INVESTIGATION OF THE USE OF SMARTPHONE APPLICATIONS FOR TRIP PLANNING AND TRAVEL OUTCOME

By

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Table of Contents

List of Tables

List of Figures

Abstract

This study explored how smartphone applications are used for trip planning and how they influence travel outcomes. The study used data from 'Smartphone Use and Travel Choice Survey - 2015' conducted in Halifax, Canada. An exploratory analysis was conducted to understand the general characteristics of the smartphone users. This study specifically investigated the determinants that affect the use of smartphone applications for trip planning and shapes travel outcomes. Ordered response models were developed for trip planning activities such as performing online tasks, deciding departure time, mode choice, trip destination and communicating/coordinating trips. Additionally, binary choice models were developed for travel outcomes which include vehicle kilometres travelled, number of new places visited, social gatherings attended and planned group trips. Results reveal that socio-demographic and attitudes significantly affect smartphone use for trip planning and their impact on travel outcomes. This study offers in-depth behavioural insights and enriches the literature on mobile ICT.

List of Abbreviations and Symbols Used

β	Parameter coefficient
ε	Random error term
μ	Threshold parameter
α	Constant
ICT	Information and Communication Technology
VKT	Vehicle kilometres travelled

Glossary

Discretionary trips	All trips other than home-based work and home-based school
Maintenance trips	Shopping related trips
Effect of ICT on Travel	
Substitution effect:	Use of ICT reduces or decreases travel
Complementary effect:	Use of ICT increases travel
Modification:	Rather than direct increase or decrease, use of ICT makes change in travel pattern
Neutral effect	Use of ICT do not influence travel

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Chapter 1: Introduction

1.1 Background

A smartphone can serve as a fully functional computer (Wang et al., 2014a) and with its various dynamic applications, it offers a wide range of travel supporting solutions (Gretzel, 2010 and Wang et al., 2011). Within a single device, it can facilitate telephone conversation, SMS and texting, email, information browsing, online social networking, online and teleshopping/e-shopping, etc. Using smartphone applications, people are now able to map their travel routes and destinations. They can make decisions on their purchase without physically arriving to the destination, reducing their daily travel distance and time. Moreover, many people use their phone as a tool to get traffic updates, look up bus-train schedules, pre-book shows, make online purchases, telecommunication, etc., which also enhance convenience regarding daily travel needs. Statistics show that the number of smartphone users has significantly increased in recent years. In 2014, the smartphone penetration rate in Canada was 55% which is supposed to increase to 68% in 2015 (Catalyst, 2015a). However, the interaction between Information and Communication Technology (ICT), society and travel is very complex (Lyons, 2002). As smartphones have become part of our lifestyle, it is expected that it has an influence on our personal travel. According to Jain and Lyons (2008), there is a possible relationship between the use of smartphones and daily travel and improved understanding on this evolving area is demanding (Wang et al., 2014b).

An extensive body of literature is available that explores the relationship between ICT and travel. Previous relevant studies tried to explore the general impact of ICT on travel such as work related trips (e.g. Choo and Mokhtarian, 2007), discretionary trips (e.g. Cao et al., 2010) or leisure trips (e.g. Mokhtarian et al., 2006). Research that focus on mobile ICT, more spefically on smartphones, predominantly addressed technical perspective such as designing mobile systems and individuals acceptance and adjustment with mobile

information systems (Wang et al., 2014a). Regarding travel behaviour, some recent research on smartphone usage mainly focused on leisure or recreational trips. For example: Wang and his colleagues (e.g. Wang et al., 2011; Wang and Fesenmaier, 2013; Wang et al., 2014b; Tussyadiah and Wang, 2014) tried to develop a broad foundation for understanding the impact of smartphone use on tourism related travel experiences. Tussyadiah and Wang, (2014) applied a projective method on tourists' opinions and feelings about their smartphones and suggested that the immediate information availability support of smartphones helps tourists to solve travel related decisions more effectively. However, research on how mobile ICT is influencing travel is limited and needs to be introduced.

It is not clear within transportation research how smartphone use has changed day to day travel behaviour, which was identified as a gap by Wee et al., 2013. In their study, the authors listed several relevant future research agenda on ICT's impact on travel behaviour. They identified that the research on the relationship between ICT and comfort of travel remains a gap in the available ICT and travel related studies. They further elaborated this by expressing people's accessibility to several forms of travel related information such as route, transit schedule, traffic updates, etc., due to the development of mobile phone technologies, reduced travel related hassle. Additionally, they predicted the regular and extensive use of smartphones in trip planning in future.

