking and 2% of trips done by cycling. Overall, active transportation represents a very small proportion of shopping trips.

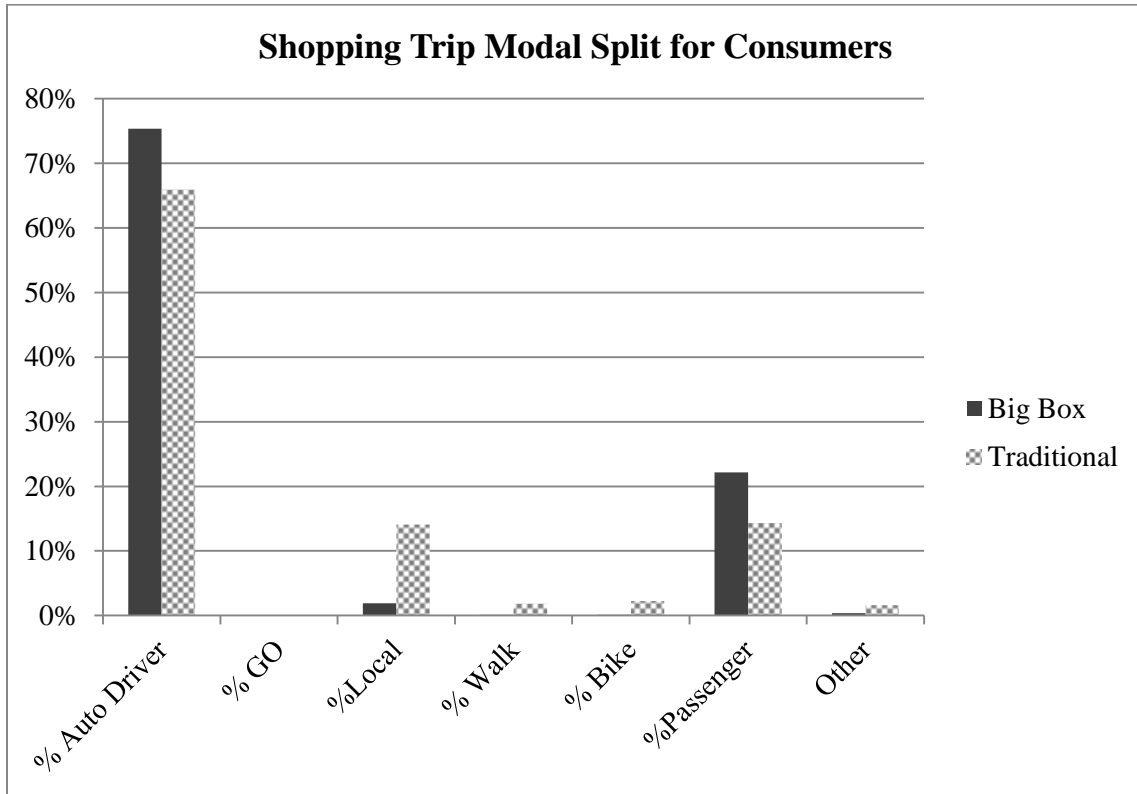


Figure 19: Consumer shopping trip: modal split

These results demonstrate that for Big Box retail, more consumers choose to drive for their shopping trip, and they must travel slightly further distances. As a result, the kgCO₂ emitted per item is higher for Big Box retail than traditional retail from consumer travel activity.

4.2 Average Emissions For Freight Trips

The freight emissions associated with the routes for the three types of retail were calculated based on case studies of retailers in Ontario. For online, the distance was based on a case study of Grand and Toy online stores, who cited a distance between household drops of 1.2km (Transport Canada, 2010). Another courier company based in the UK listed a distance between households of 1 km, similar but slightly smaller distance than Grand and

Toy online stores (Allen et al., 2003). Although the UK distance for online retail deliveries cannot be applied in a North American context, it does support the Grand and Toy distance of 1.2 km as being a reasonable estimate.

For the physical retailer stores, Big Box and traditional retail, route data from a retailer with both types of stores throughout the GTA was used. That retailer required anonymity, but provided data on route distances, the number of drops per route and the weight of goods delivered per route. Basic descriptive statistics and scatterplots were examined for the three variables; drops, weight and distance to determine which routes were for Big Box retail locations and which were for traditional retail locations. The variable with the most distinct pattern was weight, which reflects how large trucks are usually used for Big Box deliveries, whereas small trucks are used to go into Main St. environments and deliver to traditional stores. Since the distribution centre is located in a suburban location, and both types of stores for this retailer are spread across the GTA, the distance did not reflect whether the delivery was to Big Box or traditional stores. The retailer requires the weights to be confidential, but a specific threshold was chosen based on a histogram of the weight, as well as a scatterplot of the weight for the routes classified by number of drops (ranging from 1 drop to 5 drops). Using this threshold as a division, the distances travelled per item delivered for the three types of retail is shown in Figure 20. The figure shows that the distance travelled per item for Big Box retail is 0.026 km, while the distance travelled per item for traditional retail is more than double that, 0.061km. As would be expected, online retail has much greater freight distances travelled per item, 1.2 km, since online deliveries to individual households. The average round trip route distance for Big Box and Traditional is similar,

189km for traditional and 196km for Big Box. The significant difference is the number of items delivered, which is significantly higher for Big Box.

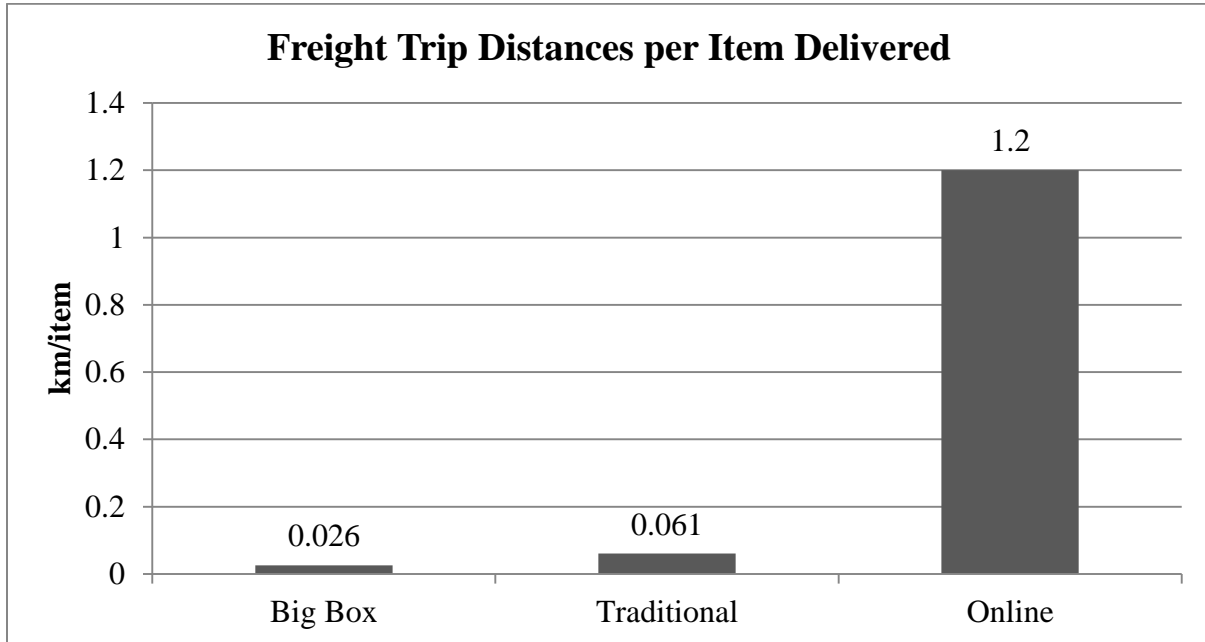


Figure 20: Freight Trip Distances per Item Delivered

To convert these distances into CO₂ emissions, the conversion factors discussed in the methodology were applied (GHG Protocol, 2012). Using the emission factors and the distances described above, the CO₂ emissions per item for the three retail types are shown in Figure 21. Online retail had the largest emissions impact at 0.467 kg CO₂ per item delivered, as is expected since the truck deliveries are to individual households for online retail. Traditional retail had the second largest emissions, at 0.0437 kg CO₂ per item delivered, and Big Box retail emitted 0.0278 kg CO₂ per item. The difference between the three types of retail was not as important as the difference for the kilometers per item delivered. This is because of the type of vehicle used, online using the smallest most efficient vehicle while Big

Box uses the largest vehicle with the greatest emissions per kilometer. Due to the large vehicles used in Big Box retail, the efficiencies for kilometer per item are not as pronounced.

