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A COMPARATIVE ANALYSIS OF HOW TRANSPORTATION SYSTEMS AFFECT SPATIAL SEGREGATION IN BRASÍLIA, BRAZIL AND TORONTO, CANADA

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ABSTRACT

This research explores how transportation systems and planning methodologies affect spatial segregation within the context of income disparity. Spatial segregation will be defined as the inability to have unhindered access throughout the city for both work and leisure. A comparative analysis between the auto-centered, planned city of Brasília, Brazil and the transit conscious city of Toronto, Canada will provide a context from which characteristics of a more socially sustainable transit system can be based. Differences in scale, cost, and land use planning will promote a better understanding of how to mitigate the reoccurring challenge of population mobility in cities where low-income populations are continuously pushed to the periphery.

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Introduction

Cities are home to the largest population concentrations in the world, and their populations are characterized by wide income disparities. In such urban contexts, population mobility becomes a key attribute for promoting social equity. By developing socially sustainable public transit systems, transportation engineers and city planners can contribute to a more homogenous mixing of socio-economic classes within a metropolitan area.

The goal of this research is to determine characteristics of transportation systems and city planning systems that mitigate or augment spatial segregation. Spatial segregation will be de defined as the inability to have unhindered access throughout a city for both work and leisure.

Two case studies, Brasília, Brazil and Toronto, Canada, will be examined and compared. These cities were chosen because of their distinct transportation histories. Brasília, Brazil's new capital was inaugurated in 1960. Designed from scratch, the city was based on the automobile. Toronto, on the other hand, has a long history in public transit spanning 161 years, since the introduction of the first horse-drawn omnibus.

The analysis of each city includes:

- A historical overview describing each city's urban and transportation evolution;
- Distribution patterns of different income groups; and
- Comparison of different transit mode usages.

A comparative analysis will follow the individual analysis of each city to determine how transit networks affect the population's mobility in an urban setting. The contextual differences in scale, cost, and land use planning provide insight into the characteristics of a socially sustainable public transit system.

Brasília

Historical Overview

Celebrating its 50th anniversary in April 2010, Brasília's conception has long been a center of discussion. Dating back to the mid 18th century, the Marques de Pombal proposed that the Portuguese colonial capital be located in the interior. A year after Brazil severed its ties with Portugal, in 1823, José Bonifácio de Andrada e Silva proposed to the Assembly and Legislature of Imperial Brazil that the capital be moved to the interior and proposed the names of Brasília or Petrópolis. (*História do Centro-Oeste*, n.d.)

With the passage of time, the suggestion of relocating the capital to the underdeveloped center of the national territory became an ever more present ideation. In the first Constitution, 1891, the proposal began gaining substance, "A zone of 14,000 square kilometers (circa 5,600 square miles) on the planalto central [central plateau] of the Republica [Republic] will be reserved to the Union and will be surveyed at the earliest opportunity so that within it can be established the future Federal Capital" (Ludwig, 1980, p. 2).

In the years to follow, Luis Cruls, a Belgium engineer and astronomer and Director of the Astronomic Observatory of Rio de Janeiro, led two exploratory expeditions, 1892 to 1894 and then from 1894 to 1896, "…in order to define the best location for Brasília, considering aspects such as climate, water resources, and topology" (Da Silva, 2007, p. 46). Further references to the new capital can be found in the constitutions of 1934 and 1946. By 1945 the Instituto Brasileiro de Geographia e Estatítica (IBGE) [Brazilian Institute of Geography and Statistics], deemed a matter of national security the capital's relocation to the interior, as most of Brazil's cities were located on the coast. ("História do Centro-Oeste," n.d.) Furthermore, such a project was to symbolize a development of the, as of yet, untapped resources of the vast national territory as well as an, "…escaping [of] the political corruption of Rio de Janeiro (the former capital), and of framing a new vision for Brazil – one of progressive development for the future" (Da Silva, 2007, p. 46).

With the election of Juscelino Kubitschek (JK) in 1955, the promise of a new capital began to materialize. As part of his campaign platform, JK's Programa de Metas [Target Plan], called for rapid industrialization. To be more precise, JK "promised 50 years of progress in the span of his five-year term" (El-Khoury & Robbins, eds., 2004, p. 47). The building of a new capital offered the perfect pretext for the construction of a new highway system that would lead progress into the vastly unexploited national territory. At this point in history, the private automobile offered maximum levels of mobility and accessibility. It was undoubtedly the essence of modernity in transportation. "Conceived primarily in terms of uninterrupted traffic flows, Brasília assimilated in its very form the importance of the car, whose production quadrupled during the Kubitshek's mandate" (El-Khoury & Robbins, eds., 2004, p. 47).

In 1956, JK created the Companhia Urbanizadora da Nova Capital (NOVACAP); a development company in charge of building the new capital that was officially to be called Brasília. Oscar Niemeyer was appointed as the head of its architecture department and Lucio Costa would go on to submit the winning urban design entry and become the capital's urban planner. (El-Khoury & Robbins, eds., 2004)

Reminiscent of utopian cities such as Ebenezer Howard's Garden City and Le Corbusier's La Ville radieuse, Costa's Plano Piloto [Master Plan] was based on ideas of functionalist urbanism. (Sewell, 1993) Shaped as an airplane, Brasília was based on the interaction of four distinct scales: the monumental scale, the residential scale, the concentrated scale, and the bucolic scale. (El-Khoury & Robbins, eds., 2004)

The monumental scale is achieved along a 9.75 km "Eixo Monumental" [monumental axis] that defines the airplane's fuselage. A sense of capital grandeur is hallmarked by, "the application of terreplein techniques, the disciplined disposition of built masses, the vertical references of the Congress and television tower, and the central green mall free of any construction as it crosses the city from dawn to dusk" (Robbins & El-Khoury, 2004, p. 52).

Figure 1. Monumental Axis looking eastward towards Congress. Source: Author, 2009.

Figure 2. Monumental Axis looking westward towards Convention Center. Source: Author, 2009.

The residential scale is composed of Superquadras [large residential blocks] that create the airplane's wings and "…provides an urban serenity. Guaranteed by a uniformity of size and a ground made accessible to all via the generalized use of pilotis and the predominance of green areas" (El-Khoury & Robbins, eds., 2004, p. 53). Strict single use zoning creates a clear divide between commercial and residential areas along the wings, which are connected by the Eixão, a 14.3 km residential axis.

Figure 3. Residential Axis, northern wing. Source: Areal, n.d.

The concentrated scale, located at the intersection of the Monumental Axis and Residential Axis is devoted to high-density urban spaces. Here are located the central bus terminal, the hotel district, and various shopping malls. (El-Khoury & Robbins, eds., 2004)

Finally, the bucolic scale creates a greenbelt that prevents urban sprawl. "It occurs in the transition, without interruption, between the inhabited and the uninhabited" (Robbins & El-Khoury, 2004, p. 54). In essence, this scale is an attempt to ensure the sanctity of the master plan. Instead, population growth would be designated to the satellite cities surrounding Brasília. (El-Khoury & Robbins, eds., 2004)

In 1987, UNESCO deemed Brasília a World Heritage Site. Interestingly, state and federal law protect Brasília's urban grammar of scales and not the buildings themselves (with certain exceptions). "...in Brasília buildings are not protected; only their outline and the percentage rate of their land occupancy are" (Robbins & El-Khoury, 2004, p. 55).

Initially, it was planned that Brasília would be able to support a population of up to 600,000 inhabitants, after which satellite cities would form. (Da Silva, 2007) However,

with the start of construction in 1957 and a predetermined date of inauguration in 1960, rapid construction led to a large influx of workers. Initially, the government was under false pretenses that once complete, the workers would return home to their places of origin. Instead, for the most part, workers brought their families hoping for a better future and a new start in the county's capital. Low-income families began to settle and form shantytowns on the outskirts of Brasília. "The government decided to evacuate the slums, transferring their population to satellite cities distancing at least 25 kilometers from the capital" (Da Silva, 2007, p. 51). Thus, began a social trend familiar to other metropolitan cities of Brazil, the push of low-income residence towards the periphery leading to issues of spatial segregation.

Currently, there are 29 Regiões Administrativas (RA) [Administrative Regions] in the Distrito Federal (DF) [Federal District]. According to 2004 statistics, the DF had a population of 2,096,534 inhabitants, of which only 198,906 reside in Brasília (9.5%). Refer to Table 1 for a complete list of population totals by RA. While Brasília houses only 9.5% of the population, approximately 45% of the job opportunities in the DF are located in Brasília. Diverging numbers such as these lead to a recurring issue of spatial segregation due to the fact that the transit network heavily favors one mode of transit, the private automobile. As will be discussed in the sections to follow, the population distribution amongst the different RAs and the centralization of most jobs are key factors that encourage spatial segregation. (Peixoto & Soares, 2008)

Table 1. Population by Administrative Region - 2004. Source: Peixoto & Soares, 2008.

Administrative Region	Population	Percentage
Distrito Federal	**2,096,534**	**100.0**
RA I - Brasília	198,906	9.5
RA II - Gama	112,019	5.3
RA III - Taguatinga	223,452	10.7
RA IV - Brazlândia	48,958	2.3
RA V - Sobradinho	61,290	2.9
RA VI - Planaltina	141,097	6.7
RA VII - Paranoá	39,630	1.9
RA VIII - Núcleo Bandeirante	22,688	1.1
RA IX - Ceilândia	332,455	15.9
RA X - Guará	112,989	5.4
RA XI - Cruzeiro	40,934	2.0
RA XII - Samambaia	147,907	7.1
RA XIII - Santa Maria	89,721	4.3
RA XIV - São Sebastião	69,469	3.3
RA XV - Recanto das Emas	102,271	4.9
RA XVI - Lago Sul	24,406	1.2
RA XVII - Riacho Fundo	26,093	1.2
RA XVIII - Lago Norte	23,000	1.1
RA XIX - Candangolândia	13,660	0.7
RA XX - Águas Claras	43,623	2.1
RA XXI - Riacho Fundo II	17,386	0.8
RA XXII - Sudoeste/Octogonal	46,829	2.2
RA XXIII - Varjão	5,945	0.3
RA XXIV - Park Way	19,252	0.9
RA XXV - SCIA (Estrutural)	14,497	0.7
RA XXVI - Sobradinho II	71,805	3.4
RA XXVIII - Itapoá	46,252	2.2

Income Group Distribution

Initially, Costa envisioned Brasília as home to all income levels. Such a coexistence within the same neighborhoods would be made possible by government regulated real estate prices and the provision of low income housing in order to prevent the formation of slums. Costa believed that apartment prices would be a function of proximity to the residential axis highway, thus placing high value on transportation. However, such a system was not economically feasible. As described in the previous section, the formation of satellite cities began to form even before the inauguration of Brasília. (Da Silva, 2007)

The Human Development Index (HDI) is a measurement based on wealth, education, and life expectancy. According to the Companhia de Planejamento do Distrito Federal (Codeplan), a government agency that functions to provide strategic planning as well as economic, social, and urban development, there is a large disparity between the RAs. Refer to Table 2 for a list of the administrative regions in comparison with international countries. Note that not all administrative regions are included in the table. (*Índice de Desenvolvimento Humano - IDH*, n.d.)

Table 2. Human Development Index by Administrative Region.
Source: Índice de Desenvolvimento Humano - IDH, n.d.

High Human Development					
1	**Lago Sul**	**0.945**	34	Slovenia	0.879
2	Norway	0.942	35	Malta	0.875
3	Sweden	0.941	36	Barbados	0.871
4	Canada	0.940	**37**	**Guará**	**0.867**
5	Belgium	0.939	38	Brunei	0.856
6	Australia	0.939	**39**	**Taguatinga**	**0.856**
7	United States	0.939	**40**	**Candangolândia**	**0.853**
8	Iceland	0.936	41	Czech Republic	0.849
9	**Brasília**	**0.936**	**42**	**Distrito Federal**	**0.849**
10	Holland	0.935	43	Argentina	0.844
11	**Lago Norte**	**0.933**	**44**	**Sobradinho**	**0.837**
12	Japan	0.933	45	Hungary	0.835
13	Finland	0.930	46	Slovakia	0.835
14	Switzerland	0.928	47	Poland	0.833
15	France	0.928	48	Chile	0.831
16	United Kingdom	0.928	49	Bahrain	0.831
17	**Cruzeiro**	**0.928**	50	Uruguay	0.831
18	Denmark	0.926	**51**	**Riacho Fundo**	**0.826**
19	Austria	0.926	52	Bahamas	0.826
20	Luxembourg	0.925	53	Estonia	0.826
21	Germany	0.925	**54**	**São Sebastião**	**0.820**
22	Ireland	0.925	55	Costa Rica	0.820
23	New Zealand	0.917	**56**	**Gama**	**0.815**
24	Italy	0.913	57	Saint Kitts and Nevis	0.814
25	Spain	0.913	58	Kuwait	0.813
26	**Núcleo Bandeirante**	**0.898**	59	United Arab Emeritus	0.812
27	Israel	0.896	60	Seychelles	0.811
28	Hong Kong	0.888	61	Croatia	0.809
29	Greece	0.885	62	Lithuania	0.808
30	Singapore	0.885	63	Trinidad and Tobago	0.805
31	Cyprus	0.883	64	Qatar	0.803
32	South Korea	0.882	65	Antigua and Barbuda	0.800
33	Portugal	0.880	66	Latvia	0.800
Medium Human Development					
67	Mexico	0.760	84	Saint Lucia	0.772
68	Cuba	0.750	85	Mauritius	0.772
69	**Santa Maira**	**0.740**	86	Colombia	0.772
70	Belarus	0.788	87	Venezuela	0.770
71	Panama	0.787	**88**	**Planalitna**	**0.764**
72	**Paranoa**	**0.785**	89	Thailand	0.762
73	**Ceilândia**	**0.784**	**90**	**Brazlândia**	**0.761**
74	Belize	0.784	91	Saudi Arabia	0.759
75	Malaysia	0.782	92	Fiji	0.758
76	Russia	0.781	**93**	**Brazil**	**0.757**
77	**Samambaia**	**0.781**	94	Suriname	0.756
78	Dominica	0.779	95	Lebanon	0.755
79	Bulgaria	0.779	96	Armenia	0.754
80	**Recanto das Emas**	**0.781**	97	Philippines	0.754
81	Romania	0.775	98	Oman	0.751
82	Libya	0.773	99	Kazakhstan	0.750
83	Macedonia	0.772	100	Ukraine	0.748

Today, the highest income groups reside in Brasília and the adjacent RAs as shown in Figure 4. The map depicts the monthly income per capita for the various urban centers of each RA. These values are based on the 2004 minimum salary (MS) which was R$260 per month. Table 3 groups the RAs based on their income distribution and includes the monthly income per capita for each RA. Note that the Jardim Botânico and SIA were not included in this data set.