Literature on how mobile ICT, more specifically, smartphone and its applications are shaping our mobility pattern is limited. Smartphone applications offer different types of travel supporting solutions such as direction, transit schedule, finding nearest restaurants, etc. Some of the applications also offer trip replacement options such as e-shopping, online banking. As use of smartphones is increasing in Canada, it will be interesting to explore whether smartphone applications usage for conducting online tasks, destination choice, departure time, mode choice and coordination of trips are bringing change to how we move. Further insights are also required on how the use of smartphones influence travel outcomes such as vehicle kilometres travelled, new places visited, social gatherings attended and number of planned group trips and what their determinants are. Under such backdrop, this

study contributed to fill this gap by collecting data and exploring the usage of smartphones and its applications in trip planning and travel outcome. Following discrete choice modelling techniques, this study analysed the determinants of trip planning and travel outcomes as an influence of smartphone applications usage. As such, it adds to a growing body of mobile ICT research by exploring how the use of smartphones and its applications are shaping our movements. The study conducted a Smartphone Use and Travel Choice Survey, 2015 in Halifax, Nova Scotia which is used as the primary data source for the analysis.

1.2. Objective

1.2.1 Overall Objective

The general objective of this study was to explore the smartphone usage pattern and the determinants that affect day to day trip planning activities and travel outcomes in Halifax, Nova Scotia.

1.2.2 Specific Objective

The specific objectives were:

a) To explore the pattern of smartphone/ smartphone applications usage for day to day trip planning activities and travel outcome.

b) To examine how socio-demographic, travel characteristics, neighbourhood characteristics and attitude affect smartphones use for trip planning including performing online tasks, communicating/coordinating trips with others, decision on destination choice, mode choice and departure time.

c) To evaluate how socio-demographic, travel characteristics, neighbourhood characteristics and attitudes determine smartphone's impact on travel outcomes, more specifically vehicle kilometres travelled, number of new places visited, number of social gatherings attended and number of trips planned in groups.

1.3 Ethical Considerations

Ethical considerations were taken into account while conducting the Smartphone Use and Travel Choice Survey, 2015 under the project The Impact of the Use of Smartphone Technologies on Travel Choices for which Ethics Approval was taken from Dalhousie University Research Ethics Board. The Ethics Approval number for the survey is: 2014-3217. Any potentially identifying information such as respondent's name, email address etc. was stripped off at the earlier stage of data processing and replaced by anonymous codes. To incorporate neighbourhood attributes in the analysis, the collected data was complied with four different data sources: i) Halifax Regional Municipality (HRM) Corporate Database (GIS) – 2012, ii) HRM Census Database – 2011, iii) National Land-use database - 2011 and iv) National Household Database – 2011.

1.4 Smartphone Use and Travel Choice Survey – 2015

1.4.1 Survey Design and Variables Considered

Smartphone Use and Travel Choice Survey, 2015 was designed to develop an understanding on how the use of smartphone and its applications are influencing travel choices, such as trip planning, destination choice, departure time and mode choice. The initial questionnaire is documented in Irvine (2014). The questionnaire was produced through two focus group discussions. The survey was designed in such a way that it required 15-20 minutes to complete. In the consent form it was assured that respnses will be kept confidential and will only be used for statistical analysis. (Questionnaire is attached in the Appendix).

Respondents were asked questions regarding their smartphone application use for trip planning associated activities such as deciding when to depart, deciding trip destination, choosing an appropriate mode of transportation, communicating and coordinating trips with others, and performing tasks online rather than travelling to a location, etc., and specific travel needs such as checking the bus schedule, finding a location, online shopping, scheduling a meeting, etc. Questions on travel outcomes include impact on vehicle kilometres travelled, number of new places visited, number trips planned in groups, and

number of social gatherings attended. Information were collected in 5 point Likert Scale, such as Not Dependent - Rarely Dependent - Moderately Dependent - Often Dependent - Highly Dependent were used for trip purpose, Never - Rarely - Sometimes - Often - Always were used for trip planning and travel needs, and Decreased Significantly - Decreased Slightly - No Impact - Increased Slightly - Increased Significantly were used for travel outcome.

