

Exploring the Relationship between Big-Box Retailing and Consumer Travel Demand in the Greater Toronto Area

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Abstract

Canada's retail landscape has been structurally transformed by the widespread development of large format (big-box) retail since the mid-1990s. Emphasis placed on convenience, price, and auto-based accessibility, coupled with design elements of big-box agglomerations has produced new modes of consumer retail interaction. This paper explores the relationship between consumer travel behaviour and the expansion of large format retail facilities within Canada's largest metropolitan region, the Greater Toronto Area. Data have been drawn from the 1996 and 2001 Transportation Tomorrow Surveys and combined with a longitudinal retail structural database. Regional consumer travel flow analysis and "big-box" case studies suggest considerable auto-dependence for shopping activities, particularly in the suburban cities of the GTA. The evidence sheds light on the current gap between the realities of consumer activities and retail development, and the declared sustainability objectives of transport and land use policy.

1.0 Introduction

The accelerated growth of large format retail during the 1990s, particularly within suburban communities, has transformed the Canadian retail landscape. The first wave of suburban retail, developed with transit in mind (e.g., early super-regional suburban malls developed in the City of Toronto with direct links to transit), has been followed by more recent and much larger auto-oriented retail opportunities. While the provision of goods and services at power retail locations (i.e., spatial clusters of large format retail opportunities) appears to confer advantages to retailers and consumers, little attention has been given to understanding the influence of large format retailing on patterns of consumer travel behaviour *in situ*, or at the regional scale. Evolution of a regulatory framework during the 1990s, favourable to the type of commercial development that at present characterises much of suburban Canada (Simmons and Hernandez, 2004b), now seems dated in the presence of more recent emphasis, in the public policy domain, on the application of smart growth planning principles (e.g., Province of Ontario, 2005). This study explores the relationship between power retail, shopping travel behaviour, and public policy favouring the provision and use of sustainable transport alternatives within Canadian cities and regions. Within this context, the paper aims to describe the extent to which regional and local consumer travel behaviour and power retail shopping activities are conditioned and dominated by auto travel.

The paper begins with the introduction of power retail concepts and a review of what is currently known about consumer mobility and spatial behaviour in relation to such locations. The study area is then described, emphasising recent trends in the growth and distribution of the population of the Greater Toronto Area (GTA). This is followed by a discussion of the data used to describe commercial activity and travel behaviour. Attention then shifts to regional trends in retail development, and an examination of gross and *per capita* indicators of consumer travel demand for shopping in the GTA for the years 1996 and 2001. The scale of the analysis then shifts to an exploration of consumer travel interaction with three prominent power retail facilities in the GTA. The analysis provides insight into the spatiotemporal dynamics of consumer interaction with large format retail locations that typically continue to expand following the initial stage of development, a feature that sets large format retail apart from the traditional enclosed malls developed during the 1970s and 1980s. Results from both the regional and case study analyses are discussed in relation to the policy and planning framework established for the study area. The policy-based contextualisation of the research is aimed at emphasising a potential disconnect between policy intent and the contemporary realities of commercial development and consumer mobility.

1.1 Power Retail and Consumer Spatial Behaviour

Much of the growth in retail over the last fifteen years has been in the form of *big-box stores* (Table 1). These stores became known as “destination” or “category-killing” retailers due to customer attraction to price or selection at a particular store (i.e., one-stop shopping), rather than comparison shopping among the cluster of stores in a regional shopping centre or downtown (Bodkin and Lord, 1997; ICSC, 2004). Initially, big-box stores could be found in freestanding locations along arterial streets, or within conventional shopping centres. *Power centres* are a more recent phenomenon, occurring some time after the introduction of big-box stores. As the number of big-box chains and big-box stores multiplied, developers increasingly built specialised power centre locations to attract big-box stores (Table 1). *Power nodes* are typically centred on

highway interchanges and consist of clusters of big-box stores and/or other power centres, or conventional stores and malls located within one kilometre of a power centre (Yeates, 2000). The conceptualisation of large format retail described here is reflective of the current state of the retail system which may be expected to continue to change with time (Hernandez *et al.*, 2003; Nuttall-Smith and York, 2007).

Table 1
Large Format Retail Concepts

Retail Structure	Typical Configuration
Big-Box	Big-box retailers are retail outlets that are typically at least three or more times larger than other comparable stores. The definition of big-box varies by sector and is determined by gross leasable area.
Power Centre	Three or more big-box retailers with a shared parking lot (the ‘pad’) and typically ancillary commercial services (e.g., smaller retailers, fast food outlets) (Hernandez <i>et al.</i> , 2003).
Power Node	One power centre with additional big-boxes or other power centres / major malls within a one kilometre radius, typically centred on a major intersection.

The typical power centre has also been developed with little attention given to pedestrian movement *in situ*, or transit supply (e.g., Bottoni *et al.*, 2004). Enclosed shopping malls were developed to encourage pedestrian movement through the mall. Anchor stores placed at either end augmented opportunities for cross-shopping (i.e., shopping across retail categories, usually at multiple stores, within a single trip). Moreover, the enclosed malls of the 1970s and 1980s were often closely integrated with municipal transit systems, enhancing transit access to large-scale shopping destinations. In contrast, power retailing offers the consumer an auto-oriented retail experience in an unenclosed space, with few additional services (e.g., washrooms, seating, strollers for children, security). The transportation issues of concern to retailers and developers are the site design issues that could limit automobile access such as congestions at intersections. Broader local and regional impacts on travel demand, and competition amongst passenger modes (e.g., auto, transit) are given little attention.

Research suggests that power retail establishments are structurally and operationally distinct from other retail formats (Lord and Bodkin, 1996; Bodkin and Lord, 1997; Wang *et al.*, 2000; Lorch, 2005). In contrast to the rather limited expansion of enclosed malls, power centres often continue to grow through in-fill development and expansion into surrounding land parcels. This temporally dynamic and local expansion of large format retail capacity presents a challenge to the development of medium or long term plans and programs established to balance economic growth against the production of transport’s negative externalities such as congestion, and emissions.