These results show that there are benefits to the Big Box retail format for freight deliveries. Being able to access the stores with large trucks means that more items can be delivered per route, making the environmental impact per item delivered less significant. Therefore, for the freight side, Big Box retail has the smallest CO₂ emissions associated with it.

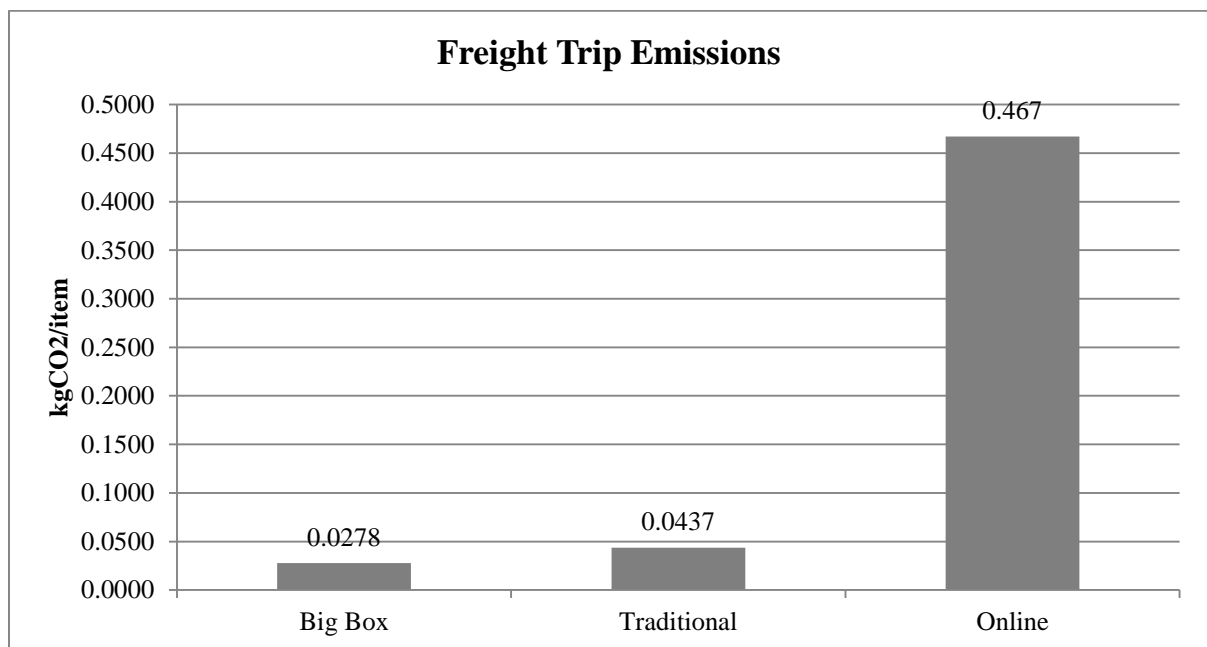


Figure 21:kgCO₂ emitted for freight trips

4.3 Base Case Emissions Scenario

The results have shown that Big Box retail has the largest CO₂ emissions on the consumer side, and the smallest CO₂ emissions on the freight side. These results support what was discussed earlier, that consumers tend to drive and travel further distances to get to Big Box stores, but the format is more efficient for freight deliveries. These differing results

for the consumer and freight transportation impacts demonstrate the importance of a combined approach considering both types of transportation.

The combined results are shown in Figure 22 **Error! Reference source not found.**, and demonstrate that for the base case, Big Box retail has the largest CO₂ emissions, while online has the smallest. It should be noted that this base case scenario assumes the consumer goes straight to the store and back, and purchases only one item. As discussed further in the scenarios, however, that is not typical consumer behavior.

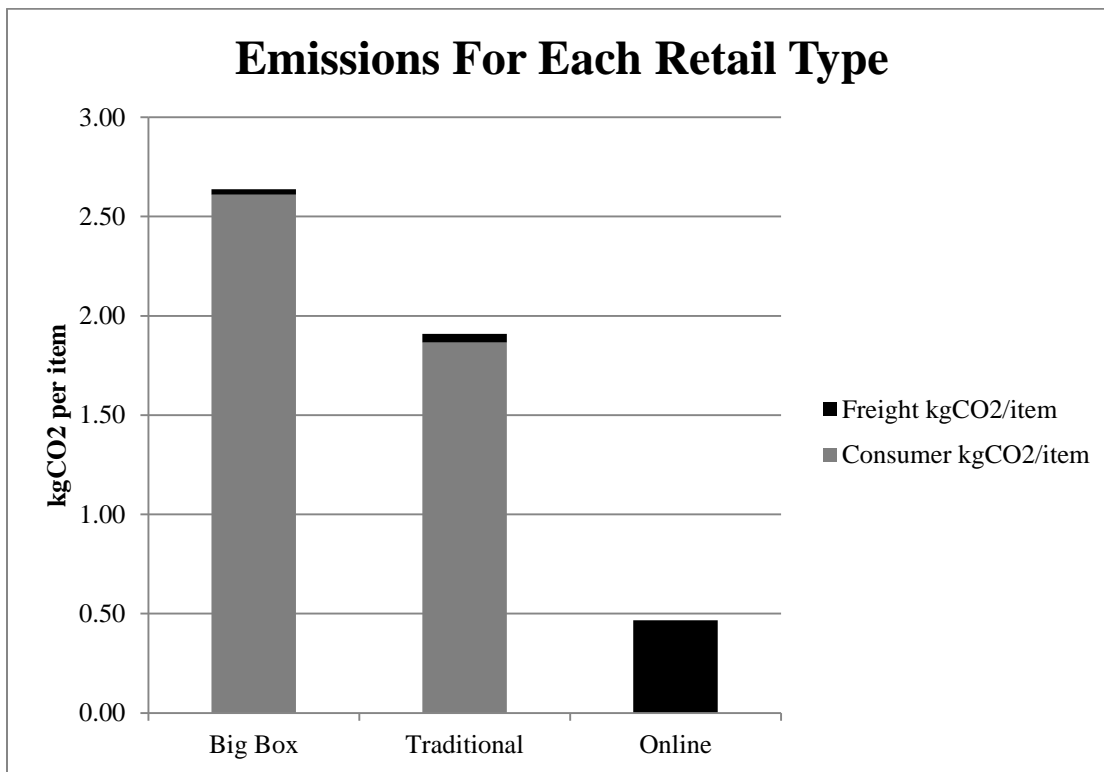


Figure 22: Base case emissions for each retail type

An important observation to take away from the combined results is that the consumer movement has a much more significant impact on the kgCO₂ than the freight movement. Freight movement consists of a very small proportion of the emissions for the

physical stores because of the number of items carried on a truck versus the one item bought by a consumer. For the case study used in the GTA, the average number of items delivered per route for traditional retail is 3133 items, and the average number of items delivered per route for Big Box retail is 8062 items. Since thousands of items are being delivered for distances around 190 km, the emissions per item are very small. Therefore, when considering the last mile, it can be concluded that the consumer movement has larger CO₂ emissions associated with it than the freight movement. Since the consumer movement has a larger impact, it follows that online will have the lowest emissions since there is no consumer movement, only a freight delivery.

The next section will further explore some of the key influences that effect the CO₂ emissions associated with each retail type. Various scenarios will be explored to gain a more comprehensive understanding of the emissions.

4.4 Scenarios – Varying the Key Influences

There are many different influences that effect the emissions related to retailers. The key influences discussed are shown in Table 7, which was originally presented as Table 2 in the methodology chapter. This table shows important influences that are considered in this research project, how they affect the emissions, and the numerical range of the influences based on literature. This section will explore different scenarios by varying the influences listed in the table. This is a very important part of the analysis, because although the base case scenario presented in the previous section gives a good understanding of the different retail types, it doesn't provide a comprehensive analysis of all the different scenarios that could occur in the real world.

| Scenario | Effect on CO ₂ emissions | Percent change for CO ₂ emissions |
|---------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------|
| Key Influences on Consumer Emissions | | |
| Return Rate | Physical Stores: Increases Consumer Online Stores: Increases Freight | Physical Stores: 5% to 10% Online Stores: 25% to 35% |
| Items Bought | Decreases Consumer | Range 0 to 20 |
| No Items Bought | Increases Consumer | Range 10% to 30% |
| Trip Chaining | Decreases Consumer | Physical Stores: 10% to 50% |
| Browsing Before Buying Online | Online Stores: Increase Consumer | Online Stores: 0% to 25% |
| Key Influences on Freight Emissions | | |
| Not at Home Delivery | Increases Freight | Online Stores: 2% to 25% |
| Items delivered | Decreases Freight | Very large range (10s to 10,000) |

Table 7: Scenarios and key influences

4.4.1 Return Rate

For Big Box and traditional retail, a return would mean an extra trip made by the consumer to bring the good back to the store. Nairn (2003) estimates a return rate between 6% and 10% for physical stores. Based on this estimate, the range of 5% to 10% is explored. For online, the return rate estimated ranges around 25% to 30% (Nairn (2003), Fernie et al. (2004), McKinnon (2009)). However, since the return policy for online retail is often to use the national mail system, the effect on emissions ranges from 0% to 30%. Using these ranges, the results for emissions per item including return rate is shown in Figure 23. The dashed boxes represent the range of emissions as a result of taking return rate into account.