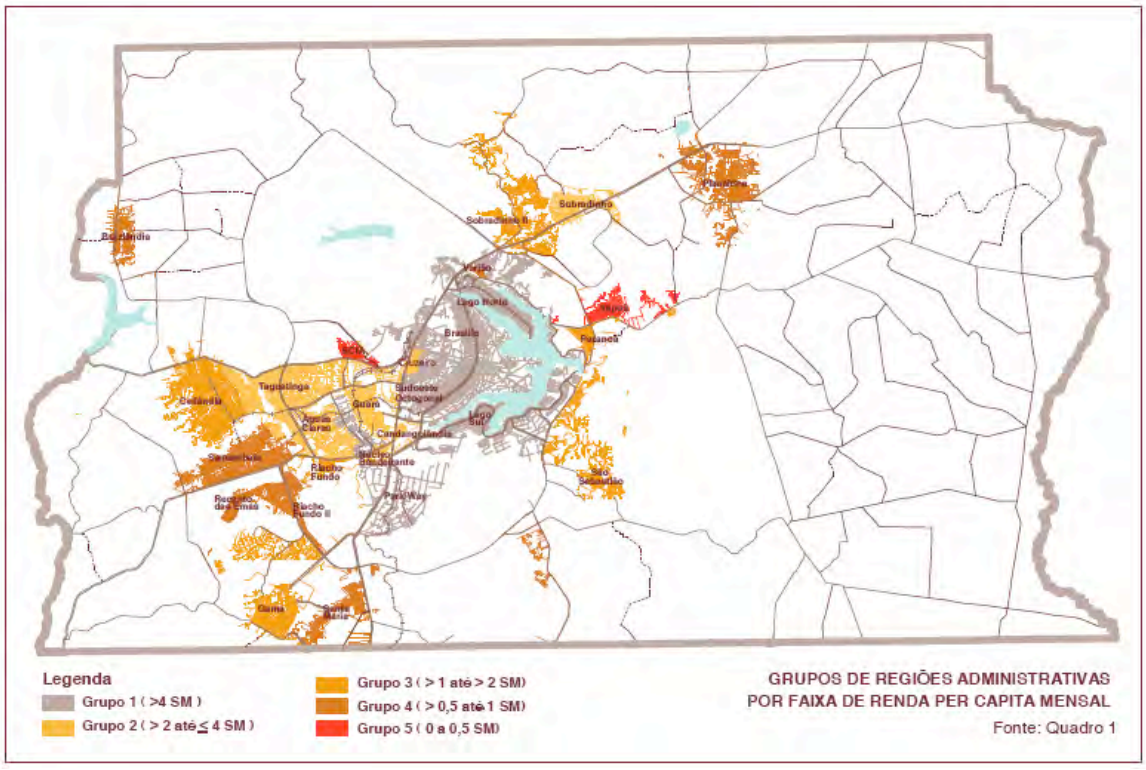

Figure 4. Administrative Regions Characterized by Average Monthly Income per Capita.
Source: Oliveira, França, & Cabral, 2007.

Table 3. Designation of Administrative Region Groups based on Income per Capita - 2004. Source: Oliveira, França, & Cabral, 2007.

Group		Administrative Region (RA)	Income per Capita (MS)
Group 1	> 4 MS	RA XVI - Lago Sul	10.8
		RA XXII - Sudoeste/Octogonal	8.6
		RA XVIII - Lago Norte	7.8
		RA I - Brasília	6.8
		RA XXIV - Park Way	4.9
Group 2	>2 - ≤4MS	RA X - Guará	3.3
		RA XX - Águas Claras	3.1
		RA XI - Cruzeiro	3.1
		RA III - Traguatinga	2.5
		RA VIII - Núcleo Bandeirante	2.4
		RA V - Sobradinho	2.4
		RA XIX - Candangolândia	2.2
Group 3	>1 - ≤2MS	RA XXVI - Sobradinho II	1.7
		RA II - Gama	1.6
		RA XVII - Riacho Fundo	1.5
		RA XIV - São Sebastião	1.4
		RA IX - Ceilândia	1.2
		RA VII - Paranoa	1.2
Group 4	>0.5 - ≤1MS	RA XII - Samambaia	1.0
		RA XIII - Santa Maria	0.9
		RA XV - Recanto das Emas	0.9
		RA XXI - Riacho Fundo II	0.9
		RA XXIII - Varjão	0.8
		RA IV - Brazlândia	0.8
		RA VI - Planaltina	0.8
Group 5	0 - ≤0.5MS	RA XXV - Estrutural (SCIA)	0.4
		RA XXVIII - Itapoá	0.4

These income disparities are further magnified when analyzing each individual group's composition by monthly income per capita. (Refer to Table 3) In 2004, Groups 3-5, which represent 60.3% of the population, earned less than two MS per month per capita, while Group 1, which represents 14.9% of the population, earned more than 4 MS per month per capita. Furthermore, 55.4 % of the households within Group 1 earned more than 10 MS per month, with 33.4% earning more than 20 MS per month. Another interesting phenomenon manifests itself in Group 1. There is a significant income gap present within the group as shown by only 9.5% of the households earning 1 - 5MS per month. One explanation for the large percentage of households earning only up to 1MS, 22.4%, is that these households are for the most part made up of maids, caretakers, groundskeepers, etc. who reside where they work.

Figure 5 shows the change in percentage of households per group at given income levels. When analyzing the percentage of households that earned more than 20 MS there is a sharp cut off after Group 1. This declining trend in percentage of households earning higher incomes continues as group number increases. Likewise, the reverse trend is also true for lower income levels. This trend only shows an exception at the lowest income level that has its second highest percentage at Group 1 due to the residence of service employees (maids, caretakers, and groundskeepers).

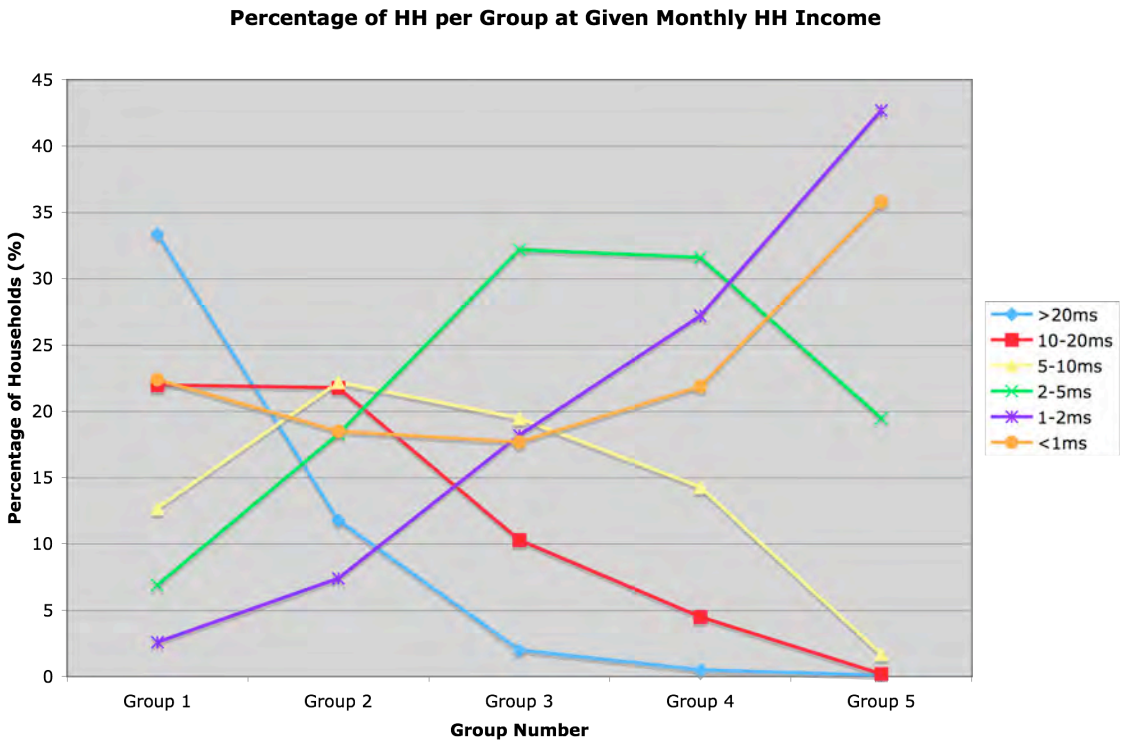

Figure 5. Percentage of HH in Group by Monthly HH Income.
Adapted from Oliveira, França, & Cabral, 2007.

Transit Mode Usages

Brasília is a city conceived on the belief that the automobile is a symbol of modernity. Lucio Costa organized his winning report of Brasília into 23 items concerning different aspects of the city's plan, eight of which are devoted to transportation. (Da Silva, 2007) The wide use of roundabouts minimized the use of signalized intersections throughout Brasília. Furthermore, the strict single-use zoning coupled with long, wide-open spaces increased reliance on the automobile for almost all trips.

According to the Departamento de Trânsito do Distrito Federal (DETRAN-DF) [Department of Transit of the Federal District] in March 2010, 74.7% of the registered vehicles in the DF were automobiles. (*Estatística de Frota de Veículos*, n.d.) Yet, for much of the population, the principal mode of transit is by bus.

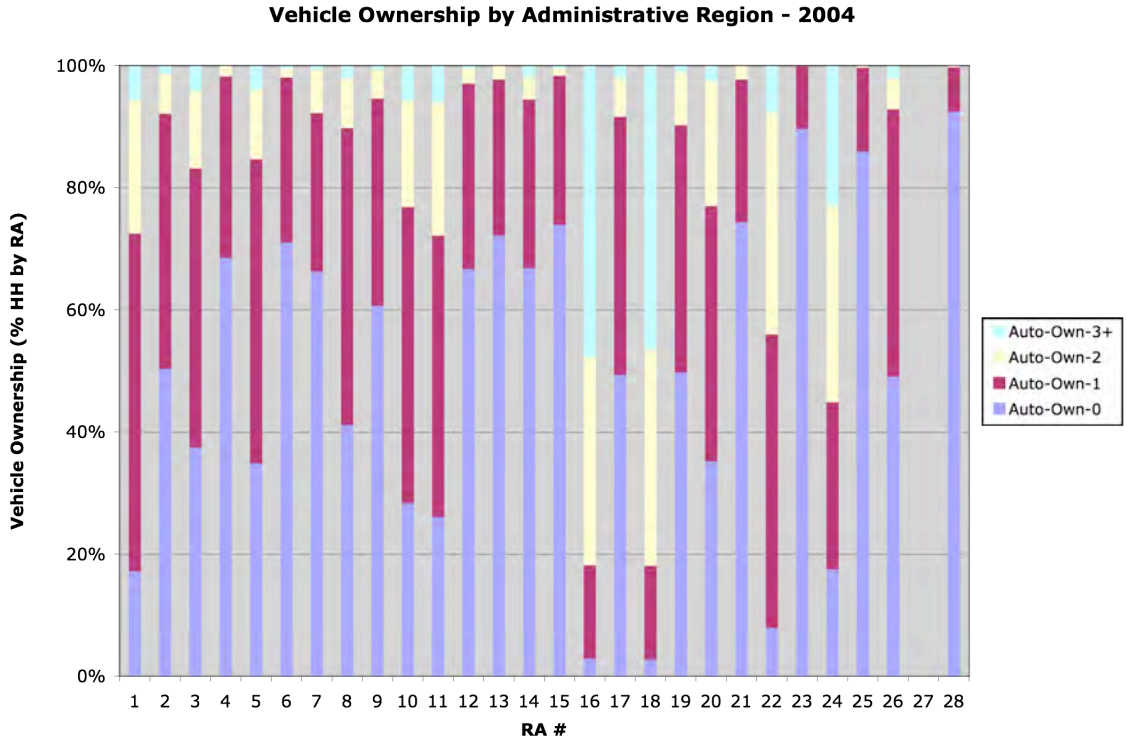

Figure 6. Vehicle Ownership by Administrative Region – 2004.
Adapted from Peixoto, Soares, & Silva, 2007.