Additionally, the survey also collected information on individuals' socio-demographic status and travel attributes such as daily trips, mode choice, travel time, vehicle, bicycle and transit pass ownership and life style choice preference. Travel log of the respondents for last weekday and last weekend were collected by reporting the trips made in that day which was considered as typical travel pattern of the repondents in a weekday and weekend. Attitudinal factors were included in the questionnaire to response in 5 point Likert Scale: Strongly Agree – Slightly Agree – Neutral – Slightly disagree – Strongly disagree (Appendix for more details). A summary of questions included in the questionnaire is presented in the Figure 1.

1.4.2 Survey Instrument and Dissemination

The survey was conducted online by Dalhousie Transportation Collaboratory (DalTRAC) researchers via the Dalhousie University operated 'Opinio' survey instrument during March-April, 2015, in Halifax, Nova Scotia. A pilot test was conducted and after incorporating the feedbacks, the questionnaire was finalized for distribution. The participation in the survey was voluntary. Extensive multi-media campaign was followed to conduct this survey. The survey was circulated by email to major employers, for example, Halifax Regional Municipality, Nova Scotia Department of Energy, Nova Scotia Department of Municipal Affairs etc. Survey invitation was also sent to non-profit organizations such as Ecology Action Centre, Fusion Halifax, and Bicycle Nova Scotia etc. A promotional leaflet (attached in appendix) was also prepared by DalTRAC and distributed in various locations of HRM as well as in different events for instance, Carmichael Lecture 2015 and SHIFT Rural 2015 Conference organised by Dalhousie School of Planning. Facebook advertisement was also done to reach a wider audience in

Halifax. Additionally, all DalTRAC channels, such as the DalTRAC blog, DalTRAC website, DalTRAC Twitter, DalTRAC Facebook and DalTRAC Share the Road NS Facebook Page and other social media accounts were utilized for the survey dissemination.

Figure 1: Summary of Data Collected through Smartphone Use and Travel Choice Survey -2015

