UTTRI

Research Report

Vehicle for Hire Bylaw Review

Report 3:

Taxi Time-Series Analysis

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April 2019

UTTRI TECHNICAL SUPPORT FOR THE CITY OF TORONTO VEHICLE FOR HIRE BYLAW REVIEW

Report No: 3

Taxi Time-Series Analysis

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April, 2019

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UTTRI

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1. INTRODUCTION

This technical report presents the work undertaken in support of the City of Toronto's *Vehicle for Hire Bylaw Review* by the University of Toronto Transportation Research Institute (UTTRI) to analyze the patterns in taxi usage over a 20-year period as recorded in the five most recent Transportation Tomorrow Surveys (TTSs): 1996 TTS; 2001 TTS; 2006 TTS; 2011 TTS; and 2016 TTS.

The trip records in the TTS data have socioeconomic attributes of trip-makers (e.g., age, sex, etc.), their household characteristics (household size, number of vehicles owned, etc.) and trip attributes attached (Data Management Group – Reports, n.d.). They therefore provide a statistically representative description of taxi-users and their reasons for travel along with the spatiotemporal attributes of the trips. Previous studies have shown that the profiles of Uber-users and taxi-users are considerably different (Habib, 2019; Ozonder and Miller, 2019). Thus, the purpose of this study as documented in this report is to identify changes or stabilities in the taxi-user group and their trip patterns by comparing various distributions through a longitudinal analysis.

This report is one of a series of project reports by the UTTRI team. It complements Report No. 1 (which examined PTC usage as reported in the 2016 TTS) and Report No. 2 (which compared PTC usage as reported in the 2016 TTS with the VfH PTC data). The rest of the report is organized as follows. Section 2 reports the results of taxi time-series analysis in three parts: in the first part, it discusses the attributes of trip-makers; in the second part, it compares distributions in household attributes over the years; in the third part, it explains the analysis results of the trip patterns. Section 3 concludes the report with a summary of findings.

2. TAXI TIME-SERIES ANALYSIS

This section presents the results and discusses the outcomes of a time-series analysis of taxi-trips, associated trip-makers and their household characteristics.

Table 1 shows the number of sampled taxi trip-makers in each survey year and the number of households along with the total number of taxi trips made in each year[1].

Table 1. Taxi Sample Totals

Year:	TTS1996	TTS2001	TTS2006	TTS2011	TTS2016
Households	1,682	2,198	2,138	1,962	1,889
Individuals	1,912	2,501	2,488	2,300	2,175
Trips	2,767	3,569	3,661	3,297	3,088

2.1. Attributes of Taxi Trip-Makers

This section focusses on the attributes of taxi trip-makers.

[1] The analyses are conducted using unweighted individual, household and trip numbers.

Figure 1 shows a stacked bar chart of the respondent versus non-respondent shares among individuals who made a taxi trip. Usually, there is only one individual from each household who is designated as the respondent, as the survey is completed through a single person if it is a phone-survey. It can be seen that the shares remain relatively stable over time, around 60% of the individuals are the respondents in the survey in each year.

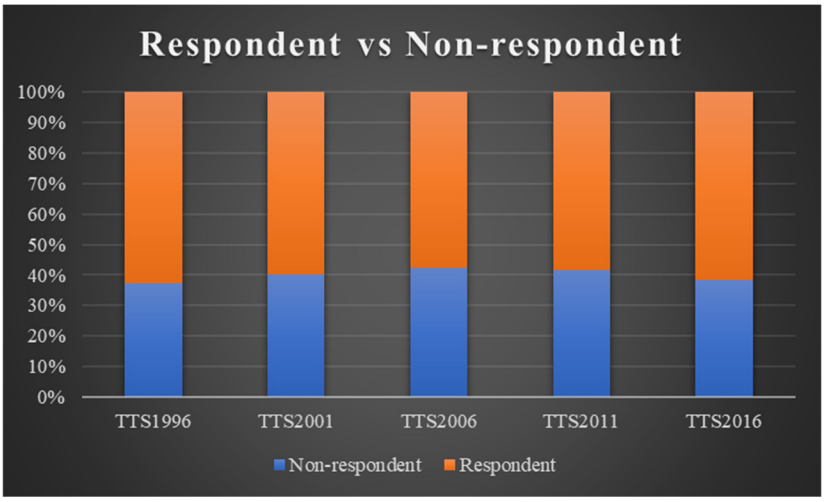

Figure 1. Respondent vs Non-respondent

Age distributions of the individuals are shown in Figure 2. Despite the peaks observed around age 25 in the 1996 and 2001 TTS, the distributions are denser after the age of 40 for taxi trip-making population, i.e., more than 60% of the trip-makers are older than 40 in the most recent three surveys.

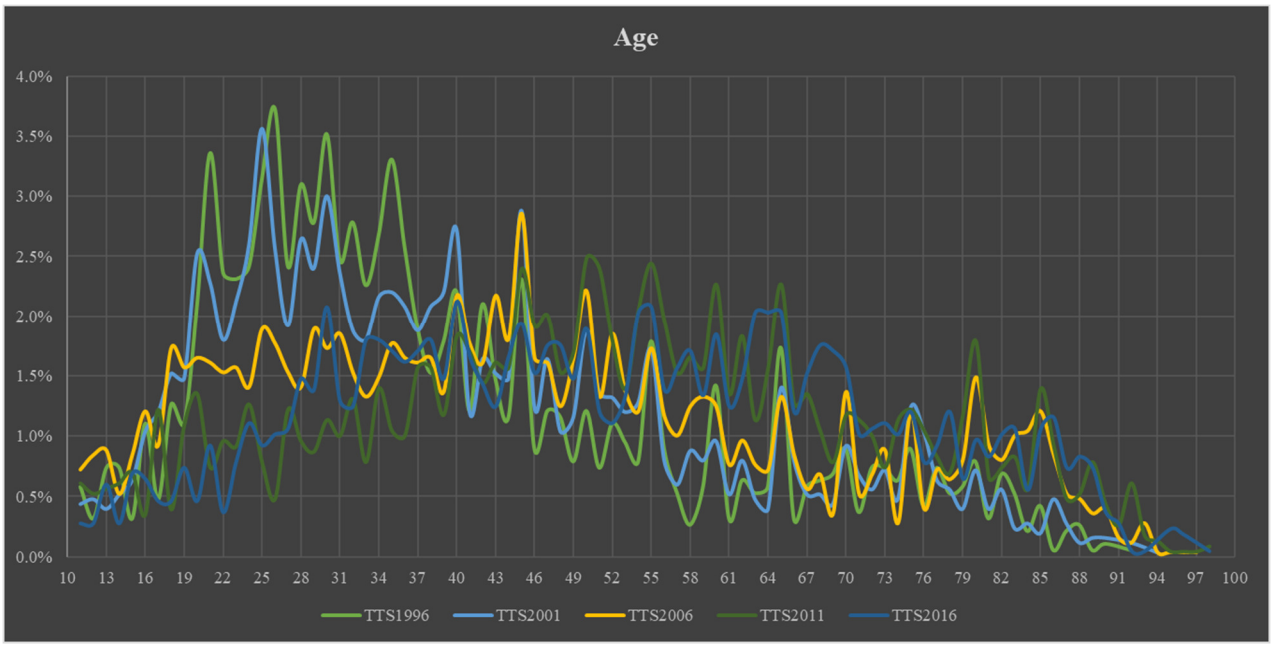

Figure 2. Age Distributions

Figure 3 shows the female and male ratios. It is observed that in all five survey years, around 60% of the taxi trip-makers are female and 40% are male.

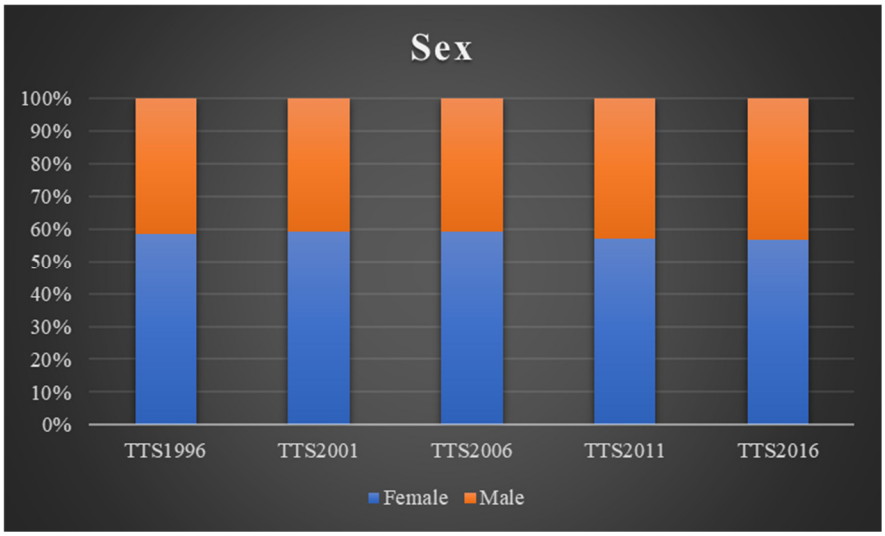

Figure 3. Sex Distributions

Four employment categories are defined in the TTS (Ashby, 2018). These are full-time workers outside the home, part-time workers outside the home, full-time workers at home, part-time workers at home. When the employment status distributions of trip-makers are plotted including the unemployed individuals, it can be seen that more than 40% work outside the home full-time, whereas 30%-40% of the individuals are unemployed in each year. The share of part-time workers who work outside the home ranges between 7% and 11%. It is seen that the ratio of individuals who work at home, either full-time or part-time, is considerably low in all five years. Even though there are slight fluctuations in ratios over time, aggregate distributions are quite similar.