Figure 6 shows the vehicle ownership distribution per household (HH) for each RA. In places such as Paranoá (RA VII), Recanto das Emas (RA XV), and Santa Maria (RA XIII), 88.4%, 75.7%, and 80.6% of households do not own an automobile, respectively. (Peixoto, Ferreira, Da Costa, & Soares, 2009) For these three regions in particular, 71%, 67%, and 65% of their populations use bus transit as their main mode of transportation, respectively. On the other hand, regions such as Lago Sul (RA XVI) and Lago Norte (XVIII), not only have the smallest percentage of households not owning a vehicle, 2.9% and 2.7% respectively, but they also have the highest percentage of houses owning three or more vehicles, 47.6% and 46.5%, respectively. (Peixoto, Soares, & Silva, 2007)

As described in the previous section, wealth is to a great extent centralized within the DF. Note that the subsequent analysis on transportation trends is based on data from the *Coletânea de Informações Socioeconômicas* report published by Codeplan. Transit usage data is based on values from 2000, while vehicle ownership, income, and distance data are based on values from 2004. Figure 7 shows the similarity between the variations of percentage of households with the highest incomes (≥10MS) and the vehicle usage within each RA.

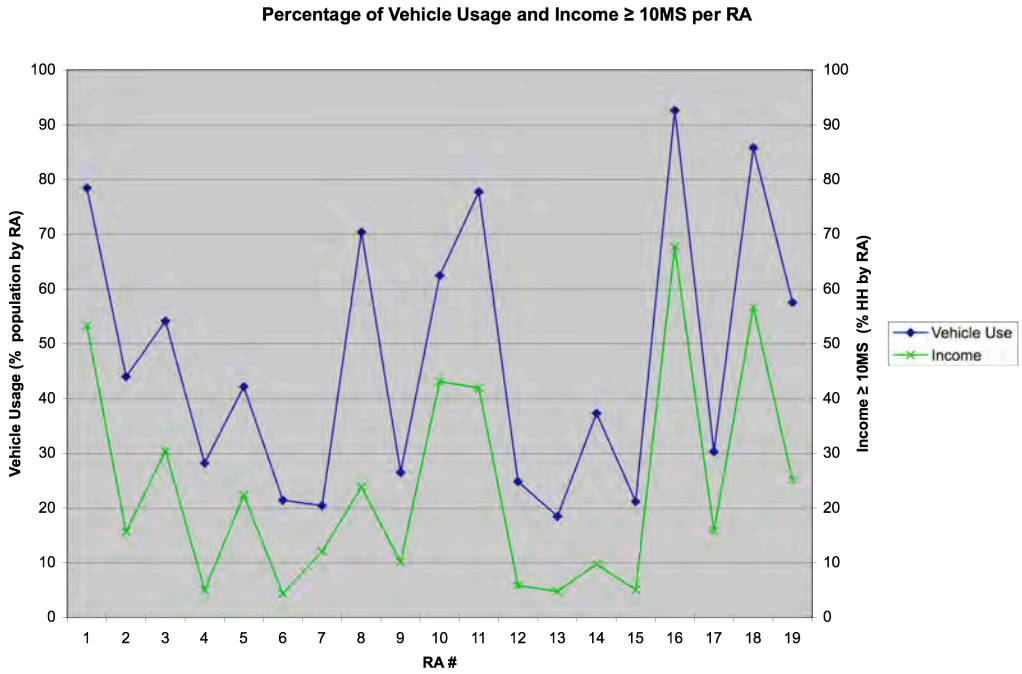

Figure 7. Percentage of Vehicle Usage and Income ≥ 10MS per RA.
Adapted from Peixoto, Soares, & Silva, 2007.

Figure 8 shows that with increasing percentage of HH owning at least one vehicle, there is an increasing trend with vehicle usage. The average elasticity for this data set was determined to be 1.23. Elasticity is defined as the percentage increase in y due to a percent increase in x. Therefore, for every percentage increase in households owning at least one vehicle; there is a 1.23% increase in vehicle usage. A sample calculation elasticity is presented below based on Figure 8.

Elasticity = dy/dx * (x/y)

y = -0.0011x^2 + 1.1252x - 9.3713

dy/dx = -0.0022x + 1.1252

Elasticity = (-0.0022x^2 + 1.1252x) / y

Average Elasticity = $[\sum (-0.0022x_i^2 + 1.1252x_i) / y_i] / n$

Where, n = number of observations

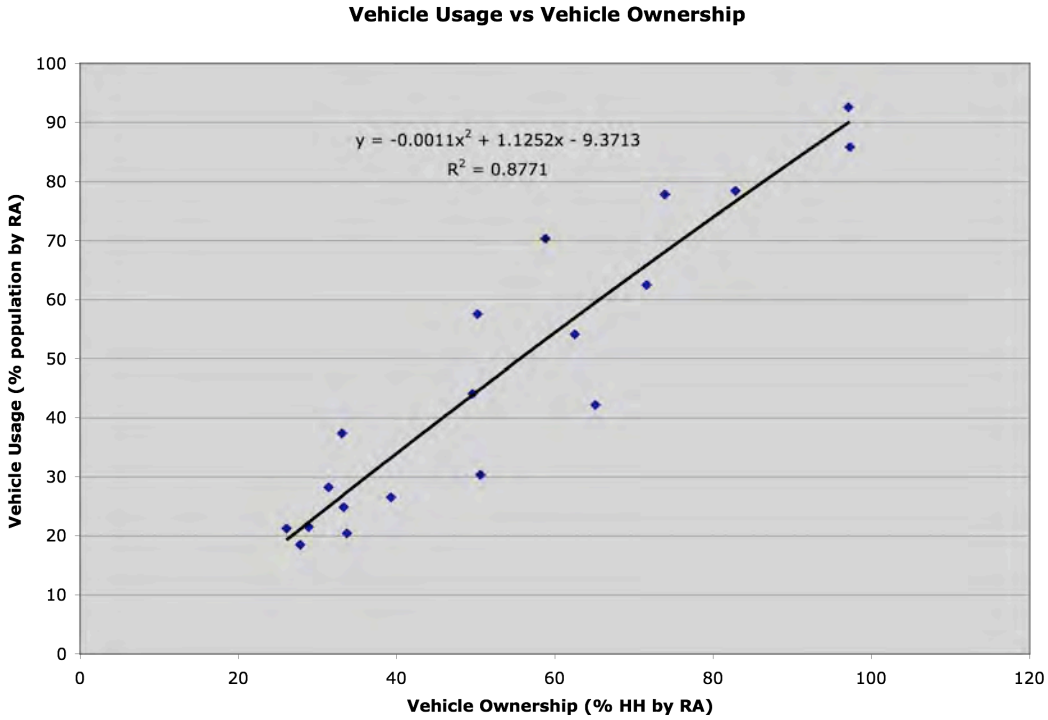

Figure 8. Vehicle Usage vs Vehicle Ownership. Adapted from Peixoto, Soares, & Silva, 2007.

A similar trend is shown when comparing bus use with the percentage of households owning zero vehicles, Figure 9. However, the average elasticity in this case is slightly lower. For every 1 percent increase in households not owning vehicles there is a 1.10% increase in conventional bus use.

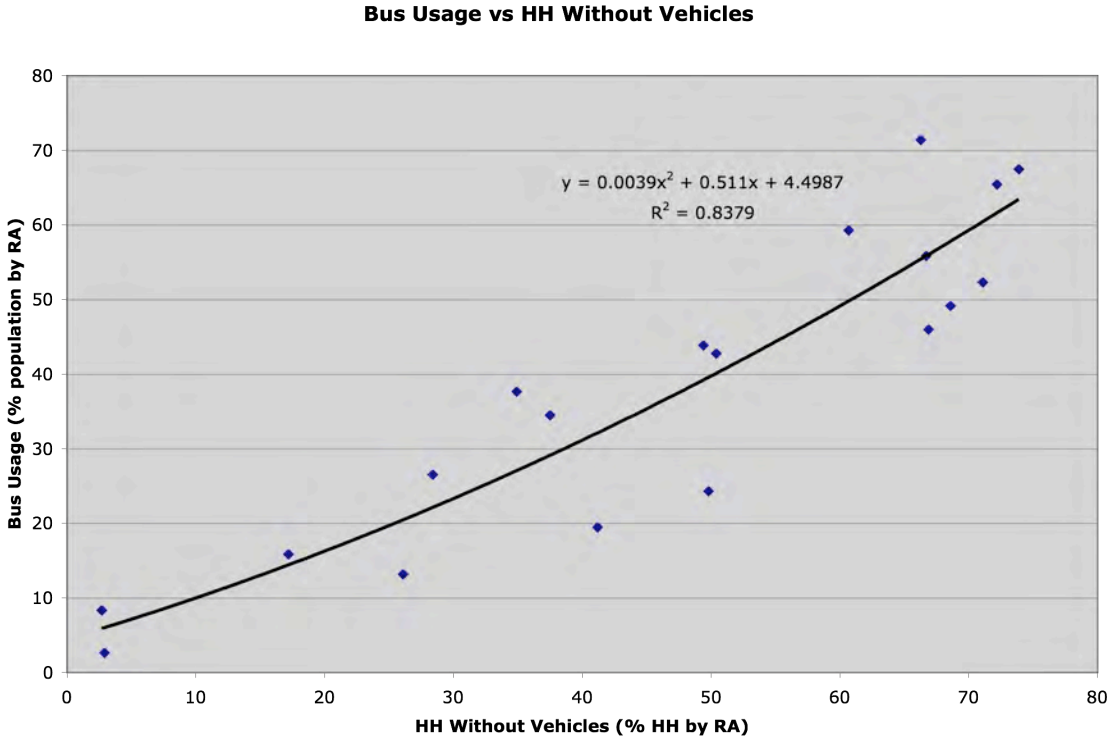

Figure 9. Bus Usage vs HH Without Vehicles. Adapted from Peixoto, Soares, & Silva, 2007.

The public transit system in the DF is comprised of buses, subway, and vans. The main mode of public transit is by the conventional bus system that serves over 14 million passengers per month. In 2008, the fleet was comprised of 13 companies running 2,337 conventional buses serving 888 routes, two companies running 55 microbuses serving 11 routes, 350 microbuses serving 89 circular routes, 21 companies running 74 rural buses serving 65 routes, and 664 registered van operators serving 37 routes. (*Tipos de Transporte*, 2008)

Currently, fares are not transferable, meaning that each change of bus or mode of travel requires purchasing a new fare. Furthermore, fares are priced based on distance in relation to Brasília's central bus terminal. Fares range from R$1.50 for circular routes within the Plano Piloto and satellite cities to R$3.00 for routes connecting further satellite cities to the Plano Piloto. (*Tarifas*, n.d.) While only 9.5% of the population resides in Brasília, it concentrates approximately 45% of the job opportunities in the DF. Therefore, individuals with the lowest incomes who most use the public transit network are forced to pay the highest fares. Another problem faced by residents of satellite cities is the long travel time associated with the current transit system. "The high number of routes results in a small number of buses per route, with consequential low bus frequencies" (Da Silva, 2007, p. 53). Figure 10 shows that with increased distance from Brasília, a greater portion of the population relies on collective transit (buses, school transit, chartered transit, and alternative transit). In turn, these individuals are faced with more expensive fares and a greater chance of requiring transfers. Also, as discussed in the previous section, lower income classes characterize the peripheries.

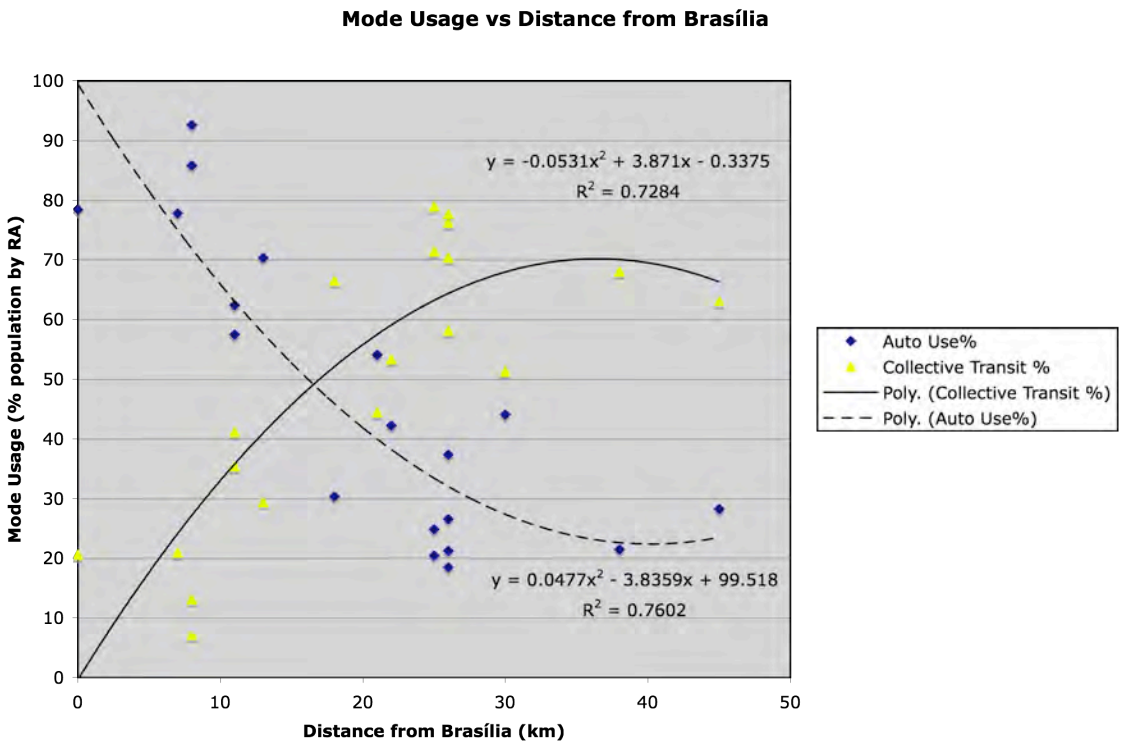

Figure 10. Mode Usage vs Distance from Brasília. Adapted from Peixoto et al., 2007.