The figure demonstrates that taking return rate into account doesn't change the overall results. Big Box still has the highest kg CO₂ emissions per item, while online has the lowest. Return rate had the largest effect on online retail, since the return rate for online retail is much higher than for retail at physical stores. However, most online retailers use the national mail system to handle returns, which means the increase in CO₂ would be zero, the lowest end of the range in the graph. The highest end of the range would mean all returns are picked up by the online delivery truck, an unlikely scenario. Overall, return rate does not have a huge impact on emissions related to retail.

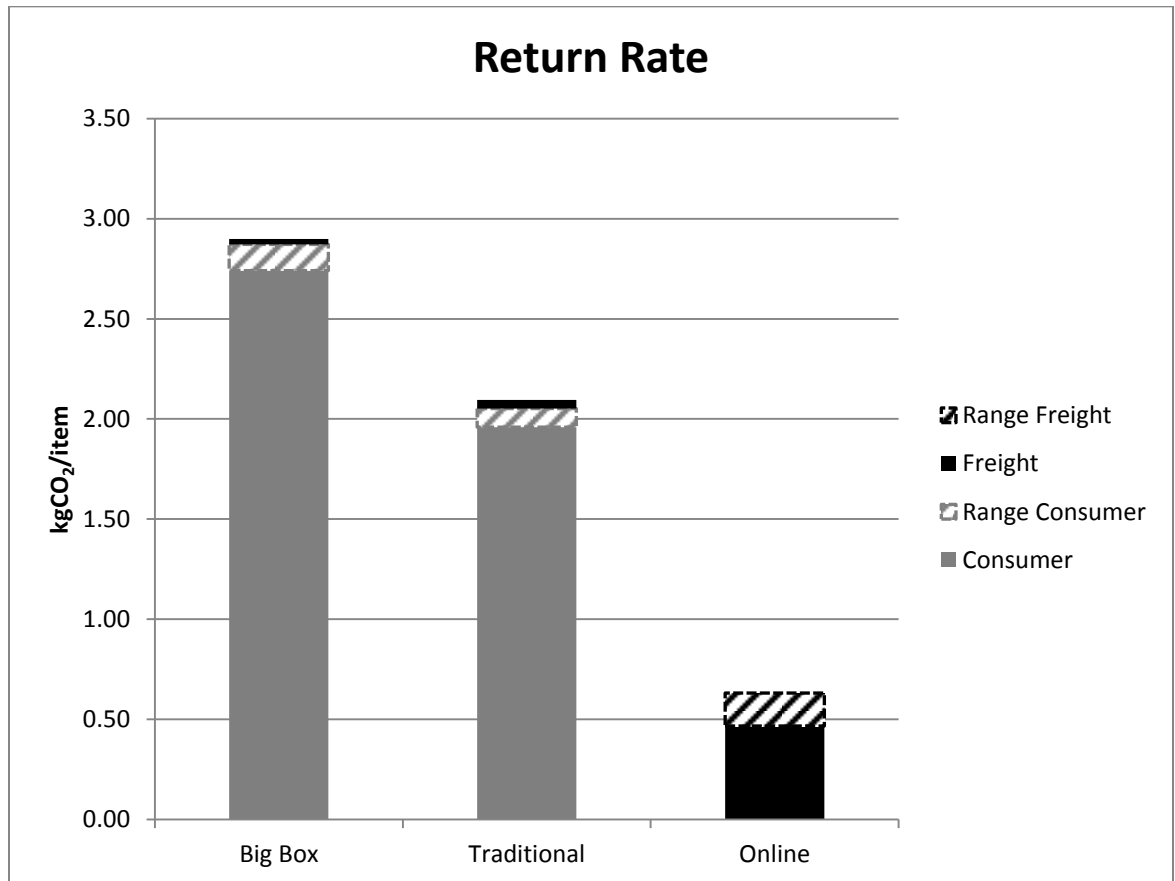


Figure 23: Emissions with return rate

4.4.2 Number of Items Bought

The base case scenario presented earlier assumes that consumers only purchased one item per shopping trip, which is not typical consumer behavior. As mentioned in the literature review, 79.4% of online purchases are for one item (Haider et al., 2009). For physical stores, Big Box and traditional retail format, the median number of items purchased is 5, while the average is 12 items (Sorensen, 2009). The data is right skewed because there are a few people purchasing a very large number of items, bringing the average up. Due to the skewed nature of the data for number of items purchased, the median is a better indicator of a typical shopping trip. A range of number of items bought is considered, and the results for the emissions per item (freight and consumer) are shown in Figure 24.

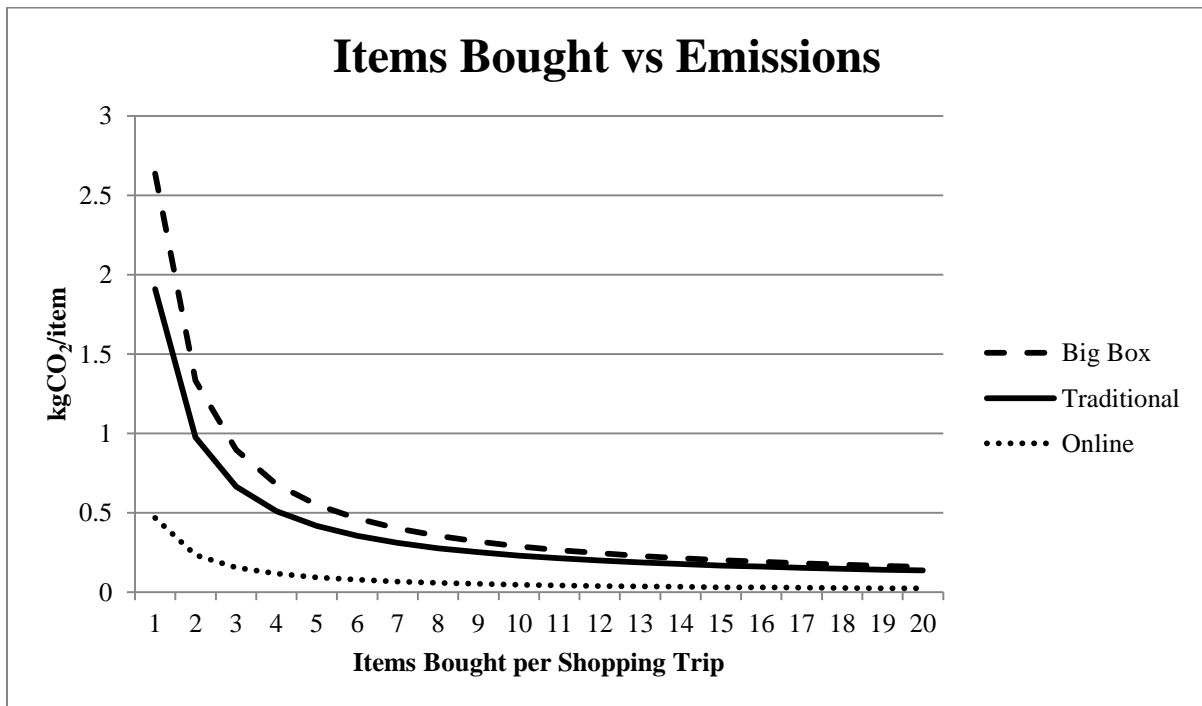


Figure 24: Number of items bought vs emissions

Figure 24 shows that as one would expect, the emissions per item decrease while the number of items purchased increases. Therefore, if one wishes to decrease their emissions as a consumer, doing shopping trips where more items are purchased would be the best shopping behavior. Doing one trip to purchase many items has less impact than many trips to purchase only one item each time. The figure also shows that the more items purchased, the less difference between the different retail types.