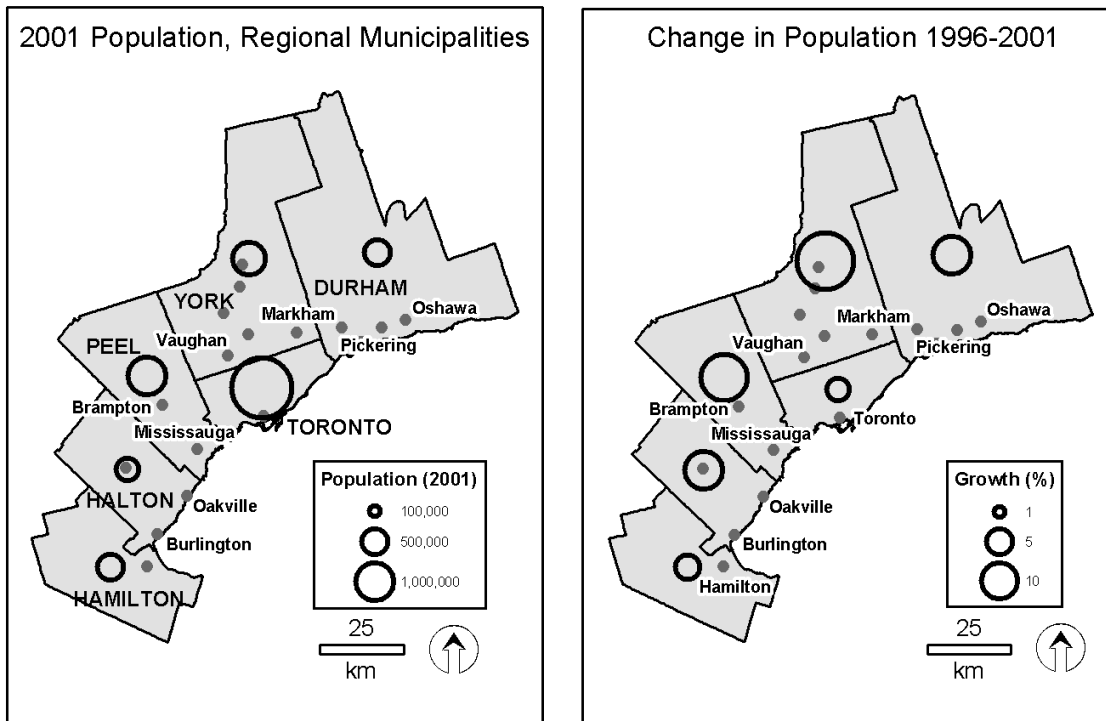
Consumer spatial behaviour has also been shown to vary across retail formats. For example, recent evidence suggests that anywhere from one-half to two-thirds of consumers visit two or

more stores in a single power centre visit, with fewer destinations accessed per visit than at the typical regional mall (Lord and Bodkin, 1996; Lorch, 2005). Consumers are also more likely to focus on a specific on-site shopping destination, limiting their movement across the larger power retail site. Additional trips *in situ* are often taken by car (Lorch, 2005). Power retail appears to be characterised by high levels of auto use for the initial trip, and for cross-shopping, although cross-shopping is less common at power retail locations than within enclosed malls (Bodkin and Lord, 1997).

1.2 Study Area

The study area encompasses Canada's largest urbanised area and includes the City of Hamilton, the City of Toronto, and the regional municipalities of Halton, Peel, York and Durham (Figure 1). Hamilton has been included due to the presence of employment and non-work interaction with the rest of the GTA. This area, known as the Greater Toronto Area (GTA), is home to roughly 5.5 million residents, 2 million households, and an employed labour force of approximately 2.9 million individuals (Statistics Canada, 2006). The GTA is also home to six cities occupying positions within the top twenty urbanised centres in Canada ranked by resident population, namely, Toronto (1st), Mississauga (7th), Hamilton (9th), Brampton (14th), Markham (15th), and Vaughan (20th). Since 1996, population growth has been heaviest in the suburban regional municipalities - York (23%), Peel (16%), Durham (10.5%), Halton (10.4%), with considerably less growth occurring in Toronto (4%) and Hamilton (4.8%).

Figure 1
Greater Toronto Area population by regional municipality



2.0 Retail and Travel Behaviour Data

2.1 Commercial Activity Data

Data describing the geographic and economic characteristics of the region's retail structure have been drawn from the Centre for the Study of Commercial Activity (CSCA) retail databases. Providing a comprehensive, national inventory of Canadian retail activities since the early 1990s, the CSCA databases have been used to trace the evolution of new retail formats in the Canadian retail economy (see Jones *et al.*, 1994, Jones and Doucet, 1998, 1999, 2000; Simmons and Hernandez, 2004a; Simmons and Hernandez, 2004b). In particular, an annual survey of power centre locations, carried out by CSCA staff to collect data and track changes in the number, mix and size of tenants, offers a unique glimpse into the evolution of power retail in Canada. Several developers provide the CSCA with supplementary information to enhance the quality of the database. Within the GTA market, the CSCA has collected commercial activity data since 1993, with the collection in 2005 totalling more than 50,000 locations. Each record contains information on the location, type of business (NAICS), size, and type of location (mall, power centre, free-standing, retail strip)¹. The CSCA databases provide a unique view of the changing nature and extent of commercial activities, and are the most comprehensive source of power retail data in Canada.

2.2 Transportation Tomorrow Survey

Consumer travel data have been taken from the Transportation Tomorrow Survey (TTS). The TTS is a repeated cross-sectional weekday travel survey of approximately five percent of the households within the Greater Toronto Area and beyond. Conducted every five years since 1986, the survey is typically carried out in the fall. Since 1991, travel data have been recorded for persons aged 11 years and older living in participating households. Expansion factors, derived from Canada Census occupied dwelling counts, are used to obtain estimates of total population and travel behaviour across the survey area (Joint Program in Transportation (JPT), 2003a, 2003b). Due to sampling issues (i.e., irregular participation of municipalities), several changes to the survey have taken place since 1986 including expansion of the survey area (JPT, 2005).

While there are compelling reasons for examining patterns of consumer travel longitudinally, the TTS data can only provide a reliable sketch of weekday travel behaviour. Examining consumer travel on the weekend, for example, is desirable because weekends typically include greater non-work travel (e.g., shopping), longer trip distances, and a decline in transit use (Hu and Young, 1999; Kitamura and Van der Hoorn, 1987; Bhat and Gossen, 2004; Bhat and Srinivason, 2005). Research also provides evidence of seasonal fluctuation in shopping frequency, scheduling, levels of cross-shopping, duration, and location choice (Roslow *et al.*, 2000; Peter and Olson, 2004). Interaction between the time-varying qualities of travel demand and shopping behaviour will be an important area of future research, particularly as retailers in North America begin to experiment with 24-hour operations.

Evidence from the US points to an increasing share of travel for discretionary purposes (Gordon *et al.*, 1988; Handy *et al.*, 2002; US Department of Transportation Federal Highway Administration (USDOT FHWA), 1995; US Department of Transportation Bureau of Transportation Statistics (USDOT BTS), 2003). Moreover, data on the home-based trips of GTA

¹ The North American Industrial Classification System (NAICS) was developed during the late 1990s to replace the Standard Industrial Classification (SIC) system. It was developed jointly by the US, Canada, and Mexico with a view to enhancing comparative analysis of economic activity.

residents over a 24-hour period suggest that since 1986, discretionary trip making has increased at a faster rate than travel for work or school purposes (JPT, 2005). Underreporting also occurs with the TTS because adult household representatives are responsible for reporting the travel behaviour of all household members (JPT, 2003a). Estimates of consumer travel reported in this study are therefore likely to understate the intensity of shopping activity in the GTA.