Inaugurated in 1993, in order to compliment bus transit, the subway system provides service to 160 thousand daily users. Currently there are two lines with a combined fleet of 20 trains and headways that vary from 4 minutes and 35 seconds to 21 minutes depending on the station, day, and hour. (*Metrô DF*, n.d.) According to Governor Arruda, twelve new trains are supposed to be added in 2010. (*Lotação nos metrôs de Brasília*, 2009) They will supposedly increase the capacity to 300 thousand passengers per day. In 2010, the fare costs R$3.00 on weekdays and R$2.00 on weekends and holidays. Figure 11 shows the map of the subway system as well as future plans of expansion along the northern wing of the Residential Axis as well as the construction of a Light Rail Vehicle (LRV) line that will run along the W3, a commercial avenue, all the way to the airport. The first phase of the three-phase LRV project is to be complete by the end of 2010, connecting the airport with the center of Brasília. The completion of the entire project is expected by 2014 before the World Cup. (*Metrô DF*, n.d.)

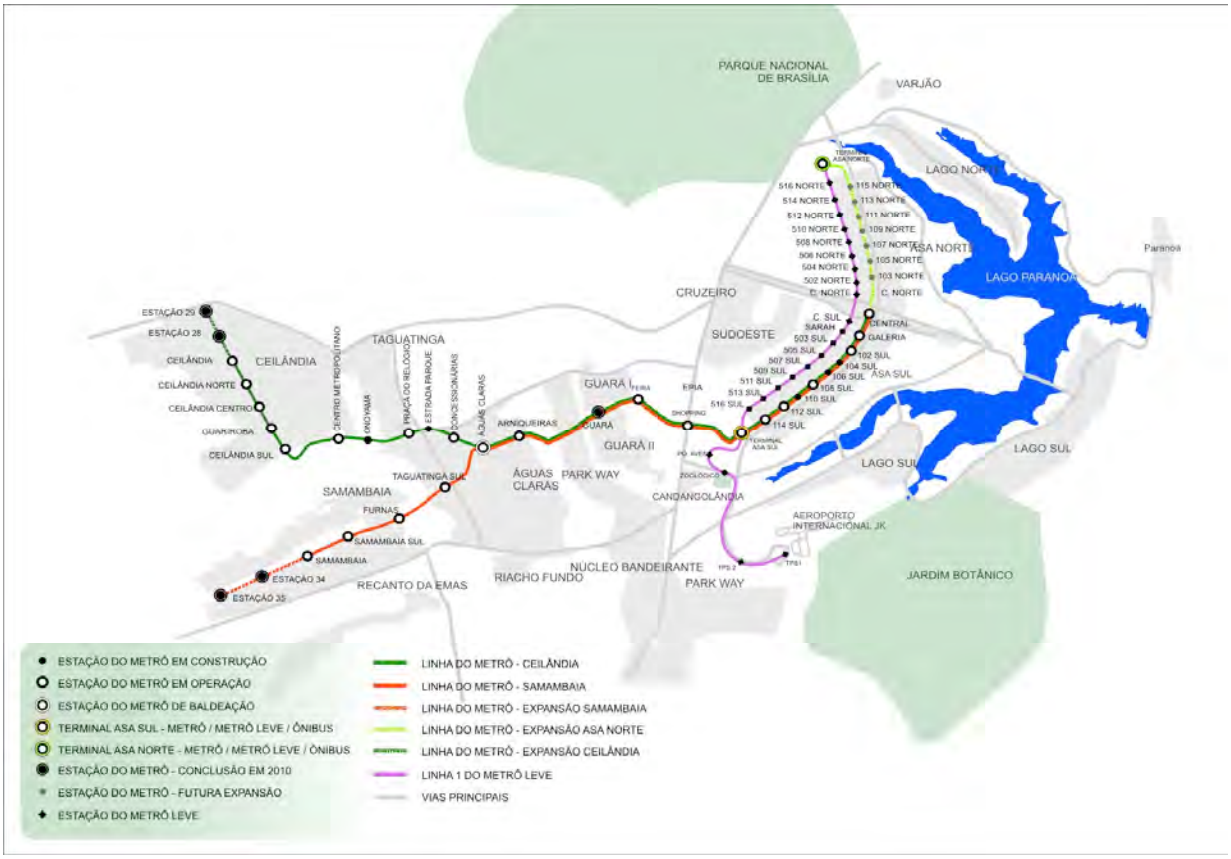

Figure 11. Map of the Subway and Planned Light Rail Lines. Source: *Metrô DF*, n.d.

Toronto

Historical Overview

In 1763, Colonel John Graves Simcoe selected the site that for hundreds of years had been called "Toronto" by Indians as the capital of the new province of Upper Canada. He named the capital York. Following the War of 1812 between Britain and the United States, York grew to a population of 9,000 persons when in 1834, it formally became a city and was renamed Toronto.

Fifteen years later, in 1849, Mr. H.B. Williams, a cabinetmaker, introduced the first form of public transit to Toronto, a horse-drawn omnibus, with a flat fare of six pence per trip. Thus began Toronto's rich history with public transit in the days when the city housed a population of 24,000 persons.

In 1861, Alexander Easton founded the Toronto Street Railway Company under a 30-year franchise. Based on networks implemented in the United States, the Toronto Street Railway Company was made up of horse drawn cars on railways. In accordance with the City, a maximum car speed of six miles per hour and a maximum headway of 30 minutes were to be maintained. During the next 30 years, the population grew from 45,000 to 170,000 persons. By 1891, the company was carrying 55,000 passengers per day at five cents per fare with no transfers.

In 1891, the City attempted at no avail public ownership of the railway. Therefore, a new 30-year franchise was awarded to William Mackenzie & Associates who named the new company the Toronto Railway Company. The five-cent fare remained. However, discounted incentives and special pricing as well as free transfers modernized the system. Furthermore, within three years, the system became completely electrified. (*Toronto Transit Commission*, 1976)

From 1891 to 1910, the city's population more than doubled from 170,000 to 350,000 persons. This massive population explosion led to new developments as the city expanded. Unwilling to extend services beyond the pre-specified city limits of 1891, at

the franchise start, the building of rail lines extending to newly formed districts was the city's responsibility. This, in turn, led to expensive public transit because, "…by 1920 there were four transit companies operating nine separate transit networks in Toronto and each collected a separate fare" (*Toronto Transit Commission*, 1976, p. 3).

Once the Toronto Railway Company reached the end of its franchise, it was time for an overhaul in public transit and the unification of the transit network. In 1921, the Toronto Transportation Commission was founded under public ownership. Thirty million dollars was invested into improving and expanding the transit network. Nine networks were welded into one, offering a single fare for the entire city, including free transfers. Of importance, 1921 also marked the year when buses were introduced to the system in order to fill voids in public transit.

Ever since 1929, the Toronto Transportation Commission was aware that it needed to offer passengers a ride that rivaled private automobiles in both comfort and quality. In 1938, the new P.C.C. streetcars were introduced. "They combined a smooth, fast, quiet ride with a clean, attractive modern appearance, and Toronto is proud to have been among the first to introduce the new cars to transit riders" (*Toronto Transit Commission*, 1976, p. 6).

A growing cultural disdain for urban density led to the movement of persons and industry to the suburbs. In 1946, 90% of manufacturing enterprises in York County were still within the City of Toronto; by 1954 this figure fell to 77%. By 1952, the post war baby boom led to suburban development of bedroom communities much like the US. Urban sprawl created the Greater Toronto Area (GTA), whose low-density communities made delivery of services harder, owing to their smaller tax base. (Benn, 2006)

In 1953, the Municipality of Metropolitan Toronto was established, "It was a federation of thirteen separate municipalities – the City of Toronto and twelve neighboring suburbs – each retaining local autonomy and responsibilities while passing over to the Metropolitan government the responsibility for major regional services" (*Toronto Transit*

Commission, 1976, p. 6). Under this new Metropolitan government was established the Toronto Transit Commission (TTC). The TTC had to purchase 4 privately owned bus lines before the consolidation of the system. 1954 marked the year that a zone fare system was introduced and the completion of the first Canadian subway, Yonge St. For the next 20 years, a massive expansion of the bus and subway network took place in order to meet the demand of the rapidly expanding suburbs, "by 1974 public transportation service was within 2,000 feet of 95% of all Metro area residents" (*Toronto Transit Commission*, 1976, p. 8).

Finally, in 1973 a single fare system was introduced for the entire metro area. The implementation of a single fare system and free transfers not only facilitated transit usage, but also reinforced the unification of the different modes of public transit: subway/RT (rapid transit), buses, and streetcars. (*Toronto Transit Commission*, 1976).

Income Group Distribution

In 2005, Toronto had the lowest median household income (C$52,833) of all the municipalities within the Greater Toronto Area (GTA). (Refer to Figure 7) (Social Policy Analysis and Research Section, Social Development Finance and Administration Division & Policy and Research Section, City Planning Division, 2008) This outwardly trend of wealthier classes can be traced back to the post World War II decades during the cultural movement of families way from cities into the suburbs. According to Ebenezer Howard, an advocate for what he dubbed the Garden City, the new community (suburbia) would offer residents the best of what the country had to offer with the technological amenities found in urban cities. (Sewell, 1993) So began the cultural migration outwards of cities across North America. As residents moved out of the city, so did traditional jobs. In the early 1900's manufacturing was the largest industry within Toronto. By 1946, 90% of manufacturing enterprises in York County were still within the City of Toronto; by 1954 this figure fell to 77%. (Benn, 2006)

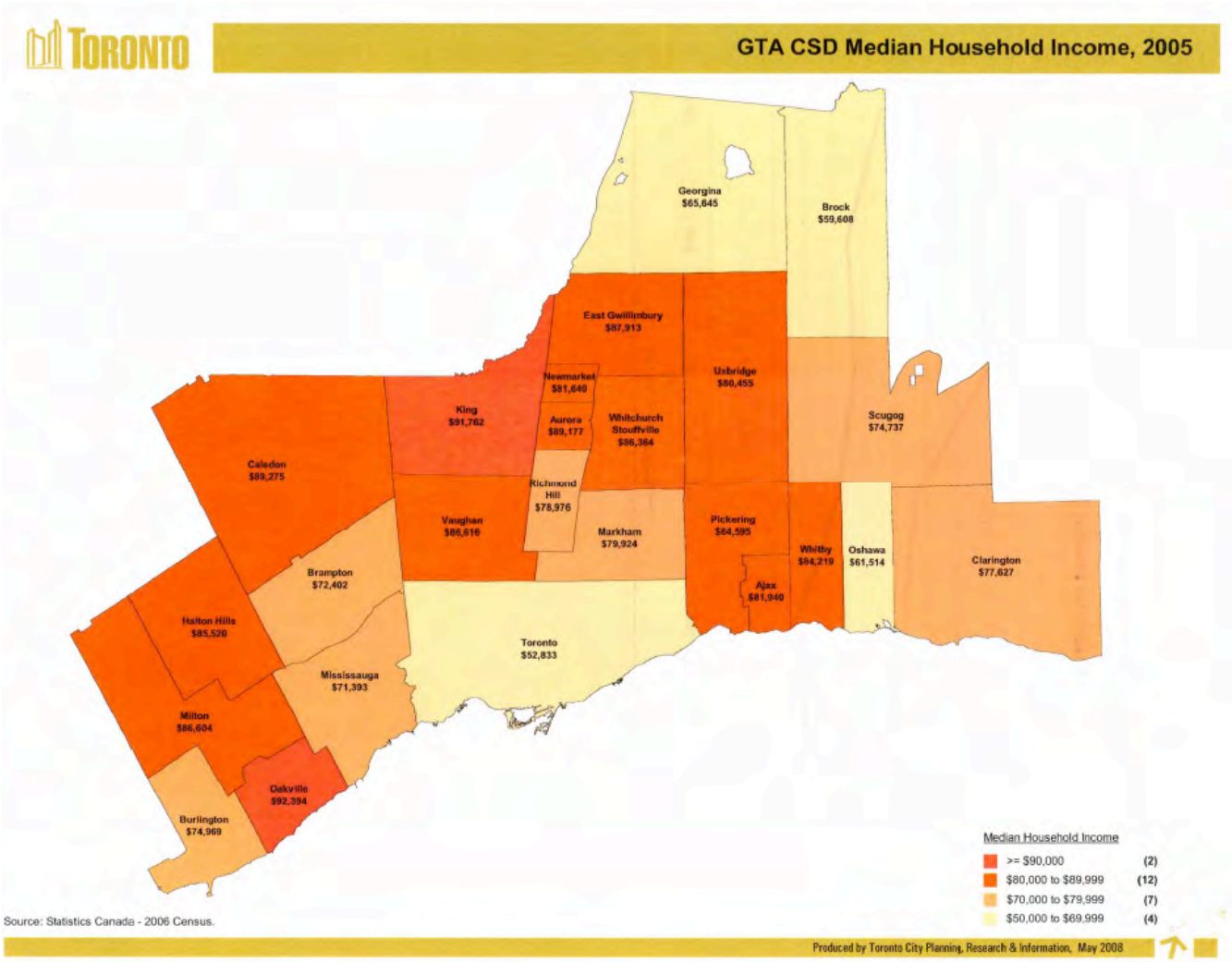

Figure 12. GTA CSD Median Household Income - 2005.
Source: Social Policy Analysis and Research Section, Social Development Finance and Administration Division & Policy and Research Section, City Planning Division, 2008.