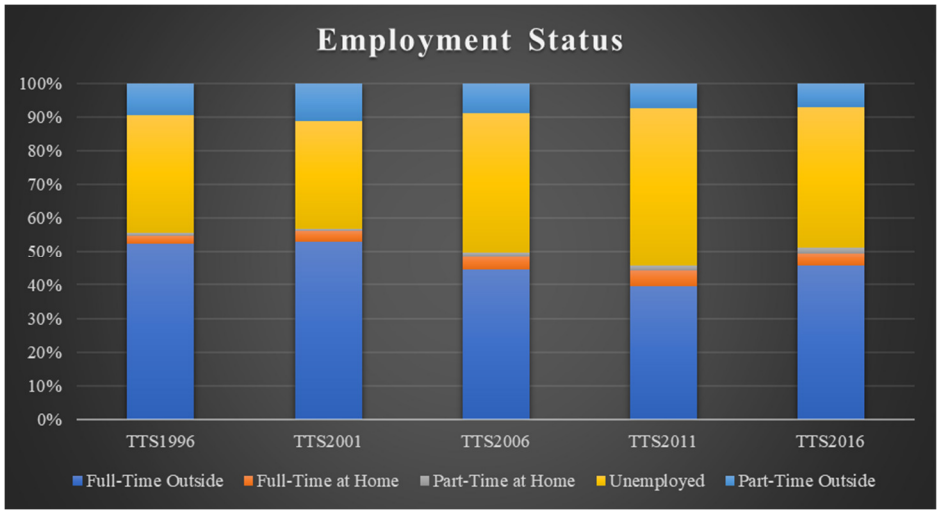

Figure 4. Employment Status Distributions

There are four occupational categories defined in the TTS (Ashby, 2018): general office / clerical (sector "G"), manufacturing / construction / trades (sector "M"), professional / management / technical (sector "P"), retail sales and service (sector "S"). The occupational distributions of individuals are shown in Figure 8, where "O" category represents the unemployed individuals. Similar to the employment distributions, despite small differences in shares, aggregate distributions display similar patterns. Sector "P" employees are dominant in all samples, followed by Sector "S" employees. The ratio of individuals who work in Sector "M" remains small over time.

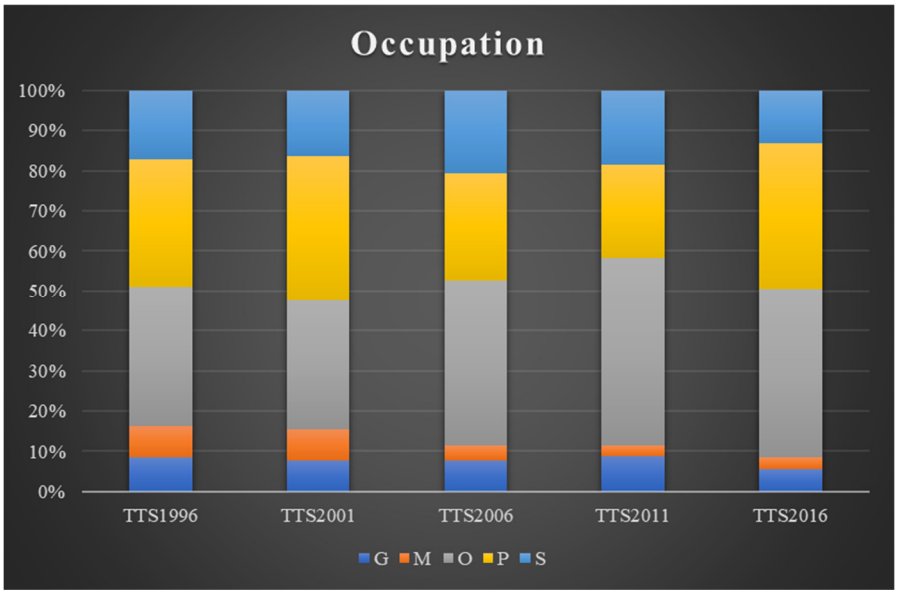

Figure 5. Occupation Distributions

Taxi trip-makers tend to be non-students (refer to Figure 6), as was observed in Report No. 1 (Ozonder and Miller, 2019). It is observed that it is very unlikely that part-time students make taxi trips, which might be correlated with their income/allowance.

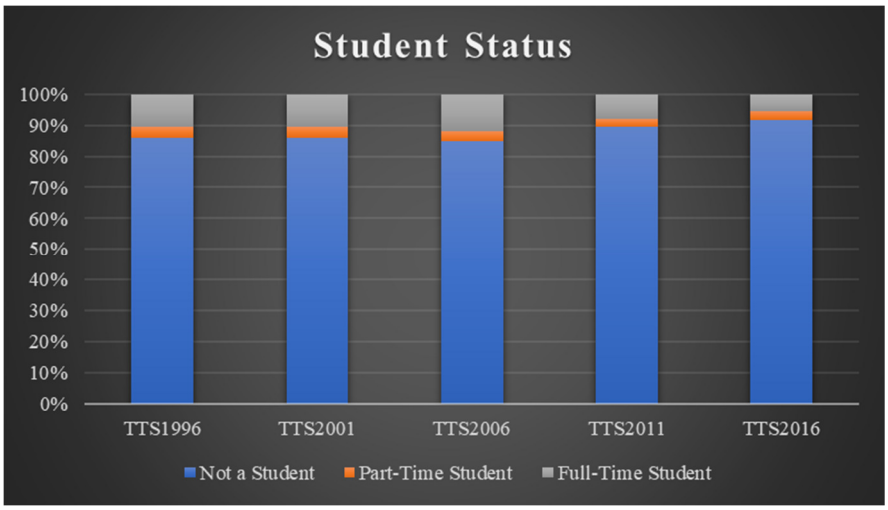

Figure 6. Student Status Distributions

Driver's license ownership distributions are presented in Figure 7. As observed in the previous distributions regarding various individual attributes, there is strong stability in the ratios. 40% of taxi trip-makers do not own a driver's license.

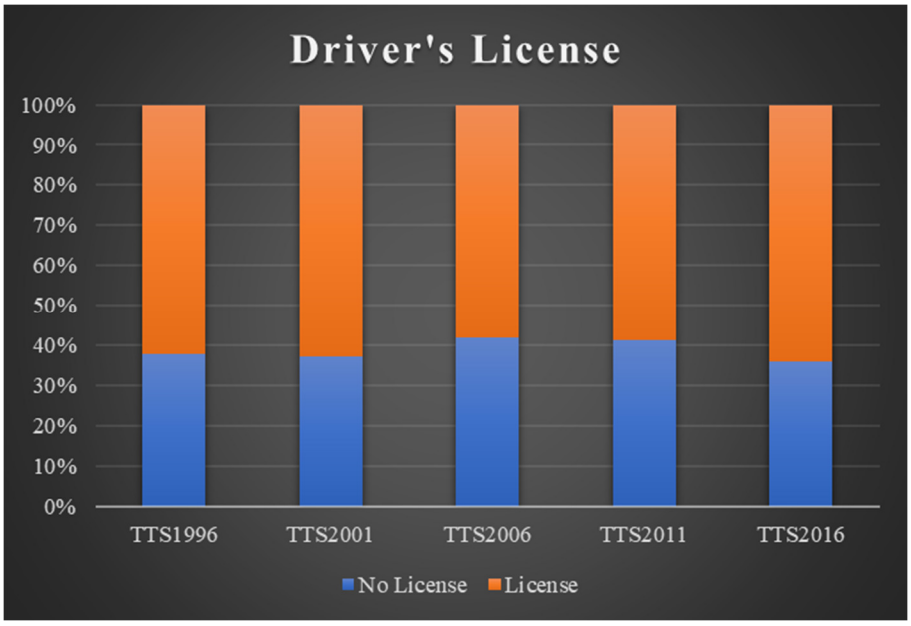

Figure 7. Driver's License Ownership Distributions

The majority of trip-makers do not own a transit pass. However, the ratio of transit pass ownership increases over the years, from 10% in the 1996 TTS to 31% in the 2016 TTS, with a considerable jump from the 2011 TTS to the 2016 TTS.