If the medians for number of items purchased are considered, a typical value for emissions per item can be determined for each retail type. Using 1 item for online, and 5 items for Big Box and traditional, the emissions per item for online is 0.467 kg CO₂ per item, for Big Box it is 0.550 kg CO₂ per item, and for traditional it is 0.417 kg CO₂ per item. Although Big Box still has the largest emissions, there is significantly less difference between the retail types when considering number of items purchased. As well, when considering the median number of items purchased online has more emissions than traditional retail. Therefore, as an influence the number, of items purchased has a very large effect on the emissions per item. This also reflects that consumer behavior can have a larger impact on the CO₂ emissions than the retail format, although retail format and consumer behavior are not independent.

4.4.3 Consumers Not Purchasing Anything

The scenario where a consumer makes a trip to the store, but purchases 0 items, is an important scenario to consider. It is not considered in the base case scenario, which assumes that one item is purchased every trip. The range considered for this scenario is that between

10% and 30% of shopping trips result in no purchases (McKinnon, 2009). Considering these shopping trips where no items are purchased, the results are shown in Figure 25.

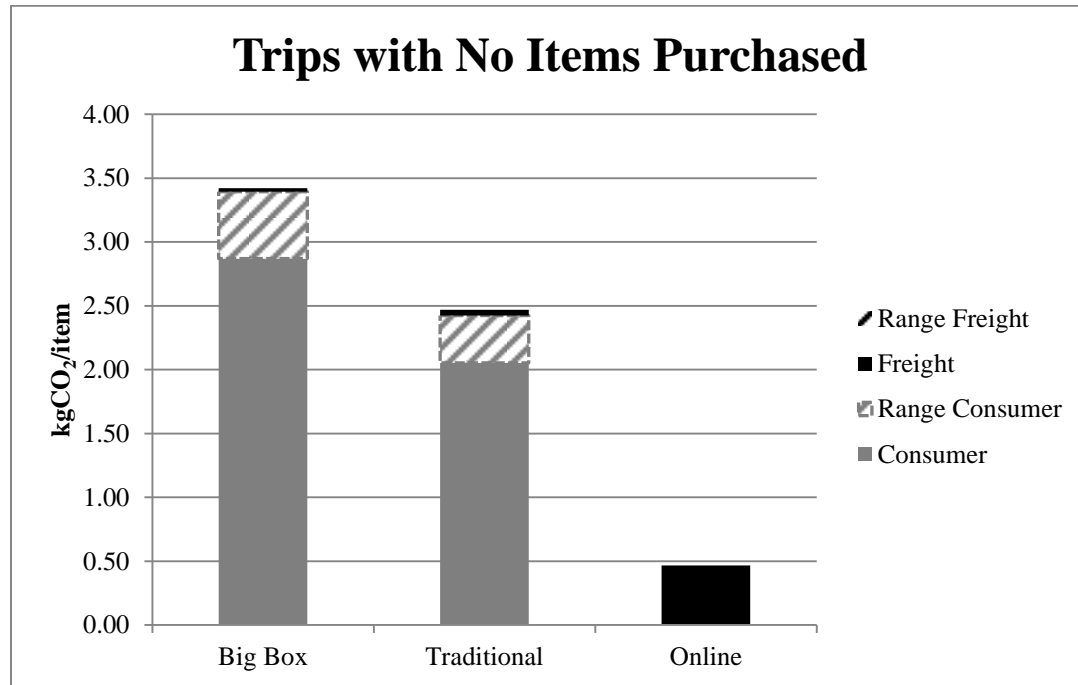


Figure 25: Emissions including trips with no items purchased

When considering the range of possible emissions per item, Big Box retail and traditional retail are close to overlapping, but Big Box still has definitively the larger emissions per item. Although considering trips where no items are purchased creates the potential for less difference between Big Box and traditional, it does not change the overall ranking of retail types from their associated emissions per item.

4.4.4 Trip Chaining

Trip chaining occurs when a person goes to several destinations in a single trip. Shopping trips are often accompanied by stops at other locations, therefore it is important to consider the scenario where trip chaining occurs. According to Mckinnon (2009), the percent

of the trip distance that can be attributed to shopping can be as low as 10%. To explore the scenario where trip chaining occurs, the full range of percentage attributed to the shopping trip is graphed. The results for the total CO₂ emissions (freight and consumer) while considering trip chaining are shown in Figure 26.

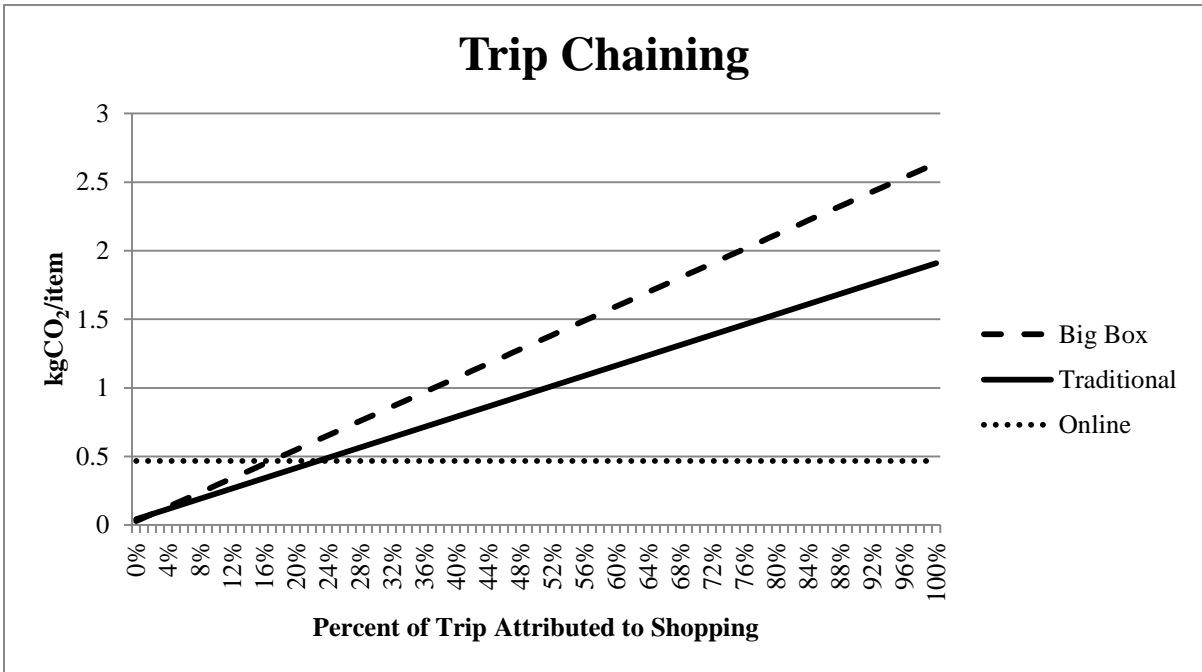


Figure 26: Emissions including trip chaining

The percent of trip attributed to shopping depends significantly on the type of good purchased. For example, when buying furniture, large appliance or clothes consumers will often make a dedicated trip. In this case of 100% of the trip distance being attributed to shopping, the emissions would be the same as the base case scenario. When 100% of the trip is attributed to shopping, the only locations visited at the destination would be retailers. On the other hand, when doing groceries consumers will often stop at the store on the way home from work, or do other errands while out. For groceries the percent of the trip distance

attributed to shopping can be as low as 10%, for example, going only 10% out of the way from the trip home from work (Mckinnon, 2009). If 50% of the trip was attributed to shopping, this would reflect that the consumer went to two locations at the destination point, for example the post office and a retailer. If two locations were visited for the one trip, only 50% of that trip could be attributed to shopping.

When considering the low end of the spectrum (10%), Figure 26 shows that online has the largest. At 10%, online retail has 0.467 kg CO₂ per item, Big Box retail has 0.289 kg CO₂ per item and traditional retail has 0.230 kgCO₂ per item. Therefore, if only 10% of the shopping trip distance is attributed to shopping, traditional retail has the lowest emissions while online retail has the highest emissions.

These results show that if a consumer is making a small detour on a predetermined trip to shop, there is little difference between the type of retail format. Trip chaining is a key influence that has the potential to have a large impact on the CO₂ emissions per item for the different retail types.

4.4.5 Browsing Before Buying Online

Many online customers choose to look at the product in person in a store before purchasing the product online. Up to one in every five online shoppers go to a store to see the item before buying online (Mckinnon, 2009). This means that for 25% of the items purchased online, there is a consumer movement to the store. Using the emissions for Big Box retail, as a worst case scenario, and a range from 0% to 25%, the results for emissions per item when considering browsing before buying online are shown in Figure 27.