Figure 13 shows this outward movement in development over the twentieth century. Note the ongoing movement away from the downtown core, especially evident in the post-war years depicted in blue. The most recent map shows extended development along the periphery, but it also includes the current initiative to revitalize the downtown area, particularly the Waterfront. (Benn, 2006)

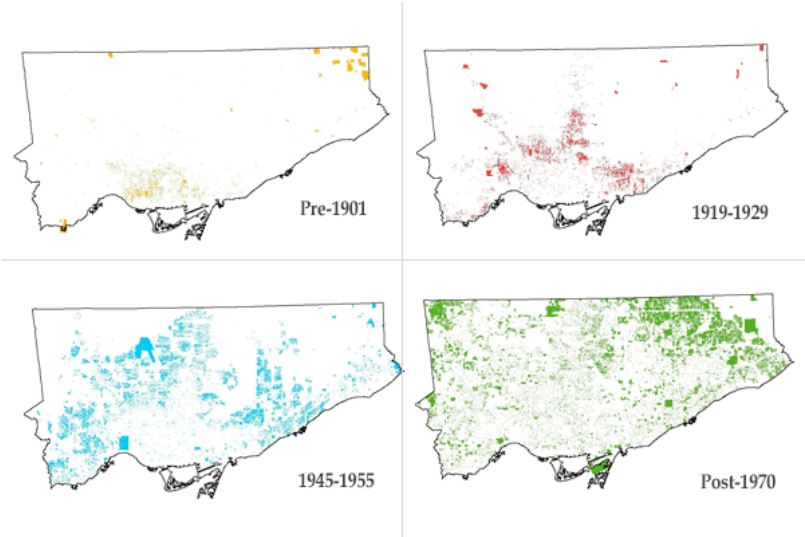

Figure 13. Construction Trends in Toronto. Source: Benn, 2006.

While the median household income was C$52,833, the average annual household income within Toronto was C$80,343. Figure 14 shows the income disparity within Toronto. There is a spike of approximately 20% of households that earn more that C$100,000, while household incomes below C$100,000 are slightly skewed leftward before falling off in the lowest income category. Figure 15 shows the centralization of the higher income levels at three distinct locations, with the highest income levels located at the city center. (Social Policy Analysis and Research Section, Social Development Finance and Administration Division & Policy and Research Section, City Planning Division, 2008)

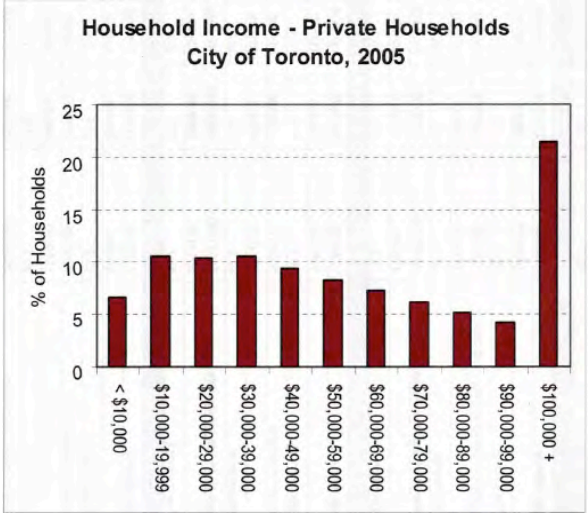

Figure 14. Percentage of Private Households in the City of Toronto by Household Income - 2005. Source: Social Policy Analysis and Research Section, Social Development Finance and Administration Division & Policy and Research Section, City Planning Division, 2008.

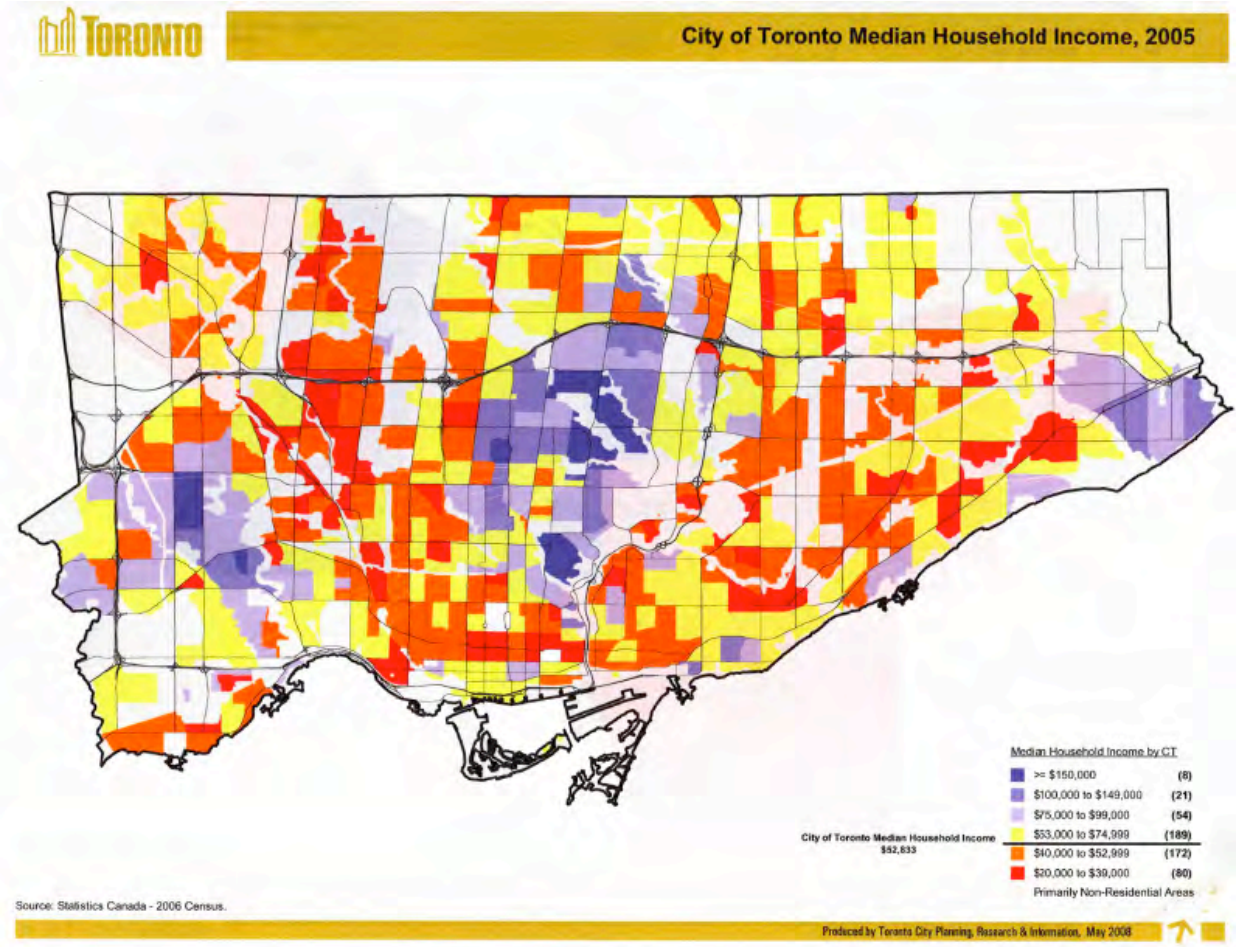

Figure 15. City of Toronto Median Household Income – 2005. Source: Social Policy Analysis and Research Section, Social Development Finance and Administration Division & Policy and Research Section, City Planning Division, 2008.

Rising poverty levels within Toronto are another point of concern. According to a report prepared by the United Way of Greater Toronto and The Canadian Council on Social Development, in 2004 the rate of family poverty was 19.4% in the City of Toronto and 12.8% in Canada. The increase in family poverty levels has also contributed to the increased number of geographically concentrated areas of poverty. The number of higher poverty neighborhoods from 1981 to 2001 increased from 30 to 120. Higher poverty neighborhoods are defined as neighborhoods in which 26.0% - 39.9% of the families have incomes below the Statisitcs Canada's Low-Income Cut-Off (LICO). Very high poverty neighborhoods are those with more than 40% of its families earning less than LICO. Figure 16 depicts the increased densification of poor families within the City of Toronto. (United Way of Greater Toronto & The Canadian Council of Social Development, 2004)

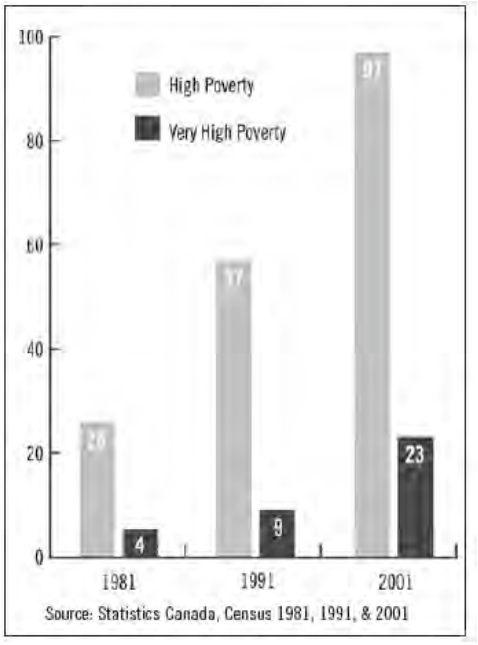

Figure 16. Number of High and Very High Poverty Neighborhoods.
Source: United Way of Greater Toronto & The Canadian Council of Social Development, 2004

Figure 17 shows the geographical growth of poverty neighborhoods over the twenty year period, 1981-2001. With the passage of time the horseshoe distribution of poor neighborhoods within the City of Toronto seems to cave in on itself, forming a centralized wealthy territory. (United Way of Greater Toronto & The Canadian Council of Social Development, 2004)

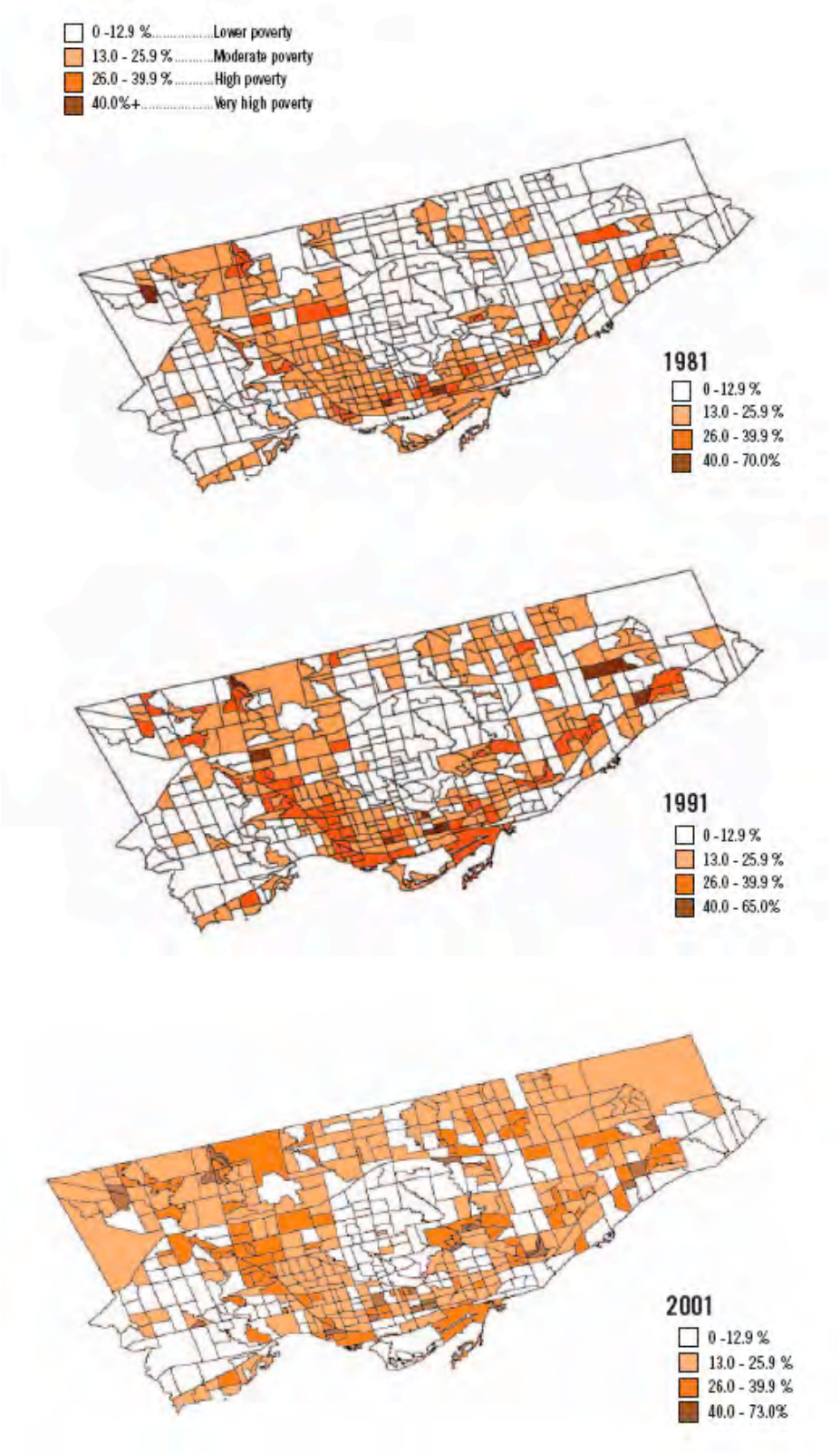

Figure 17. Geographic Distribution of Poverty Levels by Neighborhood (Census Tract)
Source: United Way of Greater Toronto & The Canadian Council of Social Development, 2004.