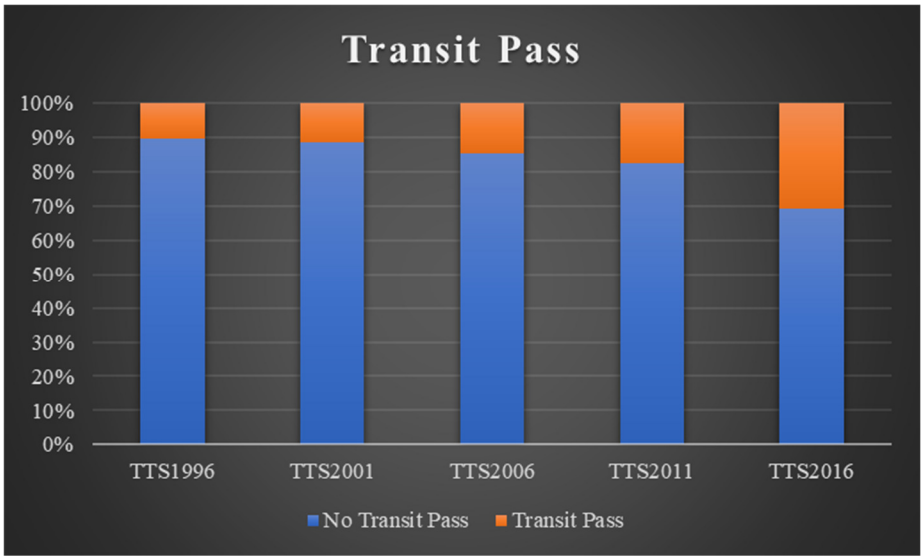

Figure 8. Transit Pass Ownership Distributions

2.2. Household Characteristics

In this section, the changes or stabilities in the distributions of several attributes pertaining to the households of the individuals who reported a taxi trip in the survey are analyzed.

In the 2011 and the 2016 TTSs, there were two methods available to complete the survey: landline phone and online. The surveys before 2011 were conducted completed through landline phone. Survey method distributions are shown in Figure 9, where the number of households that filled the survey online increases significantly in the 2016 TTS. However, it should be noted that this observation holds for the complete survey population, it does not indicate behavioural changes specific to taxi trip-makers.

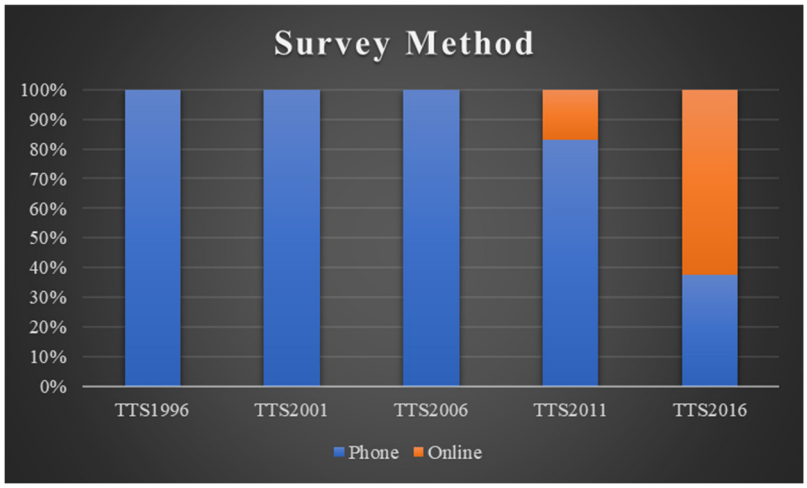

Figure 9. Survey Method Distributions

The household size distributions do not seem to change over the years (refer to Figure 10). The majority of individuals are from two-person households. In each year, the ratio of individuals who live alone is also high when compared to the other household sizes. The shares decrease with an increase in the household size after two-person households in all five years.

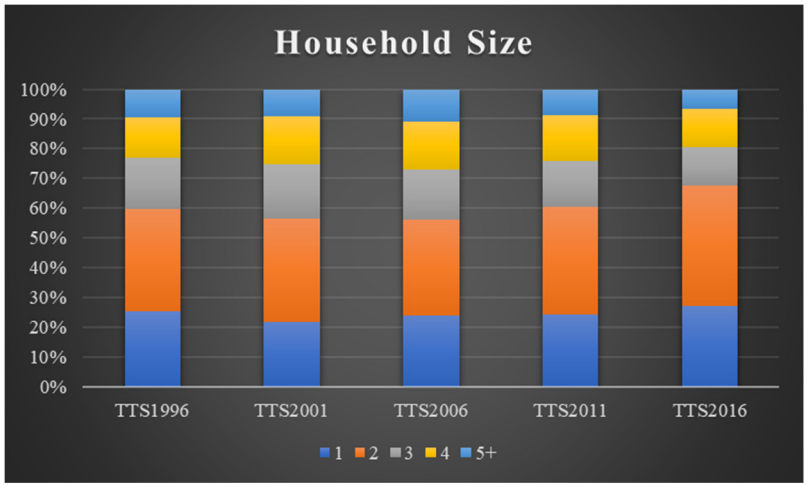

Figure 10. Household Size Distributions

When the dwelling type distributions are analyzed it can be seen that the ratios of households residing in townhouses is quite low in all the years (refer to Figure 11). The percentage of households residing in a house is higher than the percentage of households residing in an apartment, except in the 2016 TTS.

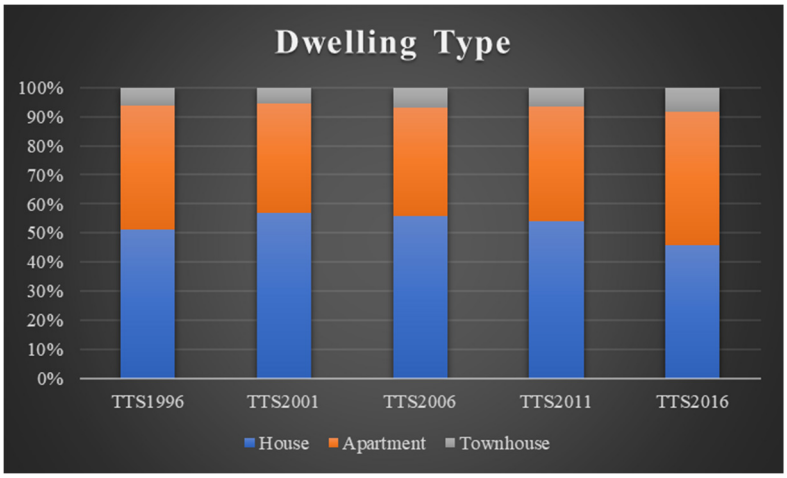

Figure 11. Dwelling Type Distributions

Figure 12 shows the distributions of residential location of households at a Planning District (PD) level (refer to Figure 35 for the PD labels) within the City of Toronto. Although the survey area covers the Greater Toronto and Hamilton Area (GTHA), for the current purposes only the residential location distribution within the City is shown. In all the years, PD1, i.e., downtown Toronto, remains the dominant residential location. However, the shares of the neighbouring PDs (e.g., PD2, PD3, PD4, PD6) are also high.