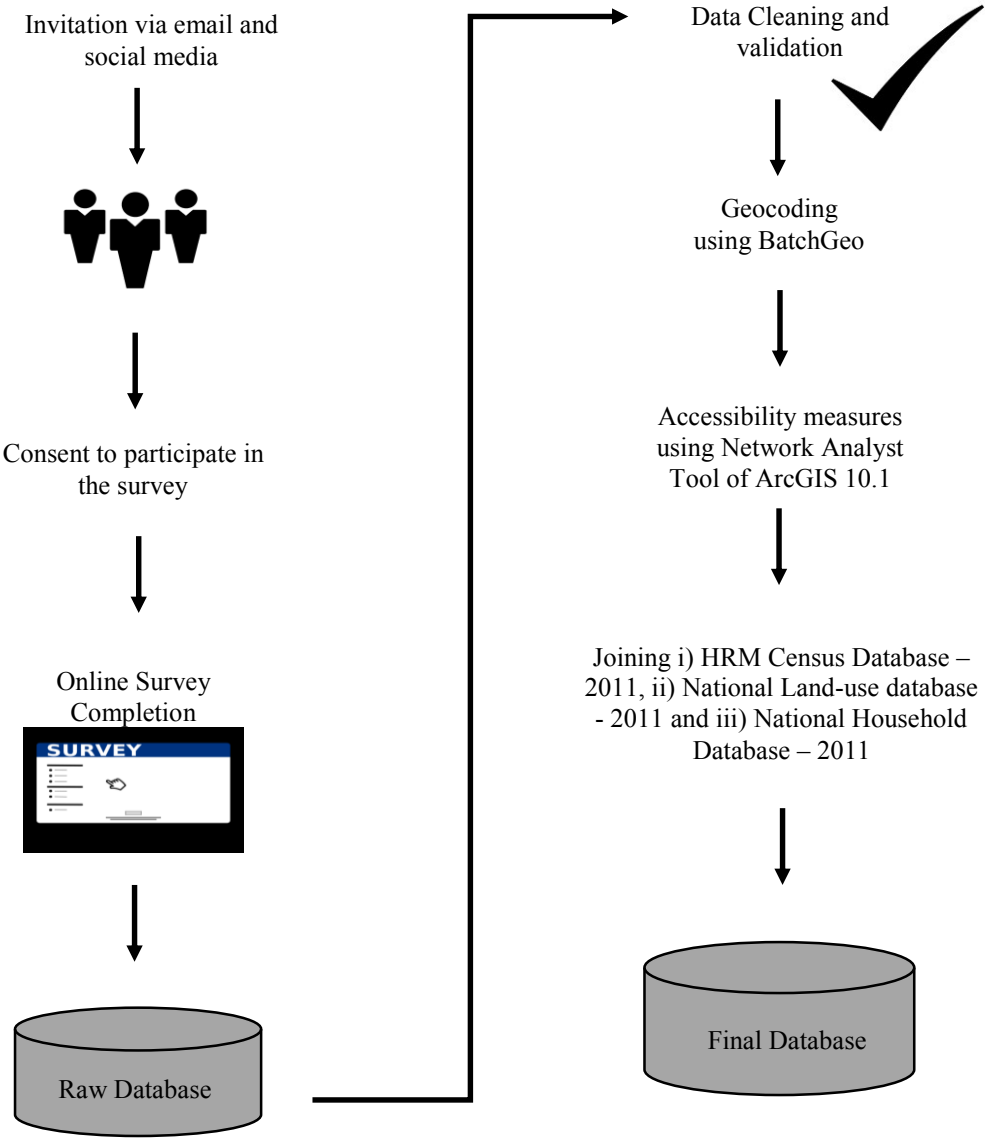

Figure 2: Flow Diagram of Database Preparation from Smartphone Use and Travel Choice Survey - 2015[1]

1.4.3 Data Cleaning and Validation

After survey data collection, the raw database was cleaned for validity purposes. All identifiable informations were replaced with annonymous codes. The survey yielded a sample of 386 smartphone users residing in Halifax. For accessibility measures, at first

[1] Clip arts used in the diagram are downloaded from the internet.

home locations were geocoded through BatchGeo software. Following the geocoding, the accessibility measures were determined using the Halifax Regional Municipality (HRM) road network in ArcGIS 10.1. The accessibility measures include home to central business district (CBD) distance, distance from home to the nearest bus stop, shopping center, and regional centre. Finally, a full database was generated by joining the survey data with the corresponding accessibility measures, land-use, and neighbourhood characteristics for further analysis.

1.5 Analysis

At first an exploratory analysis was conducted to understand the general characteristics of the smartphone users of Halifax. Following that this study explored how smartphone is used for trip planning and how they influence travel outcomes. Determinants such as socio-demographic characteristics of the individual respondents, travel characteristics, neighbourhood characteristics and attitudes were analysed for trip planning and travel outcomes following ordered response model and binary choice model. This analysis gives some in-depth insights on the use of smartphone applications for trip planning and how they are shaping our travel outcomes.

1.6 Thesis Outline

The thesis is organized in four chapters. Chapter 1 describes the motivation to explore the relationship between smartphone applications use and travel. It also provides the description and design of Smartphone Use and Travel choice Survey – 2015. The second chapter includes an exploratory analysis of the data collected from the survey. The following chapter provides and empirical analysis of how smartphone is used for trip planning, how they influence travel outcomes and what their determinants are. Final chapter summarizes overall findings and suggests potential policy implications.

Chapter 2: Exploratory Analysis of the Use of Smartphone Applications for Trip Planning and Travel Outcome[2]

2.1 Introduction

This chapter presents the findings of Smartphone Use and Travel Choice Survey -2015 conducted on the smartphone users of Halifax, Nova Scotia. Through a comprehensive exploratory analysis of the survey data, this study aimed to understand the pattern of smartphone application usage for day to day trip planning and travel outcome. Existing literature suggest that smartphones are widely used by the younger generation (Windmiller et al., 2014). The number of smartphone users has significantly increased in recent years. In 2014, the smartphone penetration rate in Canada was 55% which is supposed to increase to 68% in 2015 (Catalyst, 2015a). The interaction between ICT, society and travel is very complex (Lyons, 2002) and yet to be understood. As smartphones have become part of our lifestyle, it is expected that it has an influence on our personal travel. Jain and Lyons (2008) indicated the potentiality of existing a relationship between the use of smartphones and daily travel, and thus, improved understanding on this area is of paramount interest in recent years (Wang et al., 2014b).