In 2001, thirty percent of immigrant families and of visible minority families lived in higher poverty neighborhoods in the City of Toronto. (United Way of Greater Toronto & The Canadian Council of Social Development, 2004) Tables 4 and 5 show the significant quantity of immigrant and visible minority persons residing in Toronto. Approximately half of the Census Metropolitan Area's population and the City of Toronto's population are immigrants, while visible minorities account for a bit less than half of both areas' total populations.

Table 4. Immigrants Residing in Toronto. Source: Source: Statistics Canada, n.d.

	Toronto (CMA)	Toronto (City)
Total population	5,072,075	2,476,565
Non-immigrants	2,675,590	1,184,235
Immigrants	2,320,165	1,237,720
Before 1991	1,152,045	548,410
1991 to 2000	720,185	342,345
2001 to 2006	447,925	212,595
Non-permanent residents	76,320	54,610

Table 5. Visible Minorities Residing in Toronto. Source: Statistics Canada, n.d.

	Toronto (CMA)	Toronto (City)
Total population	5,072,075	2,476,565
Total visible minority population	2,174,070	1,162,630
Chinese	486,330	283,075
South Asian	684,070	298,370
Black	352,220	208,555
Filipino	171,980	102,555
Latin American	99,295	64,855
Southeast Asian	70,215	37,495
Arab	53,430	22,485
West Asian	75,475	42,755
Korean	55,265	34,220
Japanese	19,010	11,965
Other	46,705	25,195
Multiple visible minority	60,075	31,100
Not a visible minority	2,898,005	1,313,930

Transit Mode Usages

According to an article from the CBC News, a majority of Toronto commuters rely on private automobiles to get to work. Based on the 2006 Census there were a little over 2.4 million commuters in the Census Metropolitan Area. Table 6 summarizes the modes of transportation used by commuters. 71.1% of commuters use a car, truck or van, either as the driver or passenger, to get to work, while 22.2% rely on public transit.

Table 6. Mode of Transportation to Work. Source: Statistics Canada, n.d.

	Toronto (CMA)	Percentage	Toronto (City)	Percentage
Total - modes of transportation	2,433,060	100.0	1,148,940	100.0
Car, truck or van, as driver	1,547,540	63.6	567,465	49.4
Car, truck or van, as passenger	182,440	7.5	73,145	6.4
Public transit	540,495	22.2	394,960	34.4
Walked or bicycled	140,320	5.8	101,350	8.8
All other modes	22,265	0.9	12,015	1.0

One of the primary reasons for the work commuter's high percentage of private automobile usage is due to urban sprawl. Steve Munro, a Toronto transit advocate, states, "It's an everywhere-to-everywhere kind of demand pattern, and that's very hard to serve without building quite a large network of transit lines to make everywhere-to everywhere commuting by transit possible" (CBC News, 2008). In contrast to the Census Metropolitan Area data, within the City of Toronto, 55.8% of commuters use an automobile while 34.4% of the population relies on public transit.

In 2009, the Data Management Group within the Department of Civil Engineering at the University of Canada published the *2006 Transportation Tomorrow Survey City of Toronto Summary by Wards* that categorized travel patterns and demographic characteristics of the City of Toronto. Figure 18 maps the location of the wards used for this study.

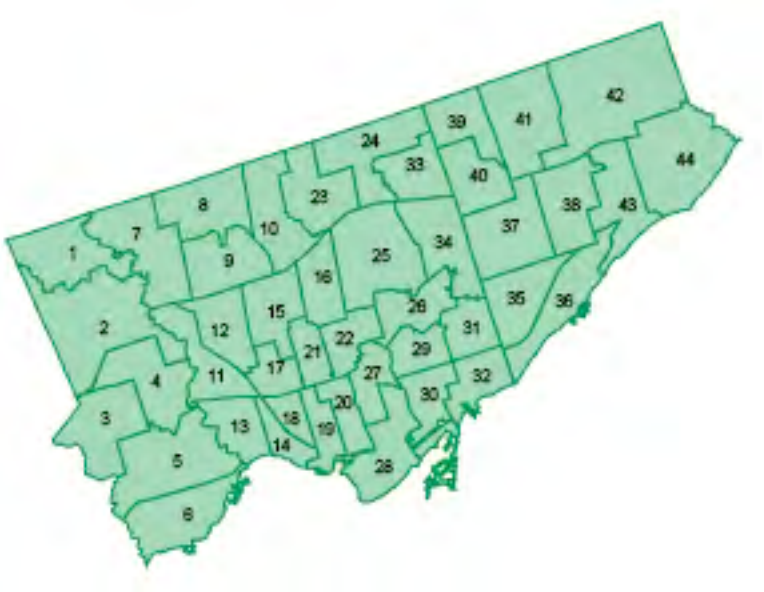

Figure 18. City of Toronto Wards.
Source: Data Management Group Department of Civil Engineering University of Toronto, 2009.

Figure 19 illustrates the different modes of travel used by each ward. The data reveal an unquestionably large reliance on the automobile as the main mode of travel. Note the green line showing the summation of the percentages for auto drivers and passengers. Local transit does, however, increase in the wards located within the downtown core, such as ward 14, 15, 17-20, 22, 28, 30, and 31, all of which had more than 30% local transit use.

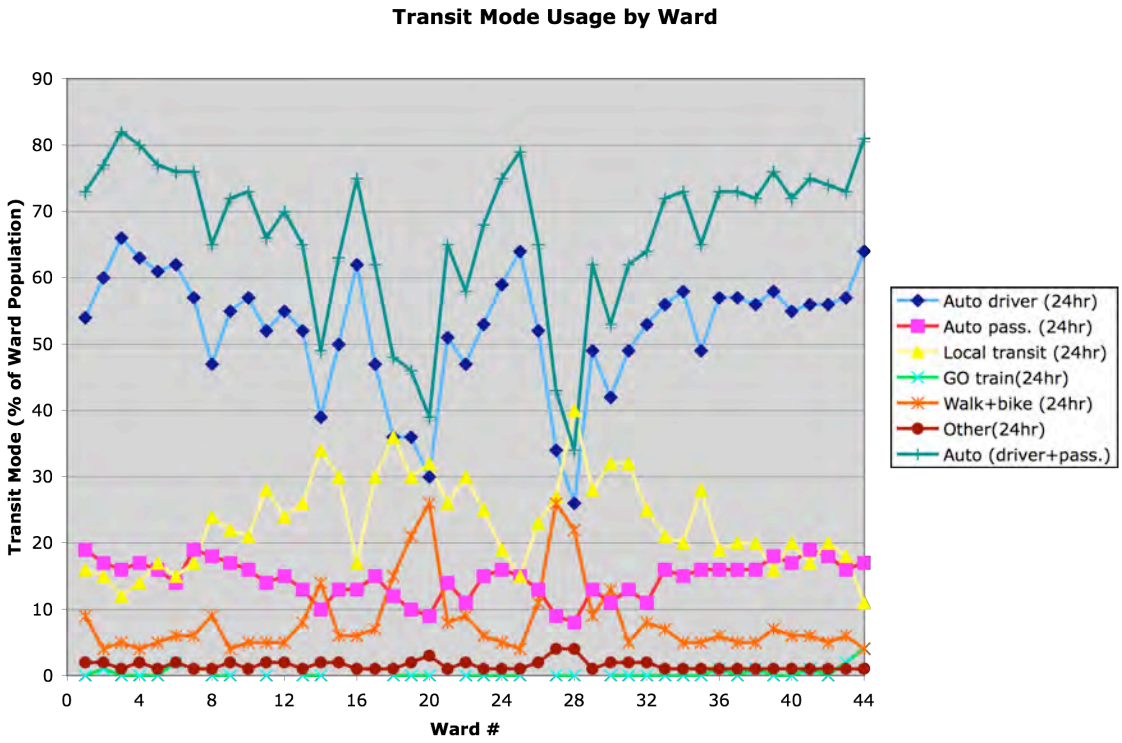

Figure 19. Transit Mode Usage by Ward – 2006.
Adapted from Data Management Group Department of Civil Engineering University of Toronto, 2009.

The next three figures 20, 21, and 22 are based on analyses of ward data from Figure 19, all the data is based on values from 2006. Figure 20 illustrates how local transit is a function of travel distance. As the median travel distance observed for local transit passengers increased, there was a decrease in the percentage of the population using local transit.

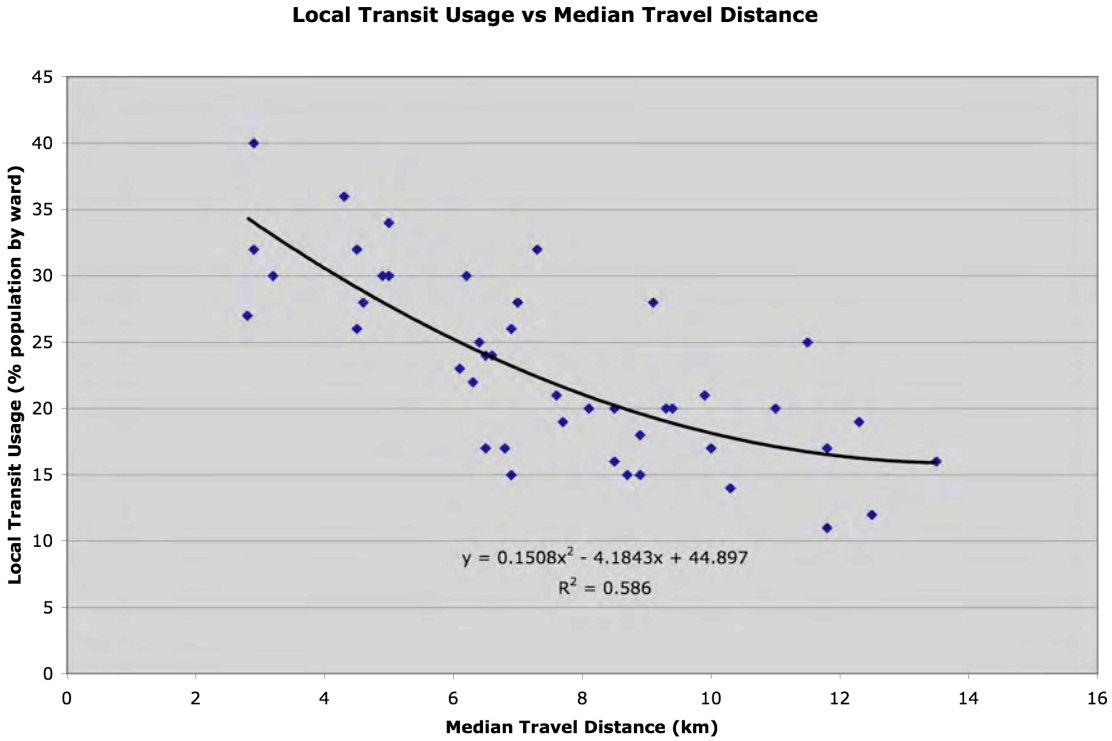

Figure 20. Local Transit Usage vs Median Travel Distance.
Adapted from Data Management Group Department of Civil Engineering University of Toronto, 2009.

Figure 21 shows the relationship between the percentage of households in a ward that own at least one vehicle to the percent of auto use both as drivers and passengers within the wards. Analysis of the data determined that for a percent increase in households with vehicles there is a 1.05% increase in the percentage of auto use.