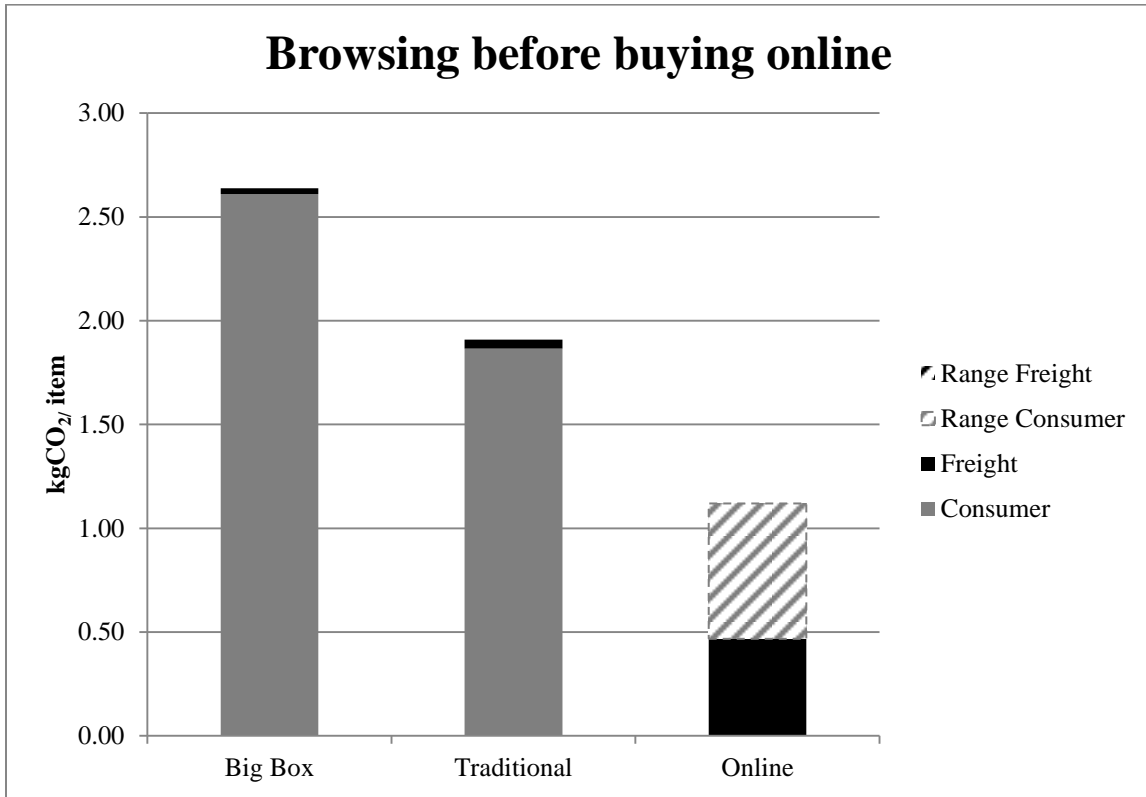


Figure 27: Emissions including browsing before buying online

Figure 27 shows that if consumers browse a store before buying online, it has a very large impact on the emissions per item for online retail. If one in five consumers go to a store, the emissions per item would be 1.12 kg CO₂ per item. The emissions from the consumer movements would be larger than the emissions from the freight, which is surprising for online retail. These results reiterate that the consumer movement has a larger impact than the freight movement on the emissions per item. Although in this scenario online still has the smallest emissions per item, browsing before buying online has a very large influence on online retail.

4.4.6 Not-At-Home Delivery

An issue that arises for online retail is delivering the product while no one is at home to accept it. There are methods to minimize this problem, such as drop off boxes, delivery time windows, even getting a package delivered to work. However, failed deliveries happen anywhere between 2% and 25% of the time (IMRG, 2007; Mckinnon, 2009). For this scenario, it is assumed that if a failed delivery occurs, the truck returns to the drop location on the next trip. Using the range of 2% to 25% for failed deliveries, the results for emissions per item are shown Figure 28.

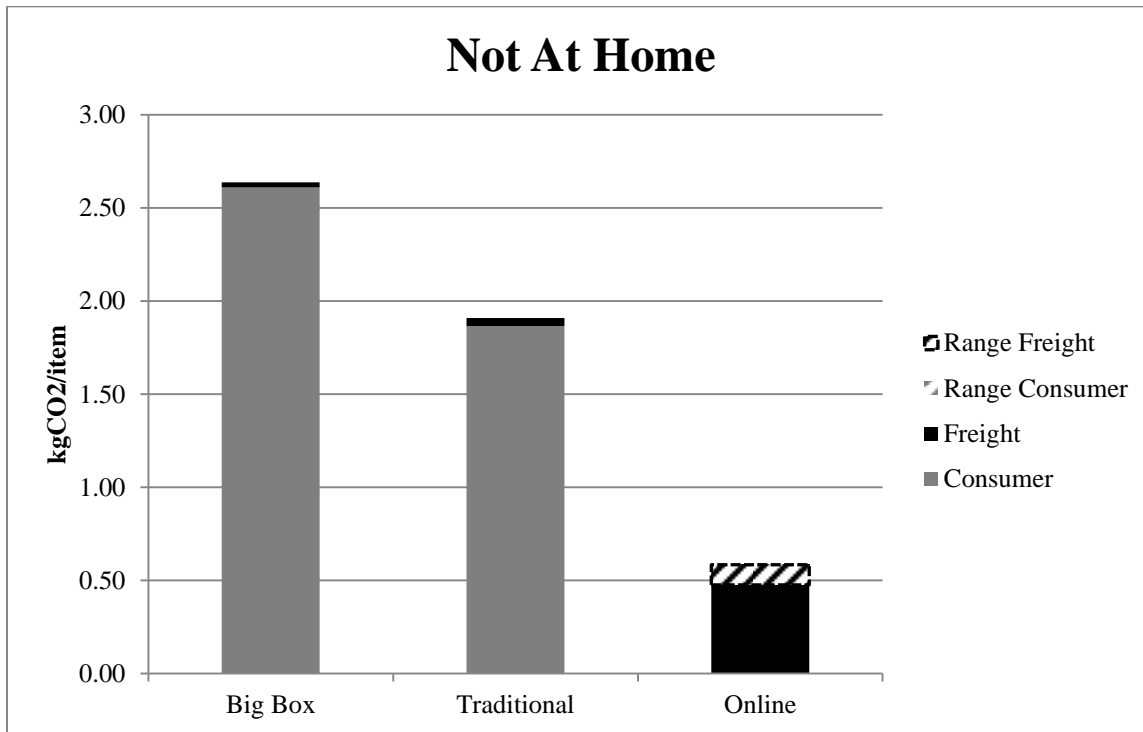


Figure 28: Emissions including Not-At-Home deliveries

Figure 28 demonstrates that the scenario where not-at-home deliveries occur only slightly effect the emissions for online retail. It has very little effect for the overall

comparison between the retail types. Therefore, it can be concluded that not-at-home deliveries is not a significant influence for emissions per item.

4.4.7 Number of Items Delivered

The effect of number of items delivered is similar to the number of items bought, but influences the freight transportation related emissions. Since the retail types are compared on a per item basis, it is important to consider how many items are being delivered. The case study used was a company that delivered relatively small products; therefore many items were delivered on each trip. As mentioned previously, the average number of items delivered per route for traditional retail is 3133 items, and the average number of items delivered per route for Big Box retail is 8062 items. However, if the items being delivered were large, such as furniture or large appliances, the number of items delivered could be in the 10s. Therefore, there is a very large range for the number of items delivered. The results showing the freight emissions where between 30 and 1000 items delivered per route are shown in Figure 29.