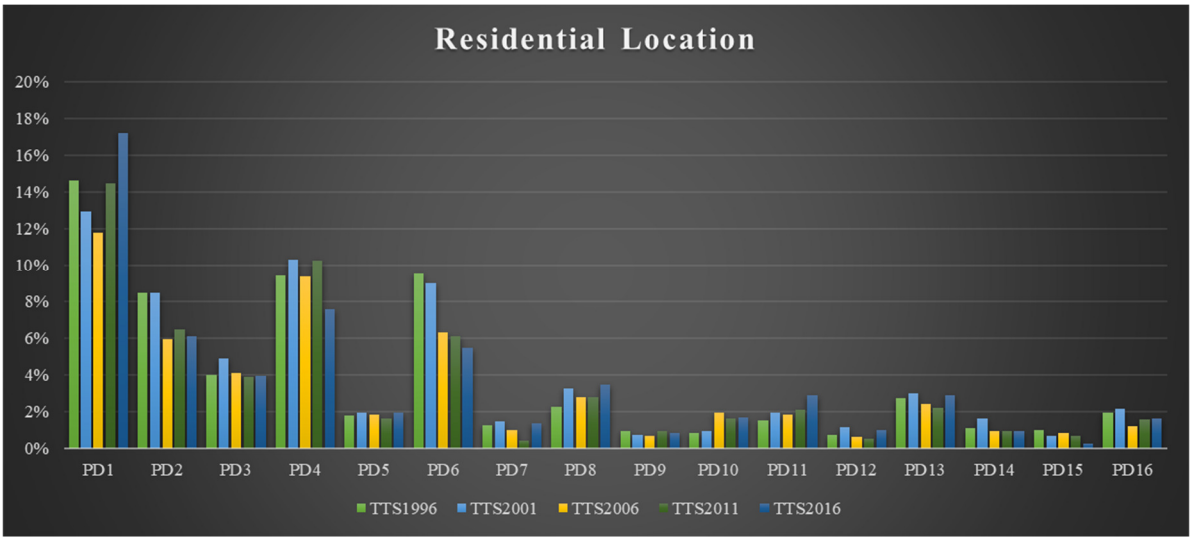

Figure 12. Residential Location Distributions within the City of Toronto

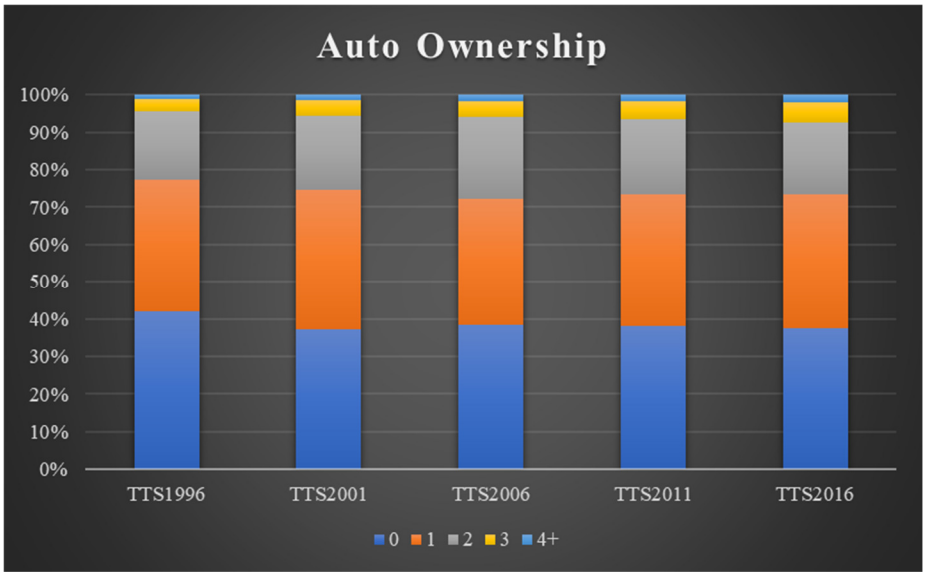

Figure 13. Auto Ownership Distributions

The distributions of auto ownership levels are shown in Figure 13. The percentages decrease as one goes from no vehicle to one vehicle and then to more vehicles owned by the household, in all five years, except 2001, where no vehicle percentage and a single vehicle percentage are almost equal. Nevertheless, it is observed that the distribution remains stable over time.

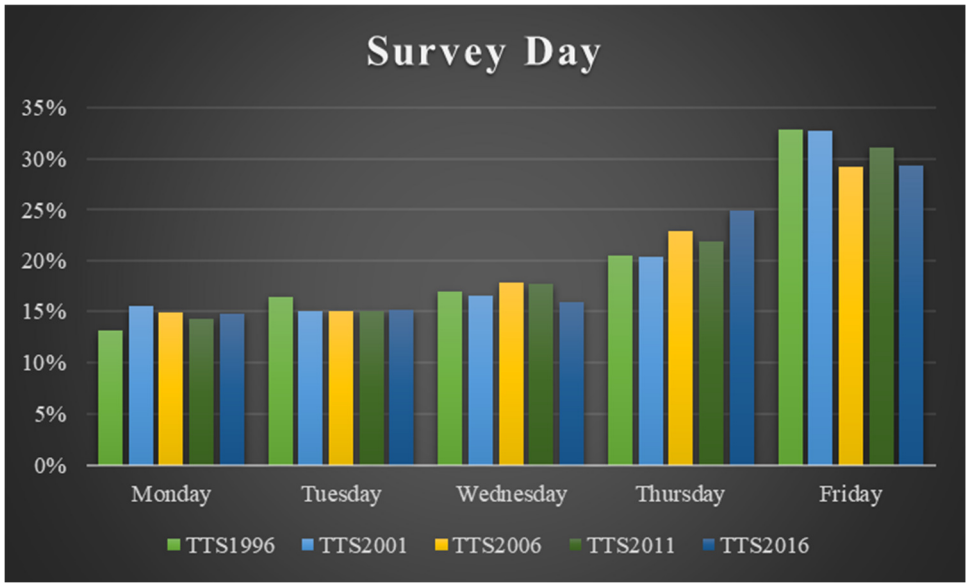

Figure 14. Survey Day Distributions

Survey day distributions are shown in Figure 14. It should be noted that "survey day" does not refer to the day the survey was conducted/completed, rather it refers to the travel day for which respondents have completed their questionnaires. In general, there seems to be an increasing trend from Monday to Friday throughout the 20-year period.

2.3. Trips

In this section, trip patterns over the years are analyzed.

Figure 15 shows the mode shares in the five survey years included in this analysis considering all the trips reported, where significantly strong stability is observed. In each survey year, the auto drive mode, which includes motorcycling, is the dominant choice of trip-makers (65% on average). Auto passenger mode has the second largest share in each year (16% on average). Local transit mode has the third largest share, again in all years, and the average share is 10%. Mode share of taxi remains quite small over time (less than 1%), and hence, the distribution of taxi mode share is shown separately in Figure 16, where the value remains relatively stable over time, around 0.4%.

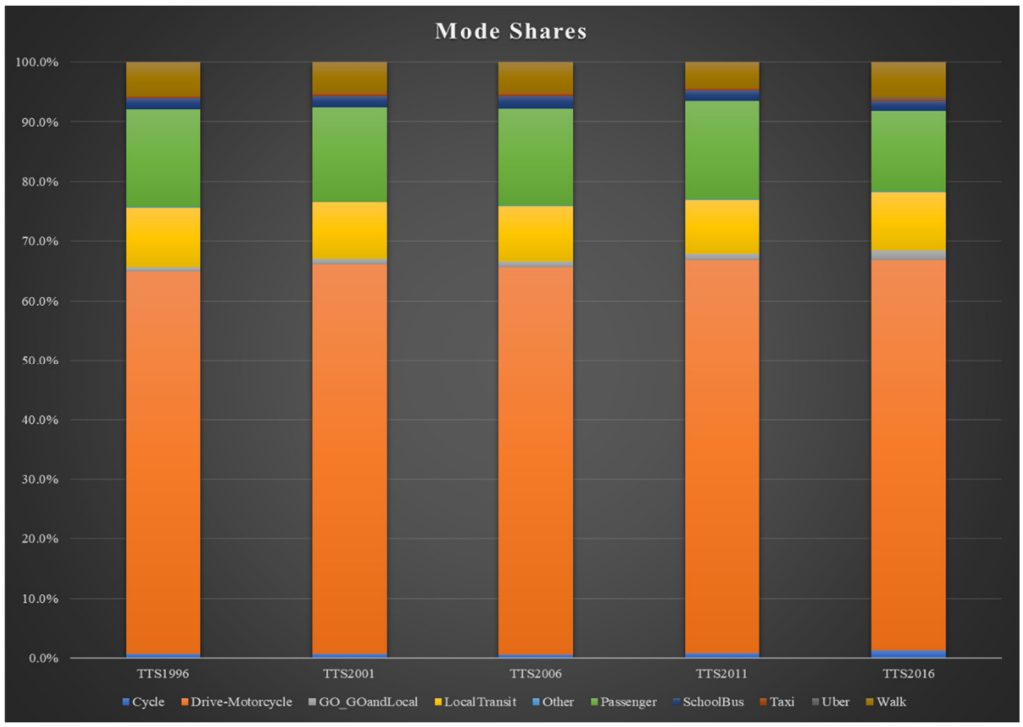

Figure 15. Mode Shares

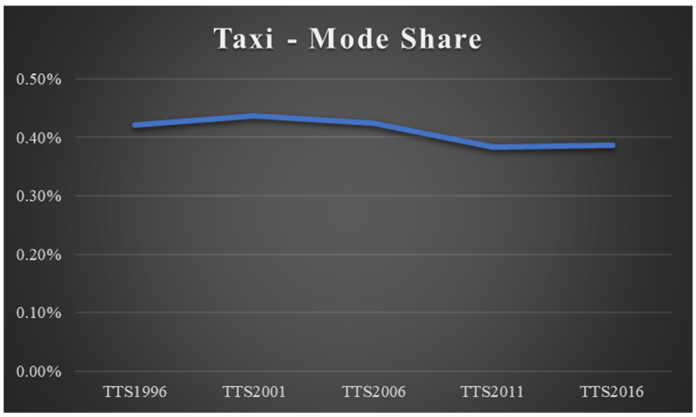

Figure 16. Taxi Mode Share

Figure 17 shows the distribution of total number of taxi trips in each survey (exact numbers can be found in Table 1). The lowest number of taxi trips is observed in the 1996 TTS, but the sample size of the 1996 survey is relatively small when compared to the remaining four years, hence, it is not surprising. Apart from this discrepancy, the total number of trips is similar in each year. Thus, it is not certain whether the slight declining trend from 2006 to 2011, and from 2011 to 2016 can be attributed to the ride-sourcing services provided by the Private Transportation Companies (PTCs) in the region. The same trend is not observed in mode share distribution.