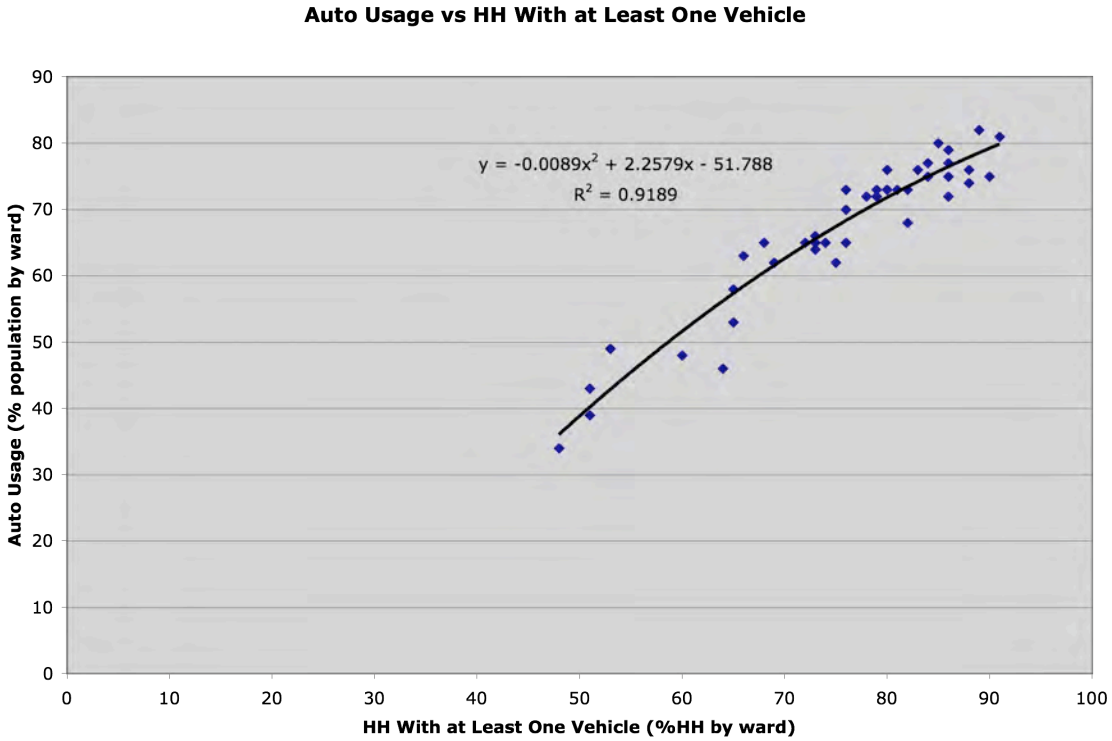

Figure 21. Auto Usage vs HH With at Least One Vehicle.
Adapted from Data Management Group Department of Civil Engineering University of Toronto, 2009.

In contrast, Figure 22, which illustrates the relationship between local transit usage and households with zero vehicles, has an average elasticity of 0.62. For a percent increase in households without vehicles, there is only a 0.62% increase in local transit. This would suggest that households without vehicles may rely to a greater extent on other forms of travel such as walking and biking which showed an increase within wards located closer to the city center, refer to Figure 19.

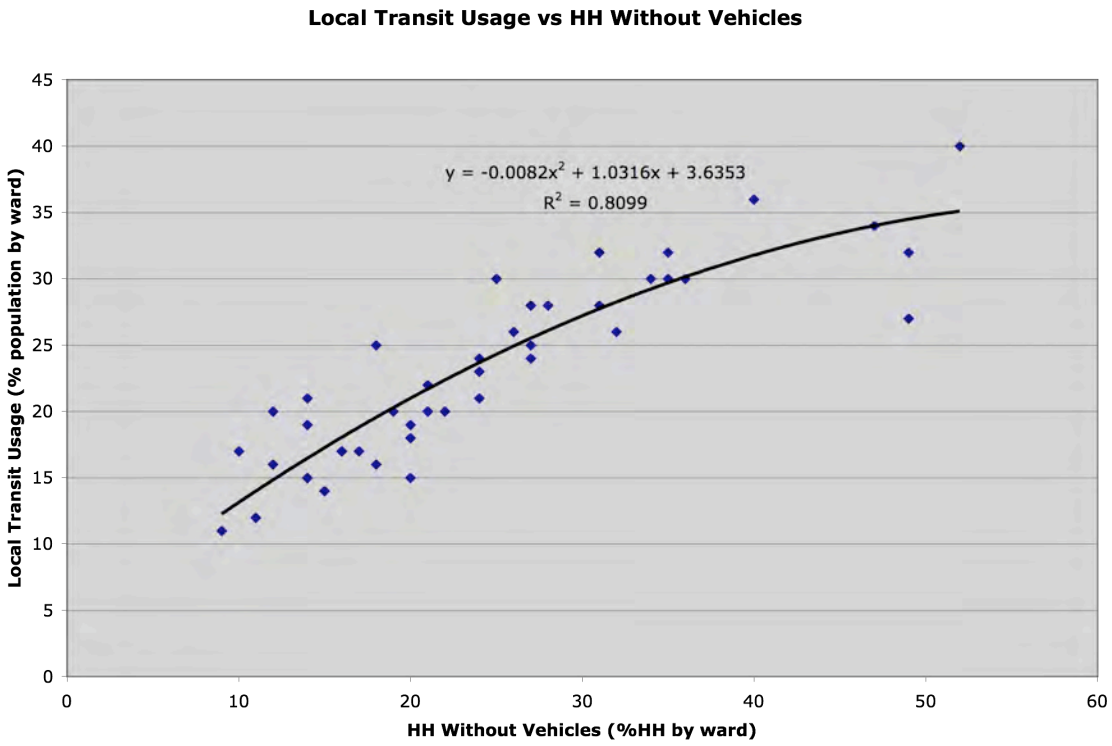

Figure 22. Local Transit Usage vs HH Without Vehicles.
Adapted from Data Management Group Department of Civil Engineering University of Toronto, 2009.

The 2006 City of Toronto Cordon Count Program tracked the mode of transportation used for inbound travel during the morning peak periods for both the City of Toronto and the central area as depicted in Figure 23.

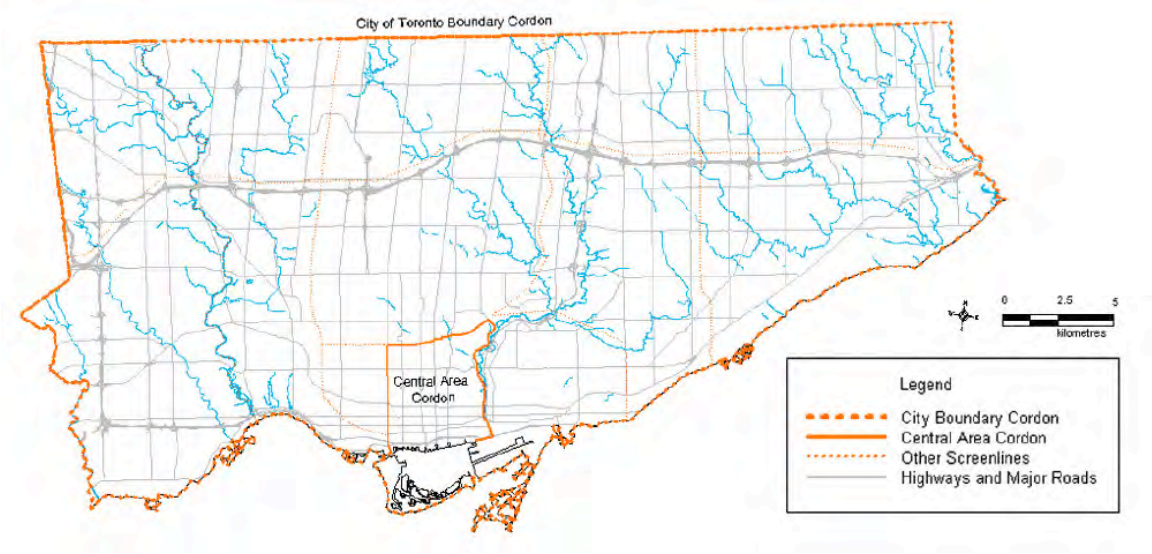

Figure 23. City of Toronto Boundary Cordon and Central Area Cordon.
Source: Toronto City Planning, 2007.

According to the study, 80.3% of inbound trips during the morning peak period (6:30am-9:30am for the City of Toronto Boundary Cordon) were made in automobiles and 66.7% in single occupant automobiles. Only approximately 20% of trips into Toronto were made using public transit. (Refer to Figure 24) In contrast, the Central Area Cordon results showed that 65.6% of inbound person trips during the morning peak period (7am-10am for the Central Area Cordon) were made using public transit. Automobiles accounted for only 34.4% of the trips, with about 25% in single occupant automobiles. (Refer to Figure 25) (Toronto City Planning, 2007)

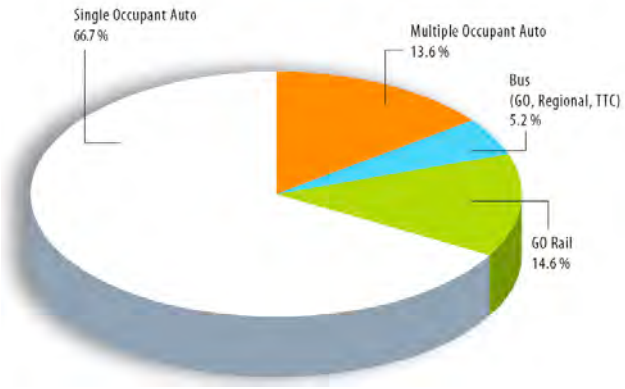

Figure 24. Inbound Person Trips by Mode of Travel for the City of Toronto Boundary Cordon in 2006. Source: Toronto City Planning, 2007.

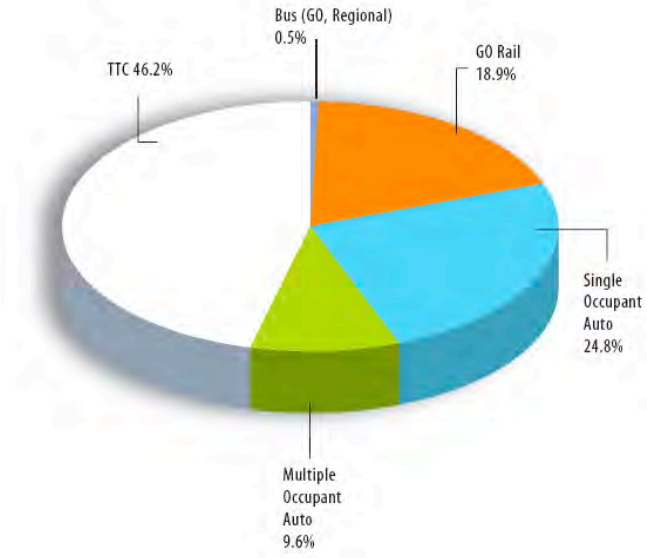

Figure 25. Inbound Person Trips by Mode of Travel for the Central Area Cordon in 2006. Source: Toronto City Planning, 2007.

Responsible for providing public transit in the City of Toronto, the Toronto Transit Commission (TTC) provides, "…more than 80% of all transit ridership in the Greater Toronto Area" (*General Information*, n.d.). The TTC consists of subway, bus, and streetcar transit alternatives. Based on an efficient and effective flat-fare structure with free transfers within and across all modes of transit, the TTC offers unlimited travel distance per trip for a fixed price. Cash fares cost C$3.00 for adults, C$2.00 for seniors or students, and C$0.75 for children. Figure 26 depicts the current and proposed extensions to the subway and streetcar routes.

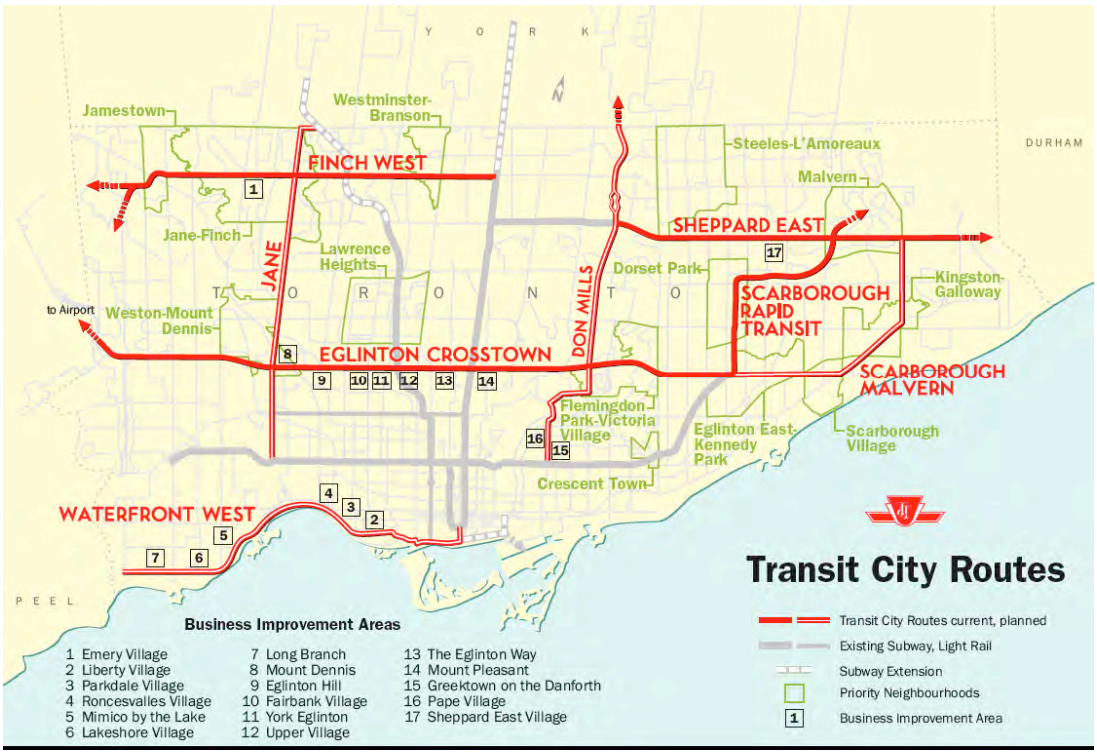

Figure 26. Toronto Subway and Streetcar Routes. Source: TTC, n.d.