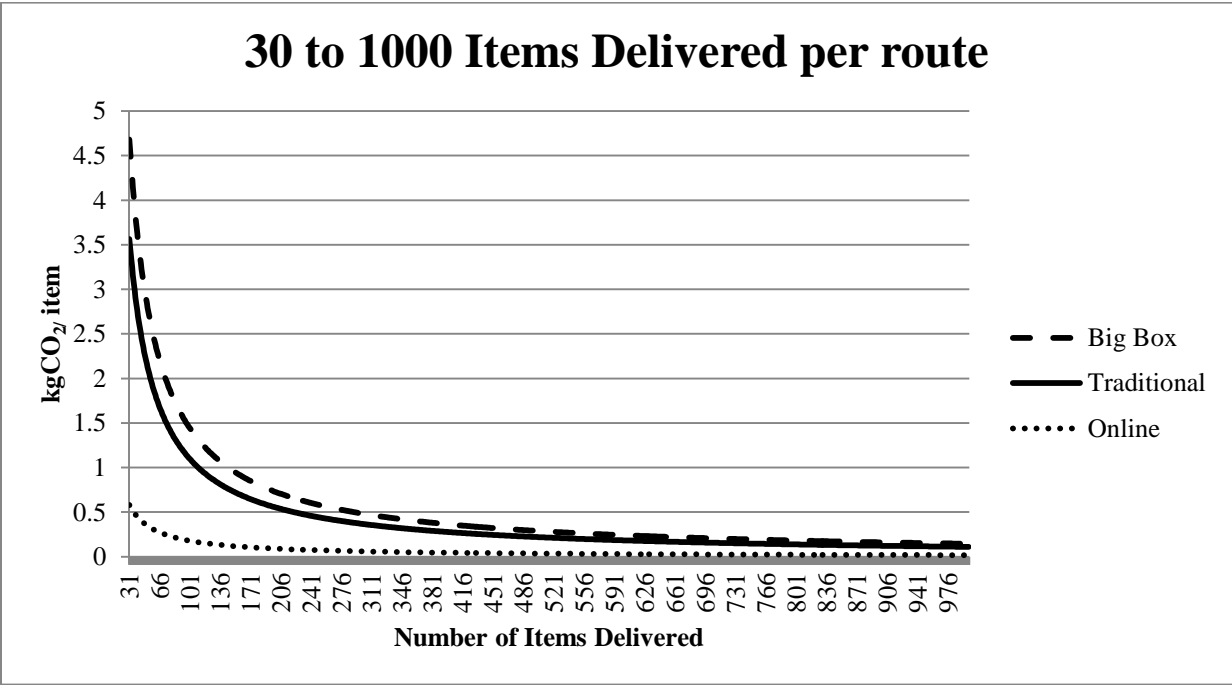


Figure 29: Emissions with 30-1,000 items delivered per route

The first thing to note about the graph, is that at approximately 500 items delivered per route, the kg CO₂ per item levels out and there is little difference in the emission with the addition of more items delivered. Therefore, for small and medium items where more than 500 items are delivered per route, the results for emissions will be very similar to what was discussed in the base case scenario. For large items where less than 500 items are delivered per route, Big Box and Traditional have a similar difference between them for the same number of items, but online has significantly lower emissions per item. This reflects that the route distance is similar for Big Box and traditional, but smaller for online retail.

The conclusions that can be drawn from these results is that when there are more than 500 items delivered, the conclusions drawn from the base case will not be significantly altered. However, if less than 500 items are delivered, the number of items can have a very

large impact on the CO₂ emissions per item for each retail type. Therefore, it can be concluded that the type of good being delivered has a large impact on the CO₂ emissions per item.

4.4.8 Combining the Scenarios

In order to get a better sense of the results when looking at all the key influences simultaneously, a final combined scenario with all the key influences is considered. For return rate, no items purchased, browsing before buying online and not-at-home delivery, the range of values discussed above is used. For number of items purchased the median value is used, 1 item for online retail and 5 items for Big Box and traditional retail. For trip chaining, it is assumed that 50% of the trip distance is attributed to shopping. A 50% trip chaining value means that two locations were visited at the destination, which is a common consumer behaviour (McKinnon, 2009). By using the median and 50% trip chaining rate, the emissions while taking into account common consumer behaviours can be determined. However, these inputs still reflect only one of several possible scenarios.

Finally, for the number of items delivered, the case study data was used as the input for number of items in the truck. The number of items delivered for the case study retailer is the best input available for the combined scenario because it is an input based on a real retailer in the GTA. Combining these key influences gives a better sense of how the key influences interact, and provides a more comprehensive understanding of the emissions per item for each retail type. However, this example is just one of many possible values for the key influences. The results for the example of combining scenarios are shown in Figure 30.

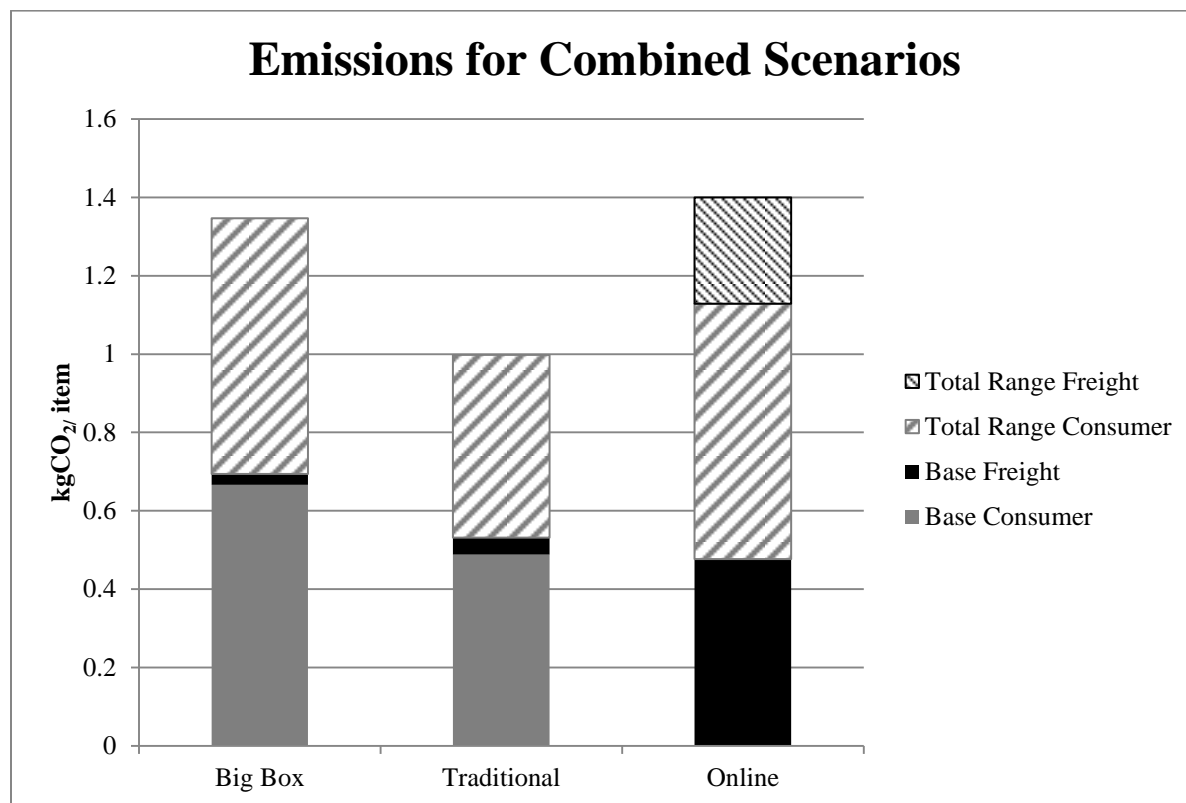


Figure 30: Emissions for combined scenarios

Looking at the scenarios in a combined example offers many insights on the comparison of Big Box, Traditional and online retail transportation emissions. First, when using the median number of items purchased and a 50% trip chaining rate, the base case results show online as having the lowest emissions per item at 0.477 kg CO₂ per item, traditional retail has the second lowest emissions at 0.532 kg CO₂ per item, and Big Box has the largest emissions at 0.694 kg CO₂ per item. These base case results take into account the key influences of number of items purchased and trip chaining.

The second interesting result is that the possible range when considering all the key influences is only slightly smaller than the base cases for Big Box and Traditional, and larger than the base case emissions for online retail. This demonstrates that combined, the key

influences discussed have a very significant effect over the emissions per item for the retail types. In particular, the range for the consumer emissions is very high because of the variability and influence of consumer behavior.

The final observation worth noting is that there is a very large range of possible values when considering the key influences on emissions, therefore it is inconclusive which retail type has the lowest emissions.

The next section discusses the overall meaning of the results, and their broader impact for cities, planners and policy makers.

4.5 Discussion of Findings

This chapter has presented the results and given general conclusions derived from these results. This section discusses the impacts of this research on cities and planning policies, in order to answer the following research questions:

- What are the characteristics and key influences on freight and consumer transportation associated with retailing?
- What are the freight and consumer CO₂ emissions associated with different retail types?
- How do these emissions vary by the key influences?

In addition to these questions, this project sought to explore the hypotheses that consumer transportation has the greatest impact on overall retail transportation CO₂ emissions. As a result, Big Box retailers would have the highest emissions, traditional

retailers the second highest emissions and online retailers the lowest emissions. However, various shopping scenarios, changing key influences on the emissions, will vary the results.

What are the characteristics and key influences on freight and consumer transportation associated with retailing?