3.0 Retail Development and Travel Behaviour in the GTA

3.1 Power Retail Development

Power retailing has transformed the GTA's retail landscape. Before 1995, most *power centres* were located on the periphery of the built-up area, with only one located within the amalgamated City of Toronto, the Crossroads Centre at Highways 400 and 401. During the next two years, two more centres opened within Toronto, and four more to the west of the city. Between 1997 and 1999, new centres were widely dispersed, both inside and beyond Toronto, but the following period saw construction to the north and west of the city as well. Most recent additions can be found throughout the built-up area. Thus, power centres began on the periphery, but were later constructed in all parts of the GTA.

In parallel to the expansion of power centres and nodes across the GTA, the power retail concept has also evolved (Simmons and Hernandez, 2004a; Simmons and Hernandez, 2004b; Morganosky and Cude, 2000; Hahn, 2000). In the late 1980s and early 1990s, power centre construction produced sites housing a small number of major big-box stores clustered together on a shared parking pad, typically adjacent to a major intersection. The retail offer of these centres was largely "destination-shop" based in certain retail categories (i.e., general merchandise, home improvement, electrical), with limited opportunities for cross-shopping. As the number of power centres increased, so too did the mix of retailers and services located within them. More recently, the trend has been to develop in-fill mini-box stores with an increasing presence of services (e.g., cinemas, restaurants, banks, pharmacies, hairdressers, etc.) and retailers especially, fashion, once the preserve of shopping malls. The opening in 2004 of Vaughan Mills, a 1.2 million square foot enclosed super regional mall in Vaughan, has been the only major mall developed in Canada since the early 1990s. Over the same time period more than fifty power centres were developed in the GTA.

3.2 Consumer Travel Behaviour in the GTA

Contemporary urban planning and policy arguably embrace conventional wisdom concerning the relationship between jobs, housing, commuting and the reduction of negative externalities like congestion and mobile emissions. At the same time, less attention is typically given to the development, accessibility, and mobility issues surrounding the growth and change of commercial space. Within the study area, for example, and between 1996 and 2001, the regional population grew by 9.3%, while retail capacity increased by 31,371,535 sq. ft., an increase of 29% since 1996. Reflective of the trend in suburban population growth, much of the new retail capacity has developed within the suburbs of the GTA (Jones and Doucet, 2000). The growth and structure of the suburban retail economy is expected to influence consumer choices regarding shopping travel, perhaps away from the modes promoted by city and regional planners.

This section provides an overview of regional consumer travel between the years 1996 and 2001². The analysis explores trends in gross and *per capita* shopping trips during a time period

² Daily (24-hour period) trip-ends are located within the GTA boundary.

characterised by rapid suburban population growth and expanding retail capacity. While several indicators of sustainable transport have been developed (e.g., Black, 2003), this summary is limited to trip making and mode shares by auto and local transit only. GO Rail (interregional rail transit), walk/bike, and other (e.g., taxi, motorcycle, etc.) modes have been excluded because trips by these modes were not systematically recorded for purposes other than work and school.

3.3 Trips

Data from the 2001 TTS suggest that shopping accounts for approximately 18.4% of all trips within the study area. Work makes up the single largest number of trips (40.8%), followed by other trips (32.4%), while school trips account for only 8.4%. The large share of total travel taken up by work is not surprising given the weekday focus of the TTS. Since 1996, and with a growth rate of 14.3%, shopping travel appears to have outpaced the growth in trips for other (12.9%), work (11.9%), and school (5.4%) purposes. Travel behaviour in the GTA parallels the general North American trend toward increasing participation in discretionary, non-work activities noted earlier.

The regional municipality with the largest growth in total shopping trips (auto, auto-passenger, and local transit) is York (33.5%), followed by Halton (23.4%), Peel (19%), Hamilton (14.7%), Durham (14.1%), and Toronto (5.7%). As expected, the data suggest that overall increases in shopping travel appear to follow the growth of the resident population of the GTA's suburban jurisdictions shown in Figure 1. Similar growth in suburban travel has also been observed for school trips and for other purposes. With the exception of Halton, there has also been an across the board rise in work trips, with all municipalities outpacing the City of Toronto's growth in this respect. Overall, data from the TTS point to increasing travel demand in suburban jurisdictions, with growth rates for shopping exceeding the growth in work trips at both regional and municipal scales. The exception appears to be Toronto, with a work trip growth rate (6.1%) slightly larger than that reported for shopping (5.7%).

A more revealing look at changing patterns of consumer travel demand emerges by examining growth in *per capita* shopping trips (trips per 1000 persons) over time (Figure 2). With the exception of Toronto and Peel, all other regional municipalities have exceeded the GTA-wide growth rate in per capita shopping trips of 4.3%. Halton has experienced the largest increase in *per capita* shopping trips (11.7%), followed by Hamilton (9%), York (5%), Durham (4.8%), Toronto (2.7%), and Peel (1.3%). These results emphasise that the greatest increases in demand for shopping travel can be found within the suburban municipalities of the GTA.

3.4 Travel Mode

Across the GTA, the share of travel carried out by transit has fallen for all trip purposes since 1996. The auto-driver (i.e., single occupancy vehicle use) mode share dominates in both years for work, shopping, and other (e.g., personal business, entertainment) purposes. Presumably in response to both increases in the resident population and the relatively slow growth in transit supply between 1996 and 2001, auto-driver mode share for work, shopping, and other purposes is typically larger within the suburban regional municipalities. Focusing specifically on shopping activities at the GTA scale, local transit appears to play a limited role, particularly within suburban jurisdictions (Figure 3).

Figure 2
Change in per capita weekday shopping trips (1996-2001)

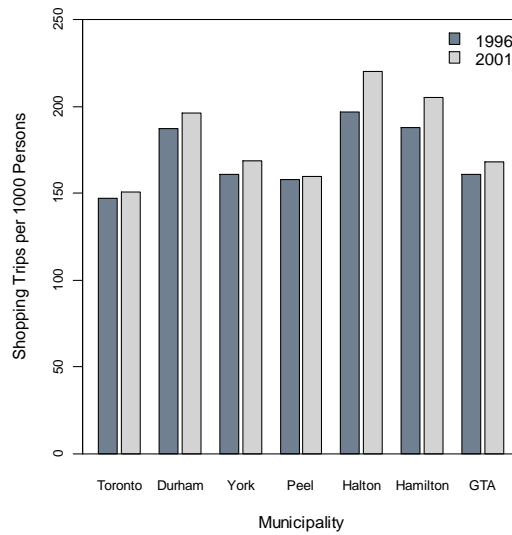
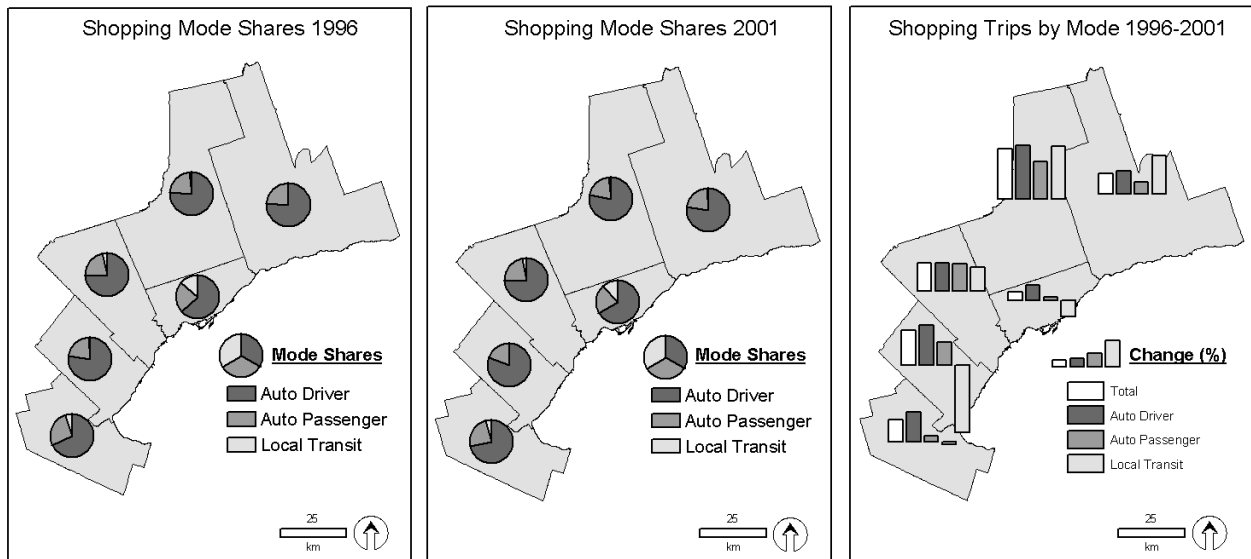