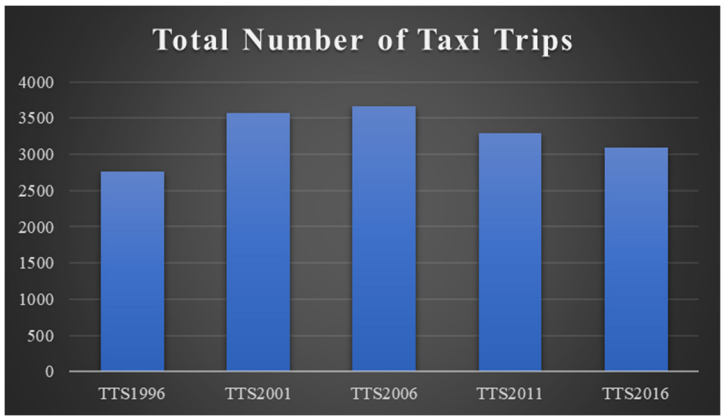

Figure 17. Distribution of Total Number of Taxi Trips

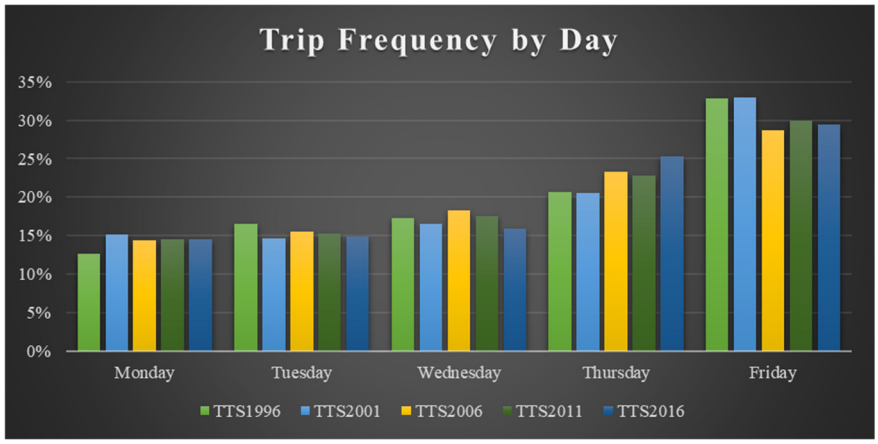

Figure 18. Trip Frequency Distributions by Day

Figure 18 presents the trip frequency distributions by day. In general, there is an increasing trend, as observed in survey day distributions, however, it might be misleading to analyze these distributions without assessing the trip frequencies per survey day. Only analyzing Figure 18, one might think that taxi-users make most of their trips on Fridays, however, since they have also completed the survey more often for Fridays, the number of trips per day gives a better understanding of the behaviour, which shows that the five days are not significantly different (refer to Figure 19).

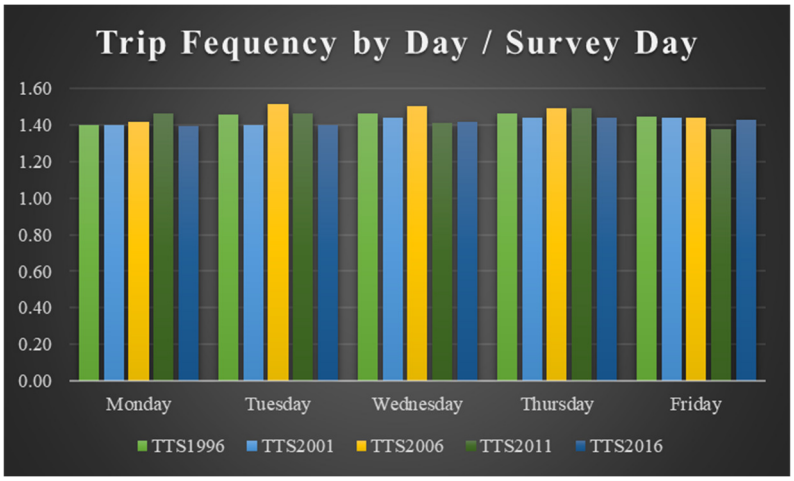

Figure 19. Trips Per Survey Day Distributions

The distributions of taxi trip by time of day is shown in Figure 20, where a day is divided into five time periods: “ON” period starts at 12 am and continues until 6 am, “AM” period starts at 6 am in the morning, continues until 9 am; “MD” period starts at 9 am continues until 3 pm; “PM” period starts at 3 pm, continues until 7 pm; lastly, “EV” period starts at 7 pm, continues until 12 am. In the “AM” and “PM” periods, when the traffic congestion in the region peaks, taxi usage remains stable over the years. There are slight differences in other periods, however, the differences are within +/- 5% of the mean, and also, these differences might be attributed to the fact that the remaining three periods are longer than “AM” and “PM”, hence, the differences might be due to the aggregation bias.

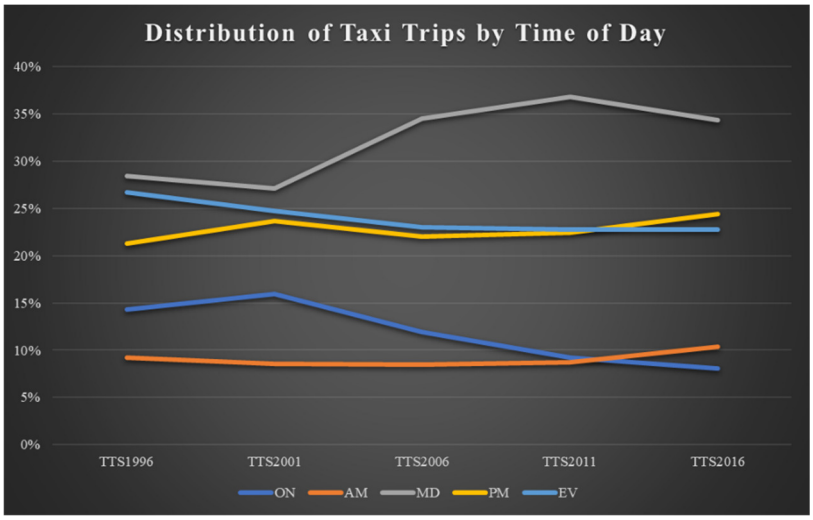

Figure 20. Distribution of Taxi Trips by Time of Day

Taxi trips have been used for eight different purposes in the TTS. These are: first-work activity of the day, second/subsequent-work activity of the day, first-school activity of the day, second/subsequent-school activity of the day, going home, marketing/shopping, other[2] and taking children to daycare. The distribution of taxi trips by purpose is presented in Figure 21. As observed in the majority of other distributions, the percentages for different purposes do not seem to vary over the years. It is observed that in all years, taxi is mainly used for going home and other purposes. Shares of work and school purposes, and shopping are relatively lower.

[2] "Other" purposes include anything other than work, school, daycare or facilitating a passenger activities.