The key influence and characteristics on freight and consumer transportation associated with retailing discussed in this research included five key influences on consumer transportation and two key influences on freight transportation. The concept of these influences was explored in the literature review, and a general summary will be presented here.

For consumer transportation, the influences explored were return rate, the number of items bought, trips where no items are bought, trip chaining and browsing before buying online. Return rate would increase consumer transportation because the consumer would have to make an extra trip to the store to return an item. Based on literature, the return rate for Big Box and traditional retail is between 6% and 10% (Nairn, 2003). For online retail, the return rate ranges from around 25% to 30% (Nairn (2003), Fernie et al. (2004), McKinnon (2009)).

The number of items bought is a key influence because the unit of comparison is emissions per item, and it reflects key consumer behavior. In the analysis, a range of 1 to 20 items purchased is used to explore different scenarios. The median number of items is also considered, and for online the median number of items purchased is one (Haider et al., 2009) and five for physical stores (Sorensen, 2009). The number of items bought would decrease the emissions per item, since more items are purchased on a single trip.

Shopping trips where no items are purchased is an influence on the emissions, since it increases the emissions per item by adding an extra consumer shopping trip. Cullinane (2009) states that the third most popular item bought is 'nothing', representing 16% of all trips. McKinnon (2009) uses scenarios between the range of 10% and 33.3% for trips where nothing is purchased. The nature of the item being purchased also affects this influence. On average 10% of trips result in no purchases, but for clothes this rate is 20%, for furniture this rate is 33.3% and for groceries the rate is almost 0% (McKinnon, 2009). Therefore it is important to understand how this range of values for the percentage of trips where nothing is purchased influences the overall emissions per item for the different retail types.

Trip chaining is an important key influence to consider because it allows more accurate emissions calculations by taking into account real world consumer behavior. Consumers often will go shopping while running other errands or during their work trip. McKinnon (2009) uses three scenarios to consider trip chaining that range from 10% to 50% of the trip being attributed to shopping trip distance. Trip chaining is another variable that depends on the type of good being purchased. Groceries are more likely than clothes or furniture to be purchased as part of a chain of other destinations. A range of trip chaining rates reflects both consumer behavior and the type of good being purchased, and is an important key influence to consider.

Browsing before buying online is the last variable that influences the consumer shopping distance. Since up to one in every five consumers go to a store before buying an item online, it is important to consider this consumer movement associated with online retail (McKinnon, 2009).

For freight emissions, the two key influences considered in this research are the not at home delivery scenario and the number of items being delivered. If the consumer is not at home to accept an online delivery, the truck must return to the same house during the next trip. This scenario is discussed in several other studies, and the rate of not at home delivery from the literature ranges from 2% to 25% (McKinnon 2009, IMRG 2007, McKinnon 2003).

The number of items delivered will influence the freight emissions because the unit used in this study is emissions per item. How many items being delivered depends on the type of good. In the case study used for a retailer in the GTA, the number of item delivered were in the 3000 to 8000 range. However, for something large such as furniture, the number of items delivered is in the 10s, not the 1000s. This has a significant influence on the emissions per item for freight transportation.

What are the freight and consumer CO₂ emissions associated with different retail types?

The results of this study show that the kgCO₂ emitted per item has a wide potential range because of the variation in the key influences. However, when considering both the base case and combined scenario base case, Big Box had the largest emissions per item, traditional retail the second largest emissions per item and online retail had the lowest emissions per item. The combined scenario represents a good example of a range of potential values since it takes into account all of the key influences. Based on the combined scenario the freight and consumer CO₂ emissions associated with Big Box retail range from 0.694 to 1.347 kg CO₂ per item, the emissions associated with traditional retail range from 0.532 to 0.998 kg CO₂ per item, and the emissions associated with online retail range from 0.477 to 1.40 kg CO₂ per item.

These ranges of potential values have a large overlap, which makes it unreasonable to definitively conclude one retail type has more emissions per item than another retail type. This reflects the fact that both the type of good being purchased and consumer behavior has a significant impact on results and are variable in the retail industry.

How do these emissions vary by the key influences?

The broad range of potential values for kg CO₂ emitted per item discussed in the previous section shows that the emissions vary significantly with the key influences. For Big Box and traditional retail the range is only slightly smaller than for the base values in the combined scenario. For online retail the range was larger than the base case value for emissions per item. This shows that key influences have a larger effect on online retail than on the physical retail stores.

Return rate had a small influence on the consumer emissions per item for Big Box and traditional retail, but did not change the overall conclusions from the base case scenario. On the other hand, the number of items purchased had a large impact on all three types of retail. As the number of items purchased increases, the emissions per item decreased. The scenario where no items were purchased slightly increased consumer emissions for traditional and Big Box retail. This key influence had a larger effect than return rate, but was not as significant as the number of items purchased or trip chaining. The overall conclusions for the base case scenario were not changed by the scenario of no items being purchased.

Trip chaining varied the results for consumer emissions for Big Box and traditional retail significantly. As the percentage of trip distance associated with shopping decreases, the emissions per item decrease as well. Since the percentage of trip distance associated with

shopping can be as low as 10% (Mckinnon, 2009), this influence can have a large impact on emissions.

Browsing before buying online had a very large impact on the consumer emissions associated with online retail. Since up to one in every five shoppers go to a store before purchasing an item online, a large consumer movement is introduced (Mckinnon, 2009). Although examining this influence on its own did not produce different conclusions than the base case scenario, it had a large impact when looking at the combined scenario. It should be noted that in the combined scenario the emissions used for this influence was based on Big Box retailers, and a dedicated trip. Trip chaining could influence the impact of browsing before buying online, but this is not considered in the scenarios. For the combined scenario, it is the influence of browsing before buying online that created a very large range of potential transportation emission values for online retail.

The influences that had an impact on freight transportation are not at home deliveries and the number of items delivered. Not at home deliveries had a minimal influence on the freight emissions associated with online retail. As the delivery failure rate increased, the emissions per item increased, but this influence did not change the conclusions drawn from the base case scenario.

The final influence is the number of items delivered, and this had a large impact on the freight emissions for all three types of retail. The results show that if the item is large, and not many items are being delivered, the difference in number of items delivered significantly changes the emissions per item. However, if many small items are being delivered, varying the number of items delivered does not result in a large change in the emissions per item.

Combined, the freight and consumer emissions associated with each retail type vary significantly. Therefore, when discussing the emissions per item for the retail types it is important to consider these key influences in order to take into account consumer behavior and the delivery patterns.

The store location and delivery method, which influence the base consumer and freight transportation, may not have as large an influence as consumer behavior or the type of product. The results show that the number of items purchased, the percentage of the trip distance attributed to shopping (trip chaining) and the number of items delivered have a very large influence on the CO₂ emissions per item. This reflects that the type of item being purchased and consumer behavior are what have the largest influence on the CO₂ emissions per item for retail, with as large an impact as the characteristics of the different retail types (location and delivery method).

The hypothesis for this research was that consumer movement would have the largest emissions, therefore Big Box retail would have the largest transportation associated emissions since it is associated with longer consumer trips. The results did support that consumer movement had the largest impact on overall transportation emissions associated with the retail types. Since only the last mile was considered in this research project, the movement of many consumers outweighed the movement of a few trucks through the city. Big Box retail did have the largest consumer emissions associated with it, and for the base cases Big Box retail had the overall highest emissions, traditional retail the second highest emissions and online retail the lowest emissions. However, the key influences discussed created the potential for a wide range of values for emissions per item. Therefore, based on

the possible range of results, it is not conclusive that any retail type is associated with lower transportation emissions than another, that depends on the key influences.

4.5.1 Significance for Planners

Retail affects many different aspects of a city, including density, accessibility, downtown vitality and transportation. Planners who want to encourage a vibrant and sustainable city need to consider the relationship between all of these aspects and retail form. This research has isolated transportation to aid urban planners in understanding how retail type can impact transportation. However, although not examined in this research, it is important for urban planners to consider all of the different influences retail has on a city. In terms of transportation alone, there are several recommendations that can be made for urban planners based on this research.

First, the results demonstrate that consumer travel has a larger impact on retail related emissions than freight travel. This shows what transportation area is more important to target; reducing consumer travel emissions will have a more significant impact on the overall emissions. Since consumer travel had the largest impact, Big Box retail general had the largest emissions associated with it. The results show that the average distance travelled for Big Box is only slightly higher than the average shopping trip distance for traditional retail. The major difference was in the modal split, where 75% of consumers were drivers for Big Box retail and 66% of consumers were drivers for traditional retail. The modal split for transit and active transportation was significantly higher for traditional retail compared to Big Box retail. Overall, traditional retail is more accessible by walking, biking and transit, which has a large impact on the amount of emissions associated with traditional retail.