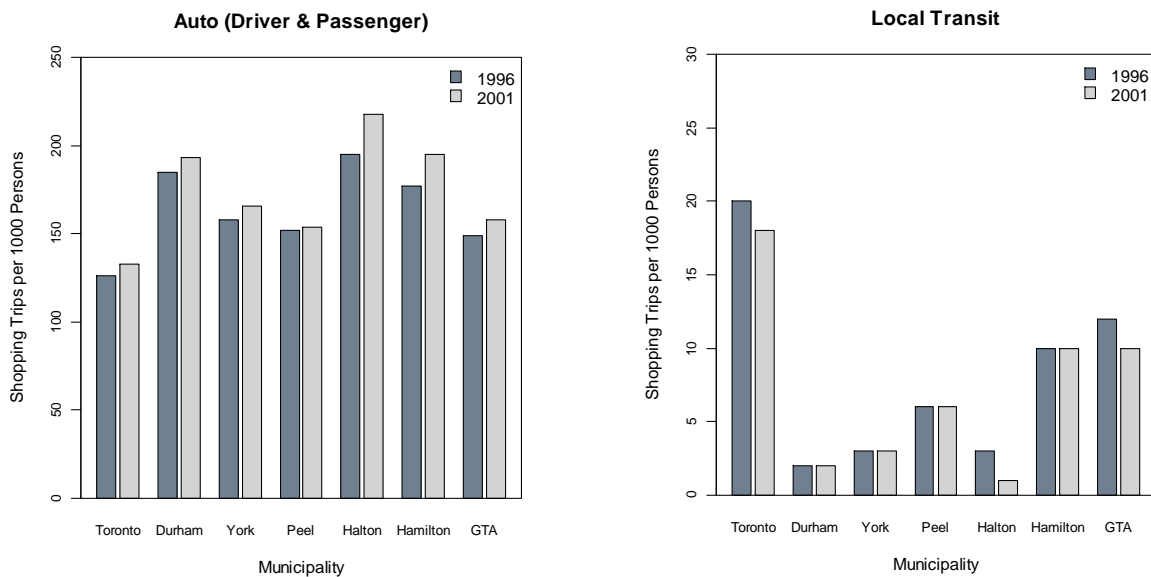
Figure 3
Mode characteristics of regional shopping travel behaviour



Evidence of marginal growth in gross transit trips for shopping (e.g., Peel: 16.6%; York: 35.3%; Durham: 25.9%) is tempered by static or declining *per capita* use (Figure 4). In other words, increases in suburban transit use for weekday shopping appear to have materialised largely in response to population growth, while *per capita* transit use for shopping remains unchanged or on the decline (e.g., Toronto, Halton). On the other hand, *per capita* automobile use for shopping is on the rise across the GTA, and within each of the regional municipalities. The automobile emerges from this analysis as the *increasingly* dominant mode for consumers engaging in weekday shopping activities.

Figure 4

Per capita weekday shopping trips by automobile and local transit (1996-2001)

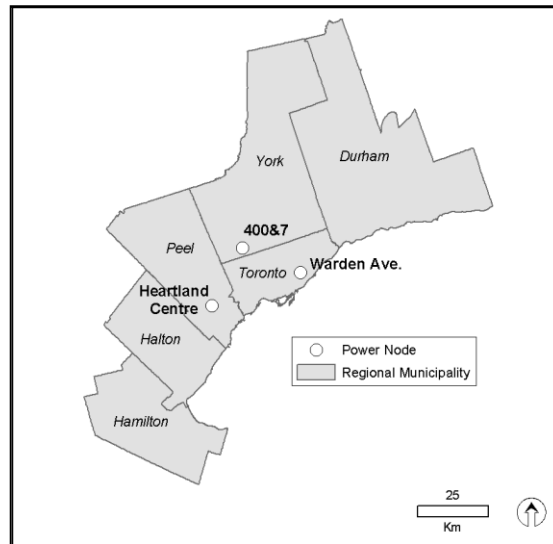


4.0 Consumer Mobility and Power Retail: A Case Study Analysis

The primary motivation for the case study is to provide descriptive insight into changing patterns of consumer travel demand over time in relation to power retail shopping. Three case study power nodes have been selected (Figure 5). Two of the sites are located in the suburbs, the *400&7*, located near Vaughan, Ontario; and *Heartland Town Centre*, Mississauga, Ontario. The last site is located within the amalgamated City of Toronto, and is commonly known as *Warden Avenue and Eglinton (Warden)*. These sites have been selected because they are differentially located in regional municipalities that have experienced rapid (*400&7* in York Region, Heartland Centre in Peel Region) and limited population growth (*Warden*) since the mid-1990s. The three sites have also experienced rapid expansion since 1996, becoming some of the region's largest power retail destinations. The *Warden* location experienced a staggering 2,805% increase in retail square footage, followed by the *400&7* (449%), and then Heartland Centre (115.68%)³. The *400&7* is the largest power retail site in Canada, hosting 160 stores and approaching 3 million square feet of retail space (equivalent to four regional shopping centres).

³ Figures exclude growth in non power retail opportunities.

Figure 5
Case study locations



The Warden site is noteworthy because the Warden “corridor” has been identified by the City of Toronto for intensification and redevelopment. The continued study of consumer travel demand associated with the Warden corridor will serve as useful feedback to planners and other policy makers, particularly with respect to understanding the efficacy of transit oriented development as a tool for shifting travel demand toward “sustainable” alternatives. The intensification of the corridor, and redevelopment of employment lands for residential uses, juxtaposed with large format retail capacity located directly to the north west, could ultimately give rise to an interesting confluence of market and policy forces that could hold implications for retail site design (e.g., increased demand for pedestrian facilities), and short term negative transport externality effects (i.e., congestion derived from a sharp rise in vehicle trips).