Currently, the TTC network is comprised of four subway lines, 11 streetcar routes, and more than 140 bus routes. With a fleet of approximately 700 subway cars, 248 streetcars, and 1,730 buses the TTC carries an average of 1.5 million passengers per day during the week. "Almost all TTC bus and streetcar routes operate all day, every day. The density of this grid is largely unchanged for 18 operating hours per day, thus providing transit services within a 5 to 7 minute walk of most areas within Toronto" (*General Information*, n.d.). Offering such an extensive grid-based system with free transfers allows passengers to minimize travel time by using surface vehicles as collectors that feed into the high-speed subway network. TTC service runs on headways of 2 - 20 minutes depending on mode and hour. Figure 27 shows a streetcar alongside traffic.

Figure 27. Toronto Streetcar. Source: Author, 2009.

Finally, a specialized door-to-door service, Wheel-Trans, for passengers with significant disabilities is comprised of 135 fully accessible buses as well as regular taxis. This service accounts for about 5,000 trips per day during the week and requires that trips be booked one day in advance. (*General Information*, n.d.)

Comparative Analysis

Scale

The Distrito Federal (DF) occupies an area of 5,789 square kilometers and is home to a population of approximately 2.4 million persons (2007). (Peixoto & Soares, 2008) Similarly, according to Statistics Canada (n.d.), the City of Toronto has a population of approximately 2.5 million persons (2006), but a land area of 630 square kilometers. While the DF has a significantly larger land area, most of its residents reside in the urban centers of each Administrative Region. More interesting, however, is the similarity regarding population.

From discussion in preceding sections, it is apparent that the Toronto Transit Commission's network is a more multimodal system than the DF's public transit network. In 2008, the public transit fleet in the DF was comprised of 2,337 conventional buses serving 888 routes, 55 microbuses serving 11 routes, 350 microbuses serving 89 circular routes, 74 rural buses serving 65 routes, 664 vans serving 37 routes, and 20 subway trains serving two lines. (*Tipos de Transporte*, 2008) The TTC network is comprised of 700 subway cars serving four subway lines, 248 streetcars serving 11 streetcar routes, and 1,730 buses serving more than 140 bus routes. (*General Information*, n.d.)

Although, the DF network has a significantly larger fleet of buses, the excessive quantity of routes leads to low frequencies which in turn results in long waiting times. In contrast, the 1,730 buses in the TTC service a fraction of the routes offered by the Brazilian counterpart allowing for higher frequencies.

Another key characteristic of the TTC network is that it is located in a higher population density environment than Brasília. Within the City of Toronto, the population density equals 3,972.4 persons per square kilometer. (Statistics Canada, n.d.) Toronto's public transit usage does, however, decreases as one moves outward from the downtown as population densities decrease in the suburbs. Brasília, on the other hand, has a population density of 441.8 persons per square kilometer. (Peixoto, Soares, & Silva, 2007) Areas of

higher population densities allow for closer spaced transit stations that allow for easy pedestrian access. By offering two surface transit alternatives, namely streetcars and buses, the TTC can offer services efficient service to faster and higher capacity modes of transit, namely subways and rapid transit lines. Within Brasília, the monumental scale dwarfs the pedestrian who becomes discouraged to walk long distances on seemingly never ending sidewalks without shade.

Cost

In today's urban environments, transportation is a basic necessity just like food, shelter, and health. Transportation ensures that people can get to and from work and have access to different parts of the city for leisure activities. In the same way as other basic needs, the cost of transportation is regressive. The cost of public transit has a far greater impact on low-income individuals as it limits the amount of income left over for other basic necessities. Under the Brazilian Constitution, employers are required to pay for transportation costs that exceed 6% of an individual's salary; this private subsidy is called the "vale-transporte". The "vale-transporte", however, only applies to registered employees. Undocumented individuals in the informal job market, generally lower income workers, are not entitled to the benefit. (Da Silva, 2007) Another issue that arises from the "vale-transporte" is that employers place preference on candidates who live closer to the job location or require fewer transfers. Therefore, low-income individuals who generally reside farther out in the periphery where real estate prices are lower have a disadvantage when searching for job opportunities.

Currently, fares are not transferable in the DF. Each time somebody changes buses or modes of travel, a new fare purchase is required. Also, fares are priced based on distance in relation to Brasília's central bus terminal. Bus fares range from R$1.50 for circular routes within the Plano Piloto and satellite cities to R$3.00 for routes connecting further satellite cities to the Plano Piloto. Metro fares, on the other hand, are a fixed rate of R$3.00 during the week and R$2.00 during weekends and holidays. While only 9.5% of the population resides in Brasília, it concentrates approximately 45% of the job opportunities in the DF. Therefore, individuals with the lowest incomes who must use the public transit network are forced to pay the highest fares. As for the bus network, the excessive number of companies representing different proportions of the market leads to a competitive struggle for passengers and routes, without fare transfer.

In contrast, Toronto's transit history has been a long story of continuing unification, especially since all public transit modes became the sole responsibility of the Toronto Transit Commission. This allowed for the adoption of a flat rate fare system that does

not segregate individuals based on residence location or number of transfers. Instead, offering such an extensive grid-based system with free transfers allows passengers to minimize travel time by using surface vehicles as collectors that feed into the high-speed subway network. Furthermore, offering a fare, which is not distance dependent, also encourages car owners who live further from the downtown core to consider public transit.

Land Use Planning

Forty five percent of the job opportunities in the DF are located in Brasília, the next highest job concentrations are 10.71% and 9.03% that are located in Taguatinga and Guará, respectively. Furthermore, the adjacent cities of Taguatinga, Ceilândia, and Samambaia account for approximately 40% of the population and 30% of the commercial and service establishments. (Peixoto & Soares, 2008) This centralization of the population and job locations coupled with strict single use zoning within Brasília is conducive to Bus Rapid Transit corridors. Currently, buses run in mixed traffic without busways to facilitate service and mobility. However, designs for new express bus corridors connecting the satellite cities with Brasília are already underway.

Toronto presents a different problem with respect to land use. Due to continued urban sprawl and the suburbanization outside of the downtown core, travel patterns are no longer as centralized towards the city center as before. This everywhere-to-everywhere demand pattern in the suburbs makes it difficult to provide a competitive public transit alternative to the private automobile. In contrast to the Census Metropolitan Area where 71.1% of commuters rely on the automobile and 22.2% use public transit, within the City of Toronto 55.8% of commuters use an automobile, while 34.4% of the population relies on public transit.

Conclusion

Cities are the nucleus for human development, a melting pot of the world's population. They are the engines of the modern economy and generally home to a wide array of income levels. Population mobility is a key measure that can help ensure social equity within the context of income disparity, which may lead to adverse conditions such as spatial segregation, the inability to have unhindered access throughout the city for both work and leisure. Therefore, within the city environment, transportation becomes a basic need. It offers residents access to essential services such as work and to leisure activities.

As described in this report, public transit is a solution to mitigate spatial segregation. However, as shown by both case studies, certain characteristics of transportation networks can intensify spatial segregation.

Brasília demonstrates the issues associated with designing a city centered around one transportation mode, the automobile. Brasília exemplifies a mid-nineteenth century utopian garden city. While the monumental scale of green open space improves the city's aesthetic, it has a negative effect on pedestrian mobility. The creation of satellite cities connected to Brasília by a network of highways led to the push of lower income families towards the peripheries under the erroneous pretext that they would be able to drive to work. Instead, this led to a thinly spread public transit system. Furthermore, high concentrations of jobs within Brasília, force lower income residents to rely on public transit in order to overcome spatial segregation. However, distance based fares without transfers place significant strain on low-income classes. Those who most need and most rely on public transit must pay the most to use it. On the other hand, Brasília's centralization of activities and large spaces allow for the implementation of rapid bus corridors and the installation of light rail vehicles within the current urban context, improvements that are beginning to take place.

The public transit network in Toronto has various characteristics that help increase population mobility. Having an integrated multimodal transit system that reaches passengers at various scales is crucial. Most important is the flat rate, free transfer

system that does not segregate groups based on where they live. The system allows users to efficiently take advantage of the transit system by using streetcars and buses to access high-speed subways for longer trips. Toronto does, however, present a problem in terms of urban sprawl. Suburbanization makes it increasingly difficult to provide efficient and effective public transit the further one moves away from the City of Toronto.

In conclusion, to improve the sustainability of the public transit system and mitigate spatial segregation, Brasília should consider changing its distance-based fee structure to a flat fee similar to Toronto, in addition to implementing planned infrastructure expansion and improvements. Toronto, in turn, should consider how its transit system could benefit from implementing policies that limit urban sprawl and favor increasing concentration of suburban and city center populations.

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Academic Vita
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EDUCATION

The Pennsylvania State University - University Park, PA **2006-2010**
Schreyer Honors College Scholar
Bachelor of Science in Civil Engineering
Minor: Architecture Studies
Honors: Interdisciplinary honors in Civil and Environmental Engineering and Architecture
Thesis Title: Comparative Analysis of How Public Transit Affects Spatial Segregation in Brasilia, Brazil and Toronto, Canada
Thesis Supervisors: Venkataraman Shankar, Associate Professor of Civil Engineering
Madis Pihlak, Associate Professor of Architecture and Landscape Architecture

AWARDS

Frank Holzer Memorial Scholarship **2009-2010**
Department of Civil and Environmental Engineering

Excellence in Transportation Engineering **2009-2010**
Department of Civil and Environmental Engineering

Second Year Certificate of Excellence **Fall 2007**
Annual Corbelletti Design Charette Competition
Department of Architecture

PROFESSIONAL MEMBERSHIPS

Chi Epsilon Civil Engineering Honor Society **Fall 2008**
American Society of Civil Engineers **Spring 2008**

WORK EXPERIENCE

Tussey Mountain Ski School – Boalsburg, PA **Winter 2008/2009 – 2009/2010**
Title: Part-time Ski Instructor and Staff Trainer

- Level II certified by Professional Ski Instructors of America (PSIA).
- Taught intermediate and advanced ski lessons to Penn State Kinesiology classes.
- Taught beginner through advanced ski lessons to school groups and general public.

ALTRAN TCBR - Brasília, D.F., Brazil **12 weeks, Summer 2009**
Title: Civil Engineering Intern

- Participated in team development of the operational studies database for the Collective Transit System of Brazil's capital city.
- Mapped and analyzed the bus schedule network within Brasília's Executive Plan for Urban Transportation.
- Conducted demand and frequency analysis of Brasília's bus rapid transit system.

Pennsylvania Transportation Institute - University Park, PA **8 weeks, Summer 2008**
Title: Research Assistant

- Revised the first volume of the report *Methods to Maintain Pavement Marking Retroreflectivity*, prepared for the Federal Highway Administration.
- Collected data for a study on the effects of on-premise sign lighting level on nighttime sign legibility and traffic safety.
- Reviewed video for PennDOT's evaluation of striped vertical panels in temporary traffic control zones.

Ted Moudis Associates - New York, NY **4 weeks, Summer 2005**
Title: Architecture Intern

- Participated in the daily operations of an architecture & interior design firm.
- Rotated weekly among project teams, each with its own clients and conditions.
- Worked on red lines, millwork details, sketches, surveys, and doing library research.

ACTIVITIES

Penn State Concrete Canoe Team, *Member* **Fall 2008 – Spring 2009**
Penn State Course CE 360: Fluid Mechanics, *Grader* **Fall 2008**

COMMUNITY SERVICE INVOLVEMENT

St. John's Episcopal Church, *Parishioner and Volunteer* **2002-Present**
Habitat for Humanity, *ASCE Volunteer* **Fall 2008**
Yestermorrow Design/Build School - Warren, VT **Summer 2005**

- Completed the Community Design/Build course that produced a kiosk/ shelter for cross country skiers and bird watchers.

INTERNATIONAL EDUCATION

Tuscan Classical Academy - Capitignano, Italy **Summer 2007**

- Developed watercolor field sketching and an architectural analytique using watercolor washes for 3 credit course credit.

LANGUAGE PROFICIENCY

Fluent in English and Portuguese