What this means for urban planners is that for physical retail stores, traditional retail has lower emissions associated with it and should be encouraged as the preferred type of retail in land use development policies. As for transportation policies, improving cycling networks, sidewalks and transit networks to retail locations, both Big Box and traditional, will help to reduce emissions. Therefore, land use planners should look to encourage traditional style retail, while transportation planners should investigate improving accessibility to all retail locations.

Online retail had the smallest emissions associated with it, and planners have a very limited influence over online retail since there is no physical store. Planners could do small things to help decrease the negative affect of some of the key influences discussed. For example, providing lockers as drop locations to prevent not-at-home deliveries.

Freight emissions related to retail were much smaller than the consumer emissions, but are still important for urban planners to consider. A key influence that had a large impact on the freight related emissions was the number of items delivered. It was this factor, as opposed to route distance, that meant Big Box retail had smaller emissions than traditional retail. Increasing loads is a prevalent issue in increasing the efficiencies of freight travel. Planners can help improve this issue by planning effective truck routes throughout the urban area to allow medium and large trucks to access the stores they are delivering to.

The last major significance from this research for planners is the impact the key influences have on emissions. The combined scenario showed that, when considering all the key influences, the range in possible values for emissions is very large. This makes it difficult to conclude with certainty which retail type has the least emissions. In particular, the

key influences related to consumer behavior (number of items purchased and trip chaining) and the types of items delivered (number of items delivered) have major impacts on the emissions. Planners can't influence the type of item being delivered, but could develop campaigns or programs to encourage certain consumer behavior. In particular, encouraging running multiple errands while out, shopping on the way to or from work, and buying more items while at the store instead of making many trips buying only 1 or 2 items.

Chapter 5

Conclusion

This thesis has presented a scenario based model to investigate the relationship between retail type and transportation emissions. The results of this project demonstrate that certain key influences vary the consumer and freight transportation emissions for the retail types, making it challenging to conclude which retail type has the lowest transportation related emissions associated with it. These findings are considered in order to answer the three research questions outlined in chapter 1. The general conclusions are as follows:

- What are the characteristics and key influences on freight and consumer transportation associated with retailing?

The key influences on consumer transportation associated with retailing are return rate, the number of items bought, trips where no items are bought, trip chaining and browsing before buying online. The key influences on freight transportation are not at home delivery and the number of items delivered.

- What are the freight and consumer CO₂ emissions associated with different retail types?

Based on the combined scenario, the freight and consumer CO₂ emissions associated with Big Box retail range from 0.694 to 1.347 kg CO₂ per item, the emissions associated with traditional retail range from 0.532 to 0.998 kg CO₂ per item, and the emissions associated with online retail range from 0.477 to 1.40 kg CO₂ per item.

- How do these emissions vary by the key influences?

The consumer related emissions vary significantly with the number of items purchased and trip chaining. The emissions vary less when trips where no items are purchased are considered, and the emissions vary very slightly with return rate. The Freight related emissions vary significantly with the number of items delivered, and only slightly with the not-at-home delivery rate.

The merit of this research project and its findings is that it provides a comprehensive examination considering all three types of retail, Big Box, traditional and online, in the context of both consumer and freight transportation. By simultaneously considering both freight and consumer transportation and the key influences, this study is able to achieve a more realistic analysis of the emissions associated with retail types. However, there are limits to this approach, as will be discussed in the next section.

5.1 Limitations

A limitation that affects this research is a non-ideal data set, which is a limitation that affects many research studies, particularly in the topic of freight transportation. The case study used to calculate the freight emissions had the needed information, but it was only one case study. In order to achieve more accurate results, more case studies should be used. However, although companies were contacted, this was the only case study achievable for this research project. The other limitation with the freight data is that it was not categorized by location or retail type. Therefore, data analysis and descriptive statistics were used to find the difference in the data and determine which retail type the route was serving. By using statistics to distinguish between Big Box and traditional retail, an assumption was made by using weight data as the classification method, which adds a limitation to the results.

For the consumer travel data, several case studies were used from the TTS data, but those data represent only 5% of the population. This was the best data source for the consumer travel movements for this research, but if the survey represented a larger percentage of the population the results could have been more accurate.

Finally, the scope of this research project was considering the last stage of the freight movement, from distribution centre to retailers and homes. It was assumed that the freight movement before the distribution center is similar for all three types of retail. This assumption presents a limitation to the study, since there could be important variations in the supply chains that change the emissions associated with each retail type.

5.2 Recommendations and Future research

Retail has an intricate relation to the city and its surroundings, and since retail has been changing rapidly over that past few decades, it is an important aspect of the city to understand. Retail has a relation to the city in many different areas. It can affect density, accessibility, downtown vitality and transportation. This research has isolated transportation, in particular the emissions associated with transportation to retail locations, in order to compare three different retail types, Big Box, traditional and online. Although an urban planner needs to consider all the aspects of retail's influence on a city, this study offers some insights on the relationship between retail and transportation.

The first relevant insight for planners and policy makers is that consumer movement has the largest impact on emissions, and that Big Box stores are associated with the largest consumer emissions. The results reflect that consumers travel longer distances, and are less likely to use public or active transportation to get to Big Box stores. Consequently, the type

of retail growth that should be encouraged in cities is traditional style retail. Although online retail generally had the lowest emissions and smallest consumer movements, there is no physical location in the city to be influenced by planners. However, planners could reduce the failed delivery rate by providing locations for lockers at which to make drops.

Although freight transportation had a significantly smaller impact on the emissions, the Big Box style format did have the smallest emissions associated freight. It is important for planners and transportation engineers to consider accessibility for trucks, in order to allow for efficient truck deliveries to reduce the emissions. Based on the results it wasn't the distance travelled, or the number of drops that had a large effect on emissions, but the number of items. Developing creative solutions of how to carry larger loads through cities is an issue that should be further explored.

Finally, the results showed that the key influences have a very significant impact on the emissions associated with retail. In particular it was key influences associated with the type of good and consumer behavior that affected emissions. The type of good cannot be altered, but certain type of consumer behavior can be encouraged. In particular, if the consumer is driving they should be encouraged to buy more items in that single trip, as opposed to making several trips where only one item is purchased. Encouraging the practice of trip chaining also has a large effect on emissions. This would involve encouraging consumers to run several necessary errands while out, or to shop going to or from work or school.

This study is a starting point for many other research projects. For example, if a more thorough freight survey for the GTA were conducted, the methodology used here could be

applied to the data in order to achieve more detailed results. Another area for further research is exploring the whole supply chain associated with the three retail types. As mentioned in the previous section, considering only the last mile does present a limitation for this study.

The results show that consumer behavior and the type of good have a large impact on the emissions per item. Therefore further research into consumer behavior and the types of goods sold at the different retail types would be a good expansion on this study. This would entail a more thorough study of the key influences described in this study.

5.3 Final Remarks

In this project, the Greater Toronto Area has served as the study area in order to examine the relationship between retail type and transportation emissions. The retail environment has been changing over the past few decades, and its relation to transportation in the urban area is an important aspect to understand for planners and policy makers. A scenario model was used in order to calculate the emissions per item for both consumer and freight transportation for Big Box, traditional and online retail. Key influences on consumer and freight transportation were varied in order to see the impact on the emissions. This approach has addressed a gap in the literature review by implementing a combined approach considering both freight and consumer transportation applied to three different retail formats. Although there are limitations in the data used and scope of the research project, this study has contributed to the literature by providing a more comprehensive analysis for both types of transportation. Conclusions to draw from this study are that consumer movement has the largest impact on emissions, and Big Box retail has the largest base case emissions per item because it induces the largest consumer emissions. However, due to the complex nature of

the retail environment and consumer behavior, it is impossible to conclusively say one retail type has less emissions associated with it than any other retail type.

Appendix A

Data Retrieval System Query

In the Data Retrieval System, the Survey Year 2006 was chosen, the Data Unit was “Trip” and the tabulation was “Cross Tabulation”. In the query form, the row variable chosen was “2006 GTA zone of destination” and the Column Variable was “Manhattan distance of trip in m”. There was nothing selected for a Table Variable. Two filters were used, the first to filter the 40 Traffic Zones selected and the second to filter for shopping trips. The first filter Field Name was “2006 GTA zone of destination”, and codes were the Traffic Zone numbers listed in the previous section (Table 3 and Table 4). This filter allows only trips with an end destination to the selected zones to be considered in the data query. The second filter Field Name was “Trip Purpose of Destination”, and the code entered was “M”, which represents trips to the Market/Shop. This filter allows only shopping trips to be considered in the data query.

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