4.1 Measuring the Travel Impacts of Power Retailing

The empirical analysis has been organised into two parts. The first part examines changes in gross measures of travel demand between 1996 and 2001. The second part explores changing patterns of consumer travel demand associated with zones producing shopping trips to the case study locations during both time periods. Shopping travel indicators include, number of 24-hour weekday trips, and kilometres travelled to power retail destinations from GTA origins. Indicators have been estimated for both auto and transit using the 1996 and 2001 versions of the TTS, with all data aggregated to the 2001 TTS zone system. A distinction has been drawn between travel by auto-drivers, and travel by auto-drivers and passengers. This distinction facilitates analysis of the change in the number of vehicles accessing power retail sites versus the change in total consumer travel to case study locations.

Recognizing that the purpose and origin of shopping trips will potentially vary during the day, indicators have also been estimated separately for shopping trips originating from home, work, and other locations (e.g., school, shopping, facilitate passenger, etc.)⁴. For shopping trips

⁴ Trips are defined as direct travel from a work, home, or other origin location to a shopping destination.

starting at work and other locations, recorded travel includes trips carried out by individuals that may have come into the study area for another purpose, and then conducted a work-to-shop, or other-to-shop trip during the survey period. This is not an issue for trips originating at home because the origin and destination of all trips has been limited to GTA traffic zones.

Each power retail destination is modelled as a representative GTA zone centroid, while trip origins are modelled as the centroids of zones producing shopping trips. The TTS geocoding procedure associates trip-ends with various levels of geography depending on the quality of survey location reporting (e.g., intersection, postal zone, block face). The geocoding process can give rise to uncertainty with respect to the spatial association between a power retail location and trips ending in adjacent traffic analysis zones. As an approach to resolving this issue, trips ending in zones immediately surrounding (queen's move contiguity) the host traffic zone of each case study location have been assigned to the GTA zone containing the majority of structures associated with each retail development. For each case study location, this procedure results in the assignment of trips from GTA shopping trip origins to a single, representative, power retail centroid.

To facilitate exploration of changes in shopping travel behaviour between the two time periods, several travel measures have been estimated for 1996 and 2001. The total number of auto-driver trips for shopping, A , ending at each case study facility, j , is expressed as:

$$A_j = \sum_i A_{ij}, \quad (1)$$

where A_{ij} is the number of auto-driver trips from an origin zone i , to a retail facility located at zone j . The total number of shopping trips, T , ending at each case study facility j , is expressed as:

$$T_j = \sum_i (A_{ij} + P_{ij}), \quad (2)$$

where A_{ij} is defined as in (1) and P_{ij} is the number of passengers (excluding drivers) taking shopping trips from an origin zone i , to a retail facility located at j .

Measuring vehicle and person kilometres travelled by auto to each retail site required estimation of network path distances from origins generating shopping trips, to each representative retail facility location. The path estimation procedure was conducted using a free-flow travel time link impedance measure. Once paths were generated, a second procedure was used to return path lengths connecting shopping trip origins to respective power-node locations. Path lengths are used to estimate vehicle kilometres travelled, VKT , to each power node, j :

$$VKT_j = \sum_i A_{ij} C_{ij}, \quad (3)$$

where A_{ij} is defined as in (1), and C_{ij} is the length in kilometres of the free-flow shortest path connecting each origin zone i , with a retail facility located at j . Change in VKT over time is expressed as the percent change in VKT between $t = 1996$ and $t+5 = 2001$:

$$\Delta VKT_{t,t+5} = \left[\frac{VK T_{t+5} - VK T_t}{VK T_t} \right] \cdot 100. \quad (4)$$

Person kilometres travelled, PKT , for each power node, j , is expressed as:

$$PKT_j = \sum_i (A_{ij} + P_{ij})C_{ij} , \quad (5)$$

where A_{ij} and C_{ij} are defined as in (3), and P_{ij} is defined as in (2). The change in PKT between the two time periods is estimated using (4), replacing VKT with corresponding estimates of person kilometres travelled for each time period.

The total number of transit trips for shopping is estimated using a similar form to equation (2), but with the exclusion of A_{ij} . Transit kilometres travelled to each power node is specified as the sum of the trip-weighted Euclidean distances connecting origins with corresponding power node destination zones. A sufficiently detailed regional transit database for the municipalities included in this study does not presently exist, contributing to the difficulty of estimating person kilometres travelled by transit. Transit path estimation using a generic road network database would not accurately reflect the spatial structure of transit routes, where individual routes are constructed from subsets of road segments of the broader road network.

The adopted approach to auto-based path estimation effectively controls for network structure, and variation in posted speed limits (i.e., free-flow travel assumes uncongested travel at the posted speed limit), but does not internalize congestion costs. Typically, congestion could alter the route location decisions of consumers, particularly in dense urban environments where the intensity of development gives rise to heightened competition for network facilities. In the case of power retailing, access and egress points are typically located on high capacity major and minor arterials, and collector roads (e.g., Bottoni *et al.*, 2004; Lorch, 2004). Free-flow path estimation should provide a reasonable approximation of network-based travel in the local area surrounding power retail facilities, but congestion impacts on route selection and path estimation could have larger effects closer to consumer origins and for regional consumers.

5.0 Empirical Results

This section reports on the analysis of consumer travel to three GTA power nodes from regional traffic zones during a 24-hour period of a typical weekday, in the fall of the year. The discussion begins by looking at changes in gross measures of travel demand between the two time periods, and changes in the spatial structure of the consumer markets associated with each retail location. Analysis by mode considers single occupancy vehicle (SOV) travel (auto-driver), auto-driver and passenger trips, and local transit.

5.1 Auto-based Shopping

Estimates of the number of auto-driver and total shopping trips made to the case study locations, summarised by trip origin purpose (home, work, other), are presented in Table 2. The “other” trip category includes trips from school, shopping, unknown, and facilitate passenger origins. All sites appear to have experienced growth in auto-based travel since 1996, with the development at the 400&7 having the largest increase in SOV, and total trips. There is also evidence of variation in trip growth rates across developments by origin purpose. For example, shopping trips to the 400&7 from origins other than home or work have a larger growth rate when compared with shopping trips from home or work. The opposite effect appears for the Warden development, with greater increases in shopping trips from home or work locations.