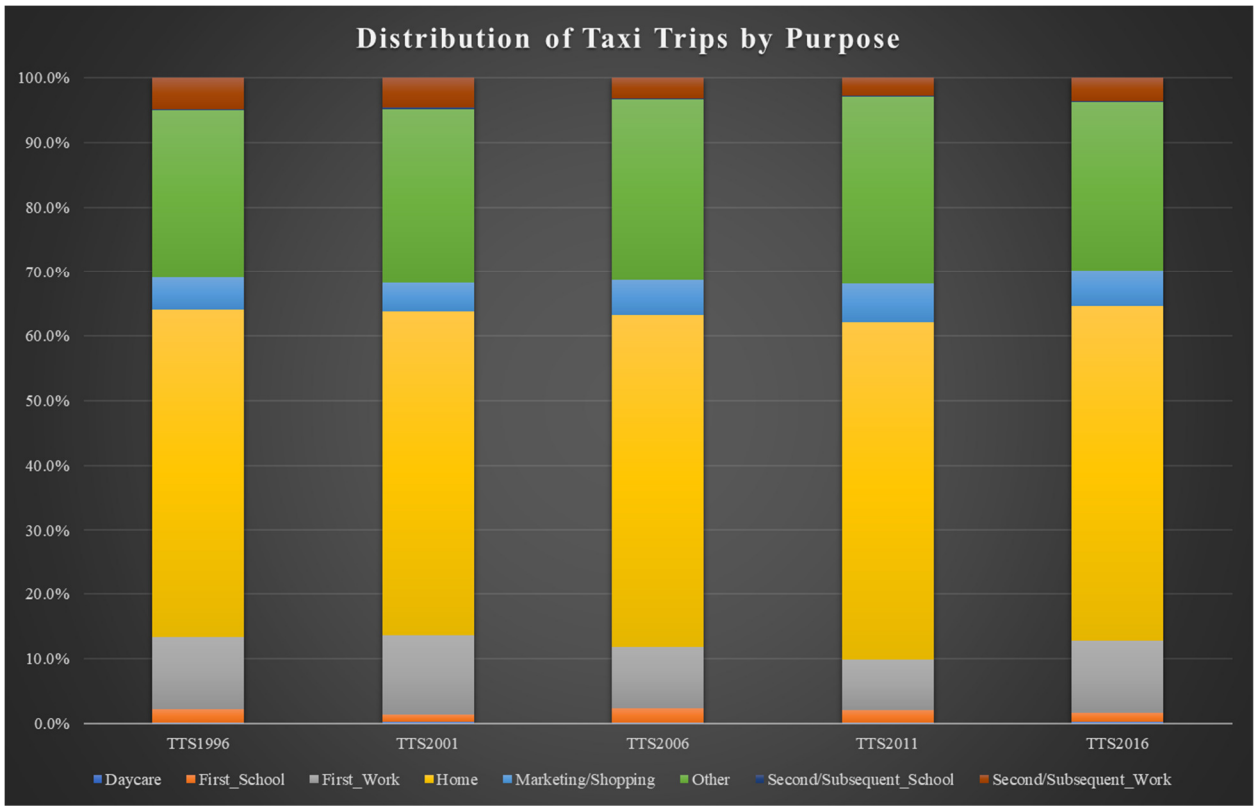

Figure 21. Distribution of Taxi Trips by Purpose

Further disaggregation regarding trip time and purpose can be found in Figures 22-29, which show the distributions of taxi trip usage by purpose by time of day over the years. Strong stability is observed in this analysis. The shares remain stable even at a time of day level comparison. Although there are fluctuations in taxi usage in certain categories (e.g., second/subsequent school "PM" period), they might be attributed to the random nature of the activity type.

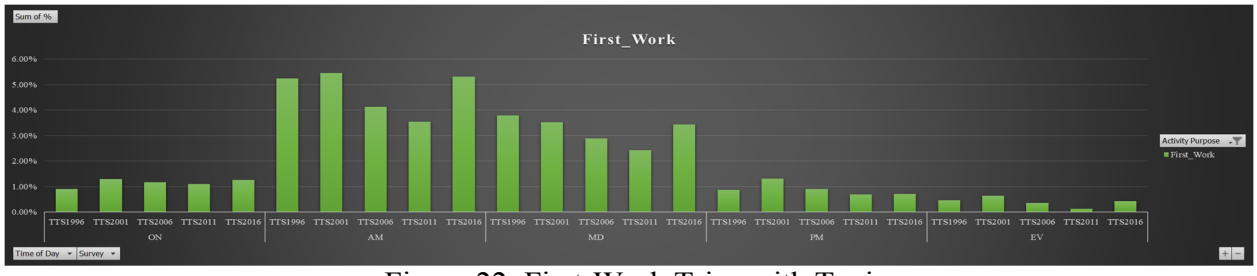

Figure 22. First-Work Trips with Taxi

Figure 23. Second/Subsequent-Work Trips with Taxi

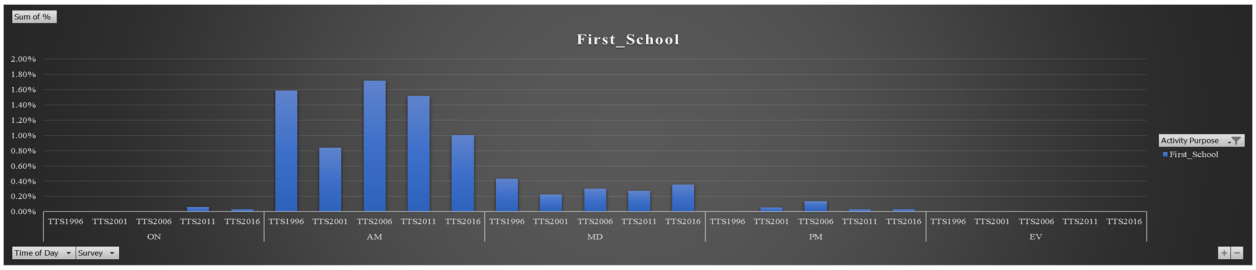

Figure 24. First-School Trips with Taxi

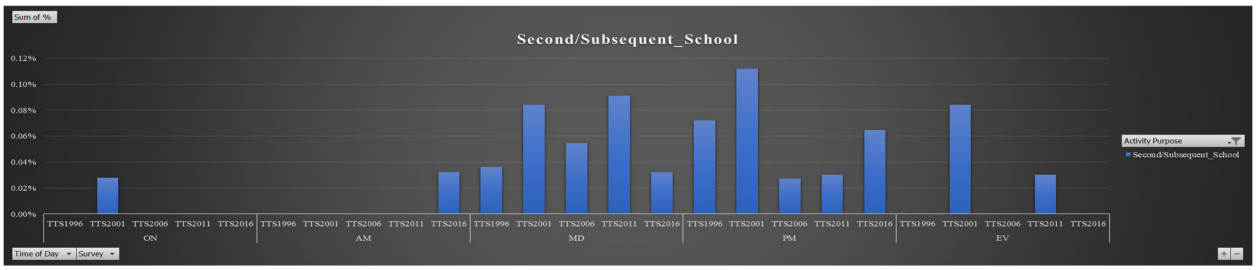

Figure 25. Second/Subsequent-School Trips with Taxi

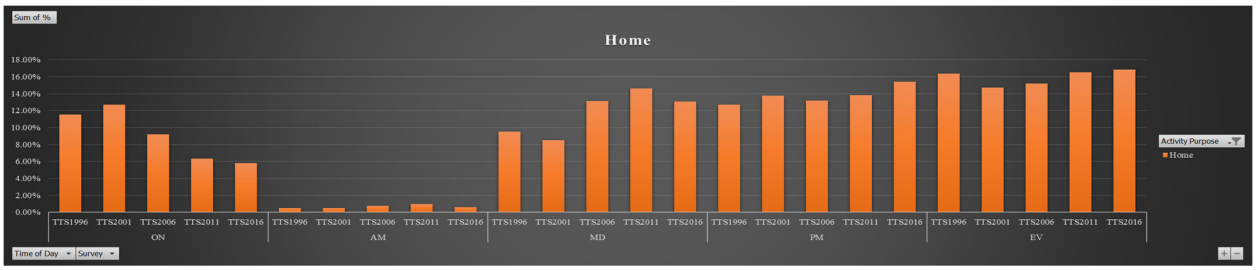

Figure 26. Home Trips with Taxi

Figure 27. Marketing/Shopping Trips with Taxi

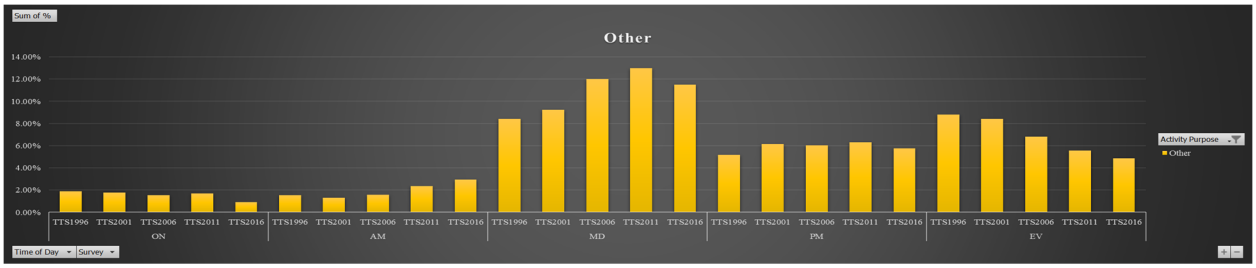

Figure 28. Other Trips with Taxi

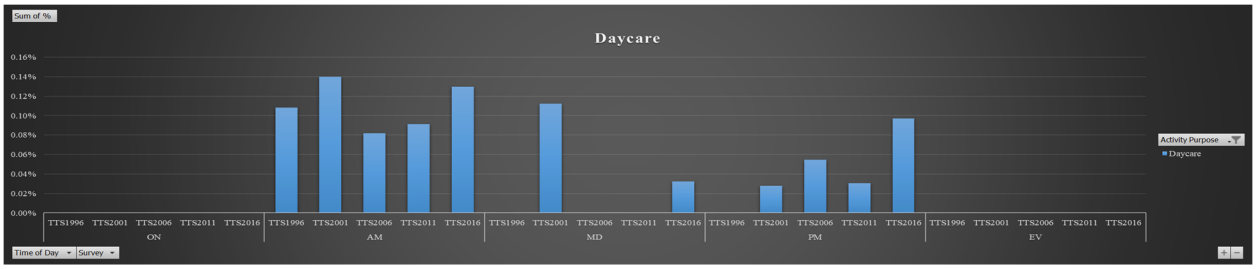

Figure 29. Daycare Trips with Taxi

Figures 30-34 show the spatial distribution of taxi trips originating from the City of Toronto at PD level for each survey year (Figure 35 shows the map of PDs within the City for further reference). For the current purpose, the trips originating from outside the City of Toronto are not shown in this report. In each figure, there are five maps which represent the distribution for a different time period in a day. It can be seen that in each time period of each year, taxi trips dominantly start from PD1, downtown Toronto. In general, some of the neighbouring PDs, such as PD2, PD4, and PD6, have the next highest number of trip origins. However, it should be noted that the gap between PD1 and the other PDs is quite large in most cases.