This could reflect differences in the local balance of jobs and housing, and the organisation of shopping trips into daily trip chains. Lastly, the ratio of total to SOV (auto-driver) trips for both years suggests a considerable amount of shuttling of passengers to these developments is taking place. This is particularly evident for trips from home or other locations to the retail locations. Evidence of this sort is reflective of joint shopping activities with family members

Table 2
Trips by auto to power node locations (1996-2001)

Location	Origin*	1996		2001		$\Delta(\%)$	
		T_j^{**}	A_j^\ddagger	T_j	A_j	ΔT_j	ΔA_j
400&7	H	2,593	2,090	6,482	4,666	150	123
	W	589	548	1,481	1,415	151	158
	O	1,141	780	3,179	2,413	179	209
Heartland	H	3,706	2,673	5,352	3,764	44	41
	W	877	710	1,559	1,483	78	109
	O	1,717	1,333	3,038	2,264	77	70
Warden	H	7,338	5,132	10,731	7,725	46	51
	W	1,336	1,092	1,800	1,478	35	35
	O	5,204	3,776	5,427	4,086	4	8

* Origin Purpose: H-home, W-work, O-other

** T_j : Auto driver and passenger trips to power node j .

‡ A_j : auto driver trips to power node j .

Table 3
Kilometres travelled by auto to power node locations (1996-2001)

Location	Origin*	1996		2001		$\Delta(\%)$	
		VKT_j^{**}	PKT_j^\ddagger	VKT_j	PKT_j	ΔVKT_j	ΔPKT_j
400&7	H	16,793	21,460	43,949	59,935	162	179
	W	6,986	7,206	18,133	18,969	160	163
	O	10,262	13,959	26,468	35,091	158	151
Heartland	H	22,254	31,793	28,207	39,738	27	25
	W	9,376	12,255	22,134	22,420	136	83
	O	15,744	19,994	21,347	28,478	36	42
Warden	H	28,602	41,808	49,960	70,447	75	69
	W	11,274	14,837	18,595	21,929	65	48
	O	36,082	51,094	35,761	47,232	-1	-8

* Origin Purpose: H-home, W-work, O-other

** VKT_j : vehicle kilometres travelled to power-node j , under free flow conditions.

‡ PKT_j : person kilometres travelled by auto to power node j , under free flow conditions.

(e.g., Pucher and Renne, 2003); the potential social role of shopping; and the possibility that, in the absence of alternative destinations, “car-less” consumers seek out ride-share arrangements to accommodate preferences for auto-based access to power retail destinations.

Estimates of vehicle kilometres travelled and person kilometres travelled to case study locations are reported in Table 3. With the exception of shopping travel from other locations to the Warden development, VKT and PKT have increased across all trip origin categories, for all power retail locations. Again, the 400&7 location experienced the greatest increases since 1996. The rise in VKT brings with it concerns over the production of negative externalities (e.g., congestion, emissions) in response to increased competition for the use of transport facilities (e.g., roads) by consumers looking to gain access to power retail destinations.

From a demand management perspective, it is important not only to articulate the change in gross levels of VKT over time, but to also document the contribution of short (e.g., local) and/or long distance (e.g., regional) trips to the overall pattern of demand associated with each retail site. The cumulative relative frequency distributions of trips by distance travelled to the case study locations for passenger and auto-driver trips are shown in Figure 6. A steeply rising curve suggests a higher share of short distance trips to case study locations. Figures for all trips suggest little change over time, with considerable consumer travel from residences located within a distance of 10 km or less from the case study locations. Of the three locations, Warden attracts the greatest share of trips from origins located a relatively short distance away. More than half of consumer travel to Warden originates at zones located 5 km or less from the retail site. That said, travel distances of 5-10 km are probably significant enough to deter adoption of active transportation (e.g., walk, bike), and perhaps even transit.

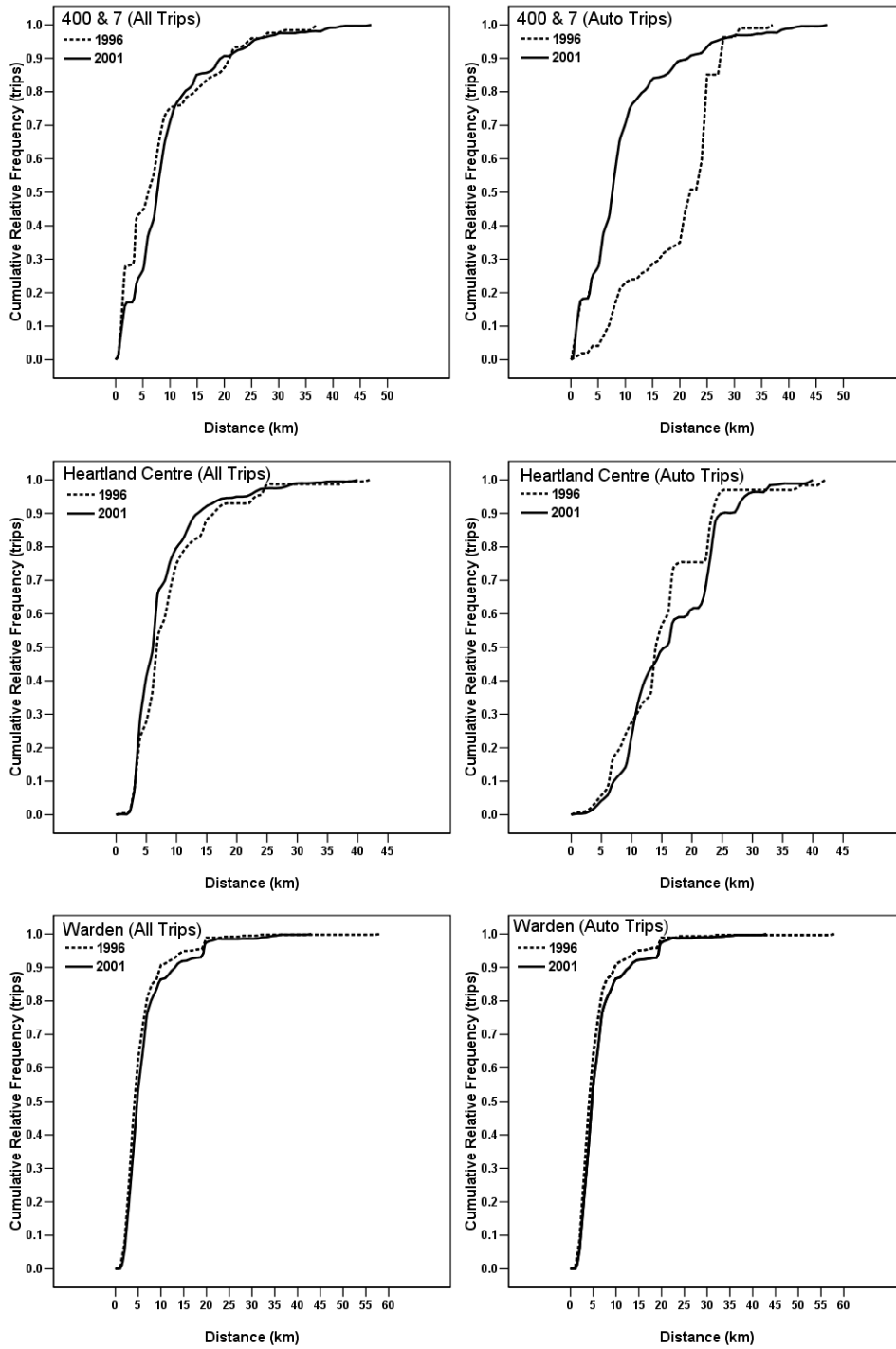
A different view emerges from inspection of auto-driver (SOV) travel. Consumers travelling to Warden as auto-drivers appear to typically drive shorter distances (more than half, from a distance of ≤ 5 km) than their suburban counterparts. For example, in 2001, only 4% of Heartland Centre’s and 28% of the 400&7’s (4% in 1996) auto-driver trips originated from residences located 5 km or less from each of the power nodes. There has also been a dramatic shift in spatial demand associated with the 400&7, with evidence pointing to local augmentation of SOV travel from closer origins when compared with 1996. This apparent increase in local demand has not materialised for the other two cases. The area surrounding the 400&7 power centre underwent significant new residential subdivision growth over the period 1996 to 2001, which may explain the increase in local trips.

Overall, a large portion of weekday travel appears to originate from local residential areas. However, the data also indicate the noteworthy presence of inter-regional travel to power node destinations. In both 1996 and 2001, consumers travelled to the 400&7 from Toronto and Peel region. Similarly, by 2001 consumers were travelling to Heartland Centre from Halton region and Toronto. Clearly, the travel impacts of the case study facilities are not limited to the site, the surrounding neighbourhood, or the host municipalities.

5.2 Transit and Power Retail

In view of the evidence concerning the auto-dominance of shopping in the study area, and the site design and location attributes of power retail facilities, there is limited *a priori* expectation regarding the role of transit in power retail shopping. The limited data available suggest that transit plays either a restricted or diminishing role in facilitating power retail shopping (Table 4). Exceptions include trips from work and other origins to the 400&7, and home-to-shopping trips associated with Heartland Centre. This evidence does not suggest that it is infeasible for

Figure 6
Cumulative relative frequency of trips by travel distance to power retail locations



consumers to contemplate or adopt transit for carrying out activities (shopping, entertainment) at power retail destinations. On the contrary, data for the Warden site indicate that consumers do in fact use transit to access areas containing power retail. Looking further into activities at the Warden node, the data suggest, as expected, that transit-based consumers travel shorter distances to shop (4.3 km) when compared with auto-based consumers (6.6 km). On the whole, data for Warden suggest that the regional market is dominated by auto-based consumers, while transit plays a larger role in shopping for local consumers. For example, in 2001, roughly 65% of home-based shopping trips by transit to Warden were less than 3 km in length; while only 21% of SOV travel took place over this same distance.

Table 4
Travel by transit to power node locations (1996-2001)

Location	Origin [*]	1996		2001		$\Delta(\%)$	
		T_j^{**}	PKT_j^{\ddagger}	T_j	PKT_j	ΔT_j	ΔPKT_j
400&7	H	***	***	***	***	***	***
	W	***	***	20	436	***	***
	O	***	***	31	655	***	***
Heartland	H	***	***	79	366	***	***
	W	46	1,104	32	781	-30	-29
	O	***	***	33	237	***	***
Warden	H	1,027	3,467	930	3,983	-9	15
	W	208	1,889	184	1,723	-12	-9
	O	208	1,329	164	886	-21	-33

* Origin Purpose: H-home, W-work, O-other

** T_j : passenger trips by local transit (LRT or Bus) to power node j

‡ PKT_j : person kilometres travelled by local transit (centroid distances) to power node j .

*** No Observations

5.4 Induced Demand

The growth in auto-based shopping is partially expected due to the rise in the population of the study area between 1996 and 2001. The second part of the case study examines, for each of the retail sites, the extent to which shopping travel demand has outpaced population growth. The analysis examines changes in *gross* and *per capita* indicators of shopping travel behaviour for zones producing shopping trips to the case study locations during both 1996 and 2001. Imposing this spatial constraint isolates the demand analysis from the expansion of the consumer market into zones that were not producing trips to the case study locations in 1996. The analysis sheds light on the extent to which power retail expansion induces increases in travel in excess of what is expected in the presence of an increase in market size (i.e., resident population).

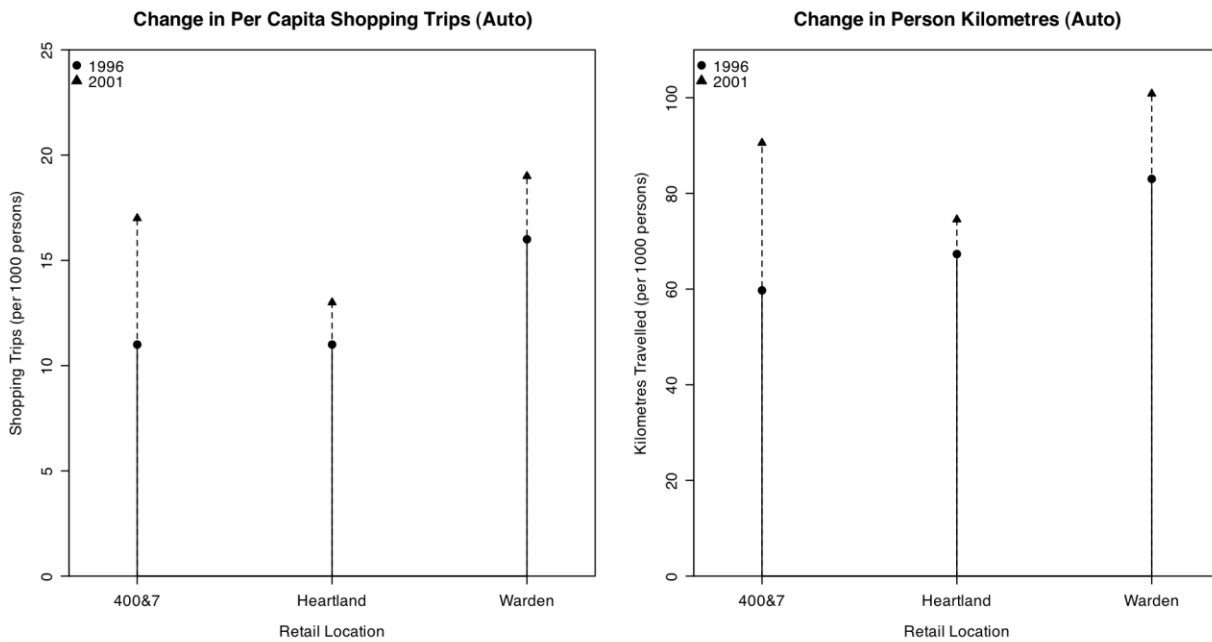
Demand elasticities have been estimated to examine, for each site, changes in shopping travel demand relative to changes in population. At the 400&7, the data suggest that a 10% increase in market size could produce a 56% increase in all auto-trips, and a 41% increase in auto-driver (SOV) trips. Notably, there is evidence of heterogeneity across retail locations in terms of the relationship described here. For example, Heartland Centre's retail capacity grew at a slower rate than the other case study locations, and the travel demand response is somewhat muted when compared with the 400&7. The data suggest that a 10% increase in the population of zones

producing trips to the traffic analysis zone where Heartland Centre is located, could produce a 21% increase in all auto-trips, and a 20% increase in auto-driver trips. While all of the results are not reported here, the data suggest the presence of marked increases in shopping travel demand in general and auto-based shopping in particular, with relatively small changes in market size.