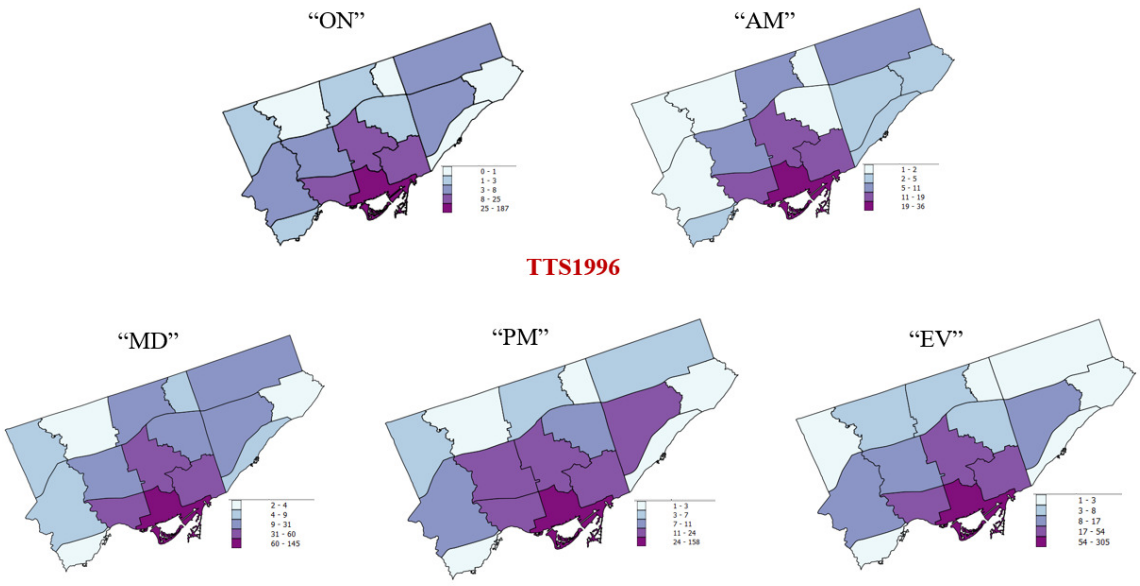

Figure 30. Spatial Distribution of Taxi Trip Origins within the City of Toronto by Time of Day – 1996 TTS

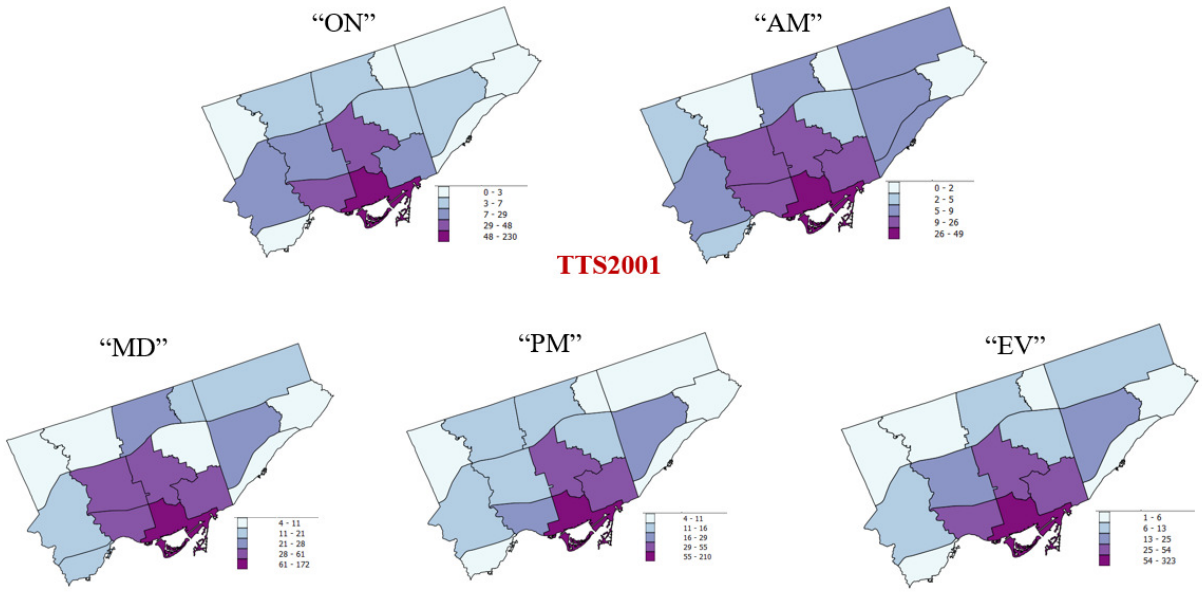

Figure 31. Spatial Distribution of Taxi Trip Origins within the City of Toronto by Time of Day – 2001 TTS

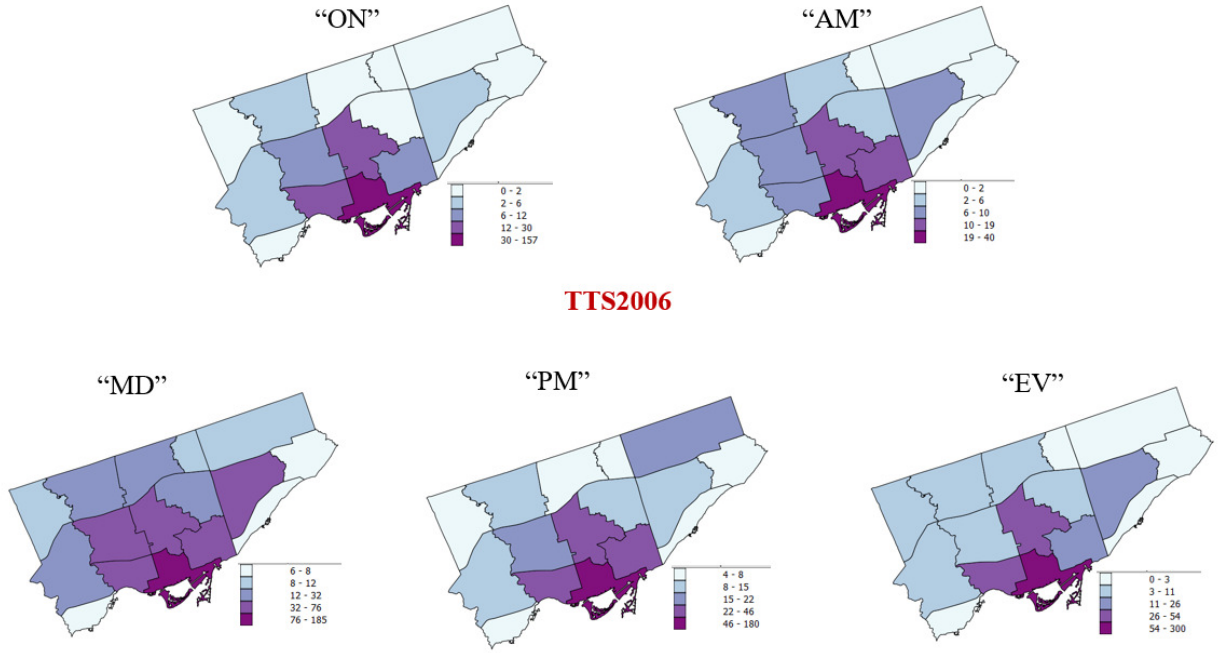

Figure 32. Spatial Distribution of Taxi Trip Origins within the City of Toronto by Time of Day – 2006 TTS