Estimates of the change in *per capita* (demand per 1000 persons) trips and vehicle kilometres travelled provide preliminary evidence of the extent to which the expanding power retail offer induces consumers to travel more frequently to power retail sites. *Per capita* trip frequency, while providing insight into the role of the power retail in daily life, is not a sufficient indicator of the potential rise in *per capita* energy use and environmental externalities associated with power retail excursions. A broader picture can emerge from the estimation of *per capita* measures of vehicle kilometres travelled. The evidence suggests both a rise in *per capita* auto-based trip making, and kilometres travelled over time, across all facilities. The most dramatic increases in all indicators materialize for the 400&7 and Warden (Figure 7). Not only then, has the demand for travel outpaced population growth for those zones producing shopping trips to the case study locations, consumers appear to be incorporating these locations into their daily lives with increasing intensity.

Figure 7

Change in shopping travel demand per 1000 persons. The change in per capita shopping trips is for all trips (auto-driver and passenger)



6.0 Implications for Sustainability

Overall, the research findings are indicative of an increasing tension between the commercial success of the power retail format, particularly in the suburban part of the GTA and Hamilton, and the broad-based sustainability agenda that appears to dominate the current discourse surrounding growth management and transportation across the study area. The evidence provides preliminary support for advancing a policy agenda that is more acutely focused on the

relationship between the location and design qualities of commercial development and the modes of consumer interaction with the retail economy.

It is also premature to conclude that power retail, as a class of commercial development, cannot functionally support a wider range of passenger transport options, particularly for consumer travel over shorter distances. Research has also shown that power nodes operate as regional entertainment destinations (Wang *et al.*, 2000). Consumer mode preferences are not necessarily tied then to the purchase of bulky or portable goods. That is, it is not always the case that consumers require an automobile to participate in activities at power nodes, or to transport smaller consumer goods (e.g., consumables, consumer electronics, fashion, etc.). Thus, other factors, including the inadequate provision of transit and pedestrian facilities, are more likely to explain the overwhelming use of the automobile for power retail excursions. Moreover, the scale and aesthetic qualities of power retail are potentially ill-suited to the task of producing a qualitatively satisfying pedestrian experience.

Gaining insight into the spatiotemporal qualities of congestion will have important implications for planning and policy. Millions of square feet of retail capacity have been recently built adjacent to network facilities constructed decades earlier (e.g., the origins of 400 series highway system can be traced to the early 20th century). The City of Vaughan for example, hosts both the 400&7 power node and Vaughan Mills, Canada's most recently developed large-scale enclosed mall. These two locations, separated by a distance of less than 5 km, coupled with ancillary retail opportunities, offer more than 5 million square feet of retail space. Unlike enclosed shopping centres that are often physically limited by site characteristics, power centres can also evolve rapidly over time through a process of *ad hoc* planning approvals. *Ad hoc* expansion of retail capacity, the growth of the suburban market, and a fixed supply of highway and arterial road capacity will likely place increasing stress on the regional transportation system.

The continued expansion of large format retailing across the GTA has further accentuated a growing disconnect between policy intent and the grounded realities of commercial real estate development. Moreover, the results indicate that retail development practices are potentially inducing a consumer response that is placing mounting pressure on the capacity of existing transport facilities. With respect to the relationship between consumer travel and development, the provincial "Places to Grow Act" in Ontario emphasises transit investment and the provision of transportation alternatives to the automobile, as the cornerstone of its set of, "Policies for Moving People"⁵. At the same time, the act identifies highway interchanges, infrastructure for, "moving people in cars", as important spaces for the ongoing development of retail capacity and other uses. Leveraging the auto-based accessibility advantage of the highway interchange, and growing retail capacity without rethinking site design and consumer mobility at these locations would establish a set of conditions favourable to the continued expansion of auto-based shopping.

7.0 Conclusions

This study represents a step toward developing a comprehensive understanding of the supply/demand linkages between power retailing, consumer travel behaviour, related externality effects, and urban planning and policy in Canada's largest urbanised region, the Greater Toronto Area. Detailed micro data describing the location and configuration of power retail facilities have

⁵ The Ontario Places to Grow Act for the Greater Golden Horseshoe Area (GGHA) does not explicitly address consumer mobility.

been combined with travel data from the Transportation Tomorrow Survey, with a view to gaining insight into consumer interaction with these expansive and remarkably “exposed” commercial spaces. Through this research, a gap has been identified between the so-called “realities” of shopping travel behaviour and the current public policy environment. This naturally raises questions around the sharing of roles and responsibilities across stakeholders (governments, developers, retailers) regarding the mitigation of negative externalities that arise from the development and use of large format retail facilities.

Regional scale results suggest considerable auto-dependence across a wide-range of activities, including shopping, and a shift in demand toward the automobile and away from transit for shopping. Overall, the share of transit for shopping was shown to be on the decline for the GTA, and within the City of Toronto, the jurisdiction with the most extensive, multi-modal transit system in the study area. With respect to power retail, exploratory analysis generally confirmed *a priori* expectations concerning auto-dependence. Trips and kilometres travelled have outpaced population growth within markets serving case study locations. Coupled with data concerning the diminishing and practically inconsequential role of transit, the evidence substantiates claims about the auto-dependence of large format retail (e.g., Bodkin and Lord, 1997; Wang *et al.*, 2000; Lorch, 2004, 2005). Moreover, the data appears to be indicative of a retail development process that has focused on reaching the auto-based consumers.

Providing some contrast to these results, some emerging evidence has also been presented suggesting that while the regional draw of power retail is auto-oriented, local markets can be comprised of a greater mix of auto and transit users, particularly when the supply of transit provides several options for moving consumers to the retail location (e.g., Warden). Overall, however, the evidence suggests that, whether an individual is driving or acting as a passenger, the automobile is the dominant travel mode for accessing power retail. Beyond the clear regional and local scale evidence of the auto-dependence of shopping and power retail activities, analysis of the change in *per capita* travel demand suggests a consumer response to power retail that includes more frequent weekday shopping trips, and an accumulation of auto-based kilometres.

An important outcome of this research is that a framework for studying the travel effects of retail across the entire GTA has now been established. The development and application of this framework in this study has led to the identification of several directions for future work. Learning more about the quality of the transportation and shopping experience *in situ*, and the impact of power retail on surrounding neighbourhoods and communities remain longer term research goals. Additional research is also required to generalize findings reported here to the entire power retail network within the GTA. While this study has focused on temporal change in travel demand, future research should examine the contribution of power retail to roadway congestion and environmental emissions. Congestion, for example, emerges as both a behavioural modelling issue (i.e., influencing consumer route choice), and the outcome of the consumer travel process. The externality question is fundamentally important, particularly for the development of policy designed to intervene in transportation and land use systems, with a view to optimising the trade-off between consumer goals, and the performance of the transportation system.

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