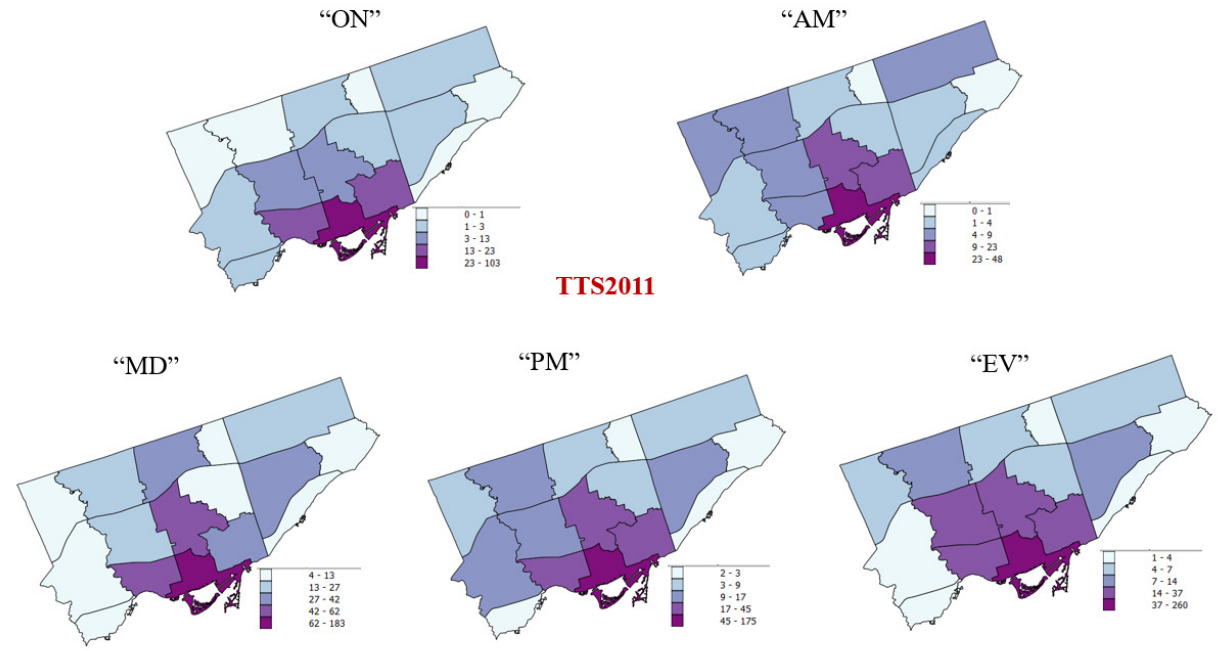

Figure 33. Spatial Distribution of Taxi Trip Origins within the City of Toronto by Time of Day – 2011 TTS

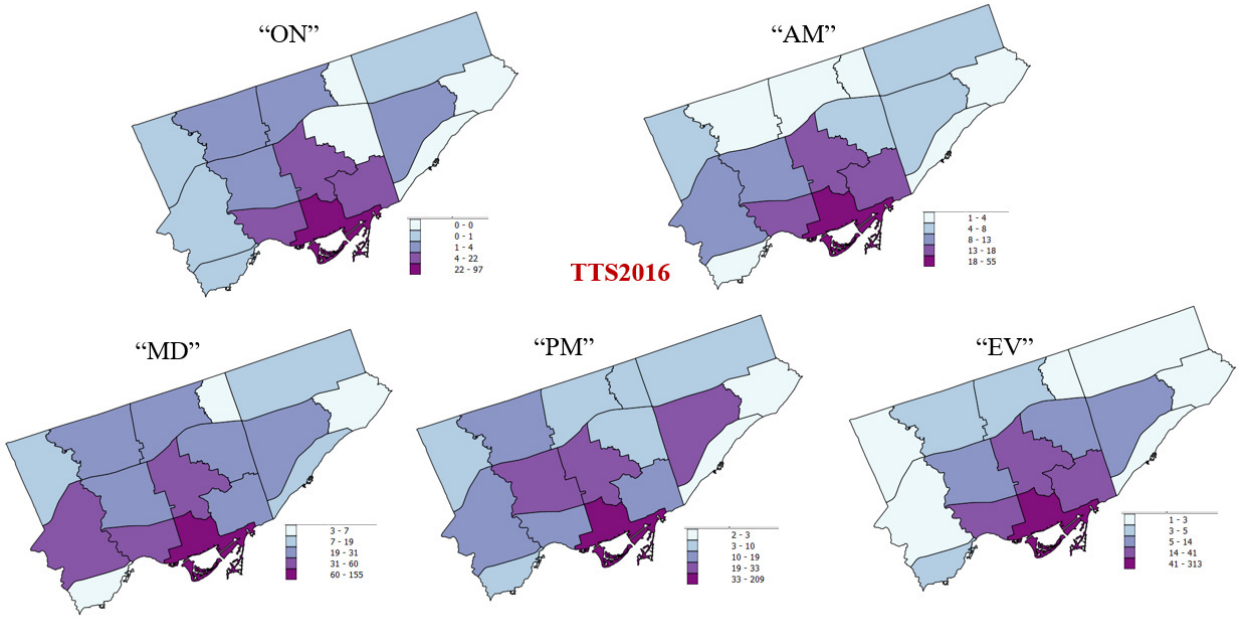

Figure 34. Spatial Distribution of Taxi Trip Origins within the City of Toronto by Time of Day – 2016 TTS

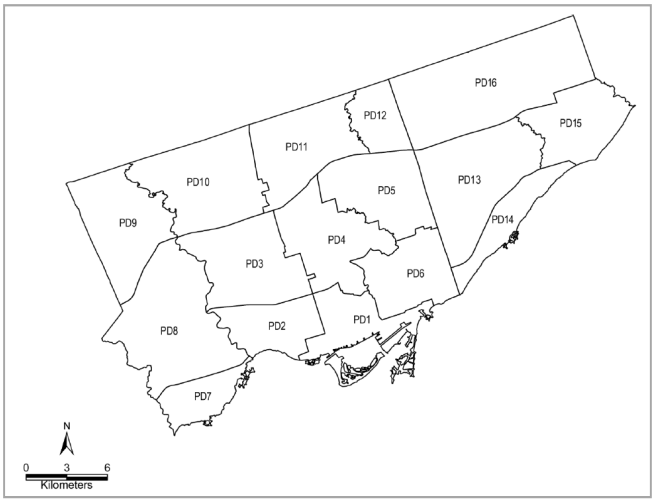

Figure 35. Map of Planning Districts in the City of Toronto - Source: (Ashby, 2018)

3. CONCLUSIONS

A time-series analysis on taxi trips and trip-makers are documented in this report. The analysis is carried out using the five most recent Transportation Tomorrow Surveys (TTSs) that is conducted in the Greater Toronto and Hamilton Area (GTHA) every five years, where the analysis period covers a 20-year period between 1996 and 2016.

Distributions of various individual-, household- and trip-specific attributes are compared between the years. In general, strong stability is observed in trip-maker profiles and trip patterns. It is useful to note that small differences, or slight fluctuations are only natural given that the survey samples are independent, i.e., since repeated cross-sectional data have been used in the analysis, not panel data, the individuals from one survey year are generally different than the set of individuals from another year. Further, taxi users are a very small proportion of total trip-makers, and so fluctuations from year to year due to sampling error within a 5% sample are inevitable.

In terms of attributes of individuals, there has not been significant changes in employment status, occupation, student status, driver's license ownership, etc. distributions. When the household characteristics are considered distributions associated with household size, auto ownership levels, dwelling type, etc. also remain stable over a 20-year period. In addition to the stability observed in trip-maker profiles, spatiotemporal trip patterns and trip purpose distributions display consistency in time.

This report provides detailed information on taxi usage patterns through a longitudinal analysis, which helps address some of the concerns expressed by taxi companies/drivers regarding customer loss, and hence, revenue loss, etc. With the survey data available, it is seen that taxi usage patterns have not changed significantly over time, even in the presence of Private Transportation Companies (PTCs), which might be explained by the differences in the user profiles for taxi, which has remained stable over time, and PTC services, as reported in Report No. 1 (Ozonder and Miller, 2019). In Report No. 1, it was shown that Uber-users have a very different demographic profile (e.g., younger, have higher income, etc.) than taxi-users. This might be the reason why taxi mode share has not changed significantly in 2016, despite the fact that PTCs were operating in the City of Toronto in the period the 2016 TTS was conducted.

The analysis of taxi trips using the TTS data indicates that the taxi industry has not been growing over time, the mode splits have been rather stable, i.e., the taxi industry has probably been maintaining a niche market. Although there is a slightly downward drift in time after 2001 in taxi mode shares, which is not valid between the 2011-2016 period, there is no evidence that the trend was accentuated by PTC services.

Nonetheless, it is important to highlight that with the TTS data, only the trips of GTHA residents can be analyzed. We are not able to comment on the trip-making behaviour of visitors to the region. They may have preferred using Uber, or similar services, over making a taxi trip. "Visitor market" cannot be captured by the survey data, which is expected to have a significant influence on taxi market, i.e., which might be the source of the issues raised by taxi companies, however, we cannot quantify this impact with the data available.

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