Mokhtarian and her colleagues have discussed the impact of several forms of ICT on travel behaviour. According to Mokhtarian (2009), existing researches on tele-commuting showed "substitution effect in short-term and direct researches whereas the complementary effect is more likely to be long-term and indirect". By substitution effect they meant decrease and by complementary effect they meant increase in travel. The study further clarified that a short-term study may not reflect the "long-term effect on residential location and indirect effect of demand for additional communication and travel". On the other hand, the long-term study findings may be weakened by the continuous improvement in

[2] Part of this chapter was published in Jamal, S. and Habib, M.A. "Investigation of the Use of Smartphone Application for Trip Planning and Travel Outcome", reviewed proceeding, 95rd Annual Meeting of the Transportation Research Board, Washington DC, January 2016.

telecommunication on travel. In 40 years of ICT and travel behaviour researches broadly used ICT as a generalized term. Several factors can shape ICT's impact on travel behavior. Examples include individual characteristics (De Graaff and Rietveld, 2007), trip frequencies (Farag et al., 2007), e-shopping/tele-shopping (Farage et al., 2007; Ferrel, 2004), vehicle miles/kilometers travelled (Zhang et al., 2007), frequency of internet use, number of mobile phones at the household, presence of telephones at home for business purposes (Zhang et al., 2007; Lilaa and Anjaneyulu, 2013), and presence of personal computers at home (Bhat et al., 2003). However, understanding on how the smartphone as a device is influencing daily trip planning of individuals is limited. To our best knowledge, limited research was conducted in this area. Therefore, this study was the initial attempt to fill this gap by collecting data and conducting exploratory statistical analysis on the usage of smartphones and its applications in trip planning and how they influence travel outcomes.

The following sections begin with a brief overview of existing literature related to ICT's impact on travel choice, travel outcome, and trip characteristics. After that, it illustrates the methodology and data. The next section describes the sample characteristics followed by exploratory analysis of the purpose of smartphone application usage, trip planning, and travel outcomes. Finally, the chapter concludes with a summary of findings.

2.2 Literature Review

Extensive literature can be found in the arena of Information and Communication Technology (ICT) and travel behaviour. However, very limited studies are available on smartphone's impact on daily trip planning and travel outcomes. Trip planning activities considered in this study are performing online task rather than travelling, communicating/coordinating trips, deciding trips destination, mode choice, and departure time. Travel outcomes include vehicle kilometers travelled, number of new places visited, social gatherings attended and planned group trips. Previous studies mostly dealt with substitution (i.e. decrease) or generation (i.e. increase) effect of ICT on travel (e.g. Farag et al., 2003; Bhat et al., 2003; Mokhtarian and Solomon, 1997; Mokhtarian and Meenakshisundaram, 1999; Cao and Mokhtarian, 2005; Choo and Mokhtarian, 2005;

Mokhtarian, 2009; Circella and Mokhtarian, 2010 etc.). This study differs from most of the previous studies however, as it particularly focused on the question of how smartphone usage is influencing day to day trip planning activity and travel outcome. In other words, this study investigated to what extent people depend on their smartphone applications for daily travel and what some influencing characteristics are.

Smartphone applications are used for many purposes. Data from The Nielsen Company (2015) on US consumers show that in 2014, people spent the highest amount of time using smartphone applications for searching, entertainment, and communication. In Canada, the five most-common smartphone application related activities are to check the weather, get directions, use twitter, check the score of a sports game, and find a new restaurant (Catalyst, 2014). Similar findings were found in a study by the Canadian Wireless Telecommunication Association (CWTA) (2012), where the top smartphone activities identified were obtaining weather information, use of social media, instant messaging (e.g. Facebook, Twitter, LinkedIn, etc.), and use of applications that link to travel, public transit, and mapping or navigation information.

As specific studies on smartphones impact on travel is very limited, more specifically on trip planning and travel outcomes, the relevant work within the scope of this study are the recent travel related studies which considered impact of telecommunication devices (home and mobile phone) and home computer ownership (as smartphone provides both facilities). For example: Senbil and Kitamura (2003) examined the relationships between communication by home and mobile phones and activities using the information of 766 individuals in the Osaka metropolitan area, Japan. The study showed a substitution effect of using telecommunication devices on work related activities, generation effect on discretionary activities, and a neutral impact on maintenance activities.

Srinivasan and Athuru (2004) explored the role of socio-demographic characteristics in ICT use. Their research suggest that young and middle age group, as well as students, are the major internet users. Similar results are observed in terms of cell-phone (Bhat et al., 2003; Mondchein, 2011) and smartphone users (Windmiller et al., 2014). Men were also

found to be higher internet users compared to women (Srinivasan and Athuru 2004). A study on St Louis Metro riders in the USA, however, suggested that smartphone ownership doesn't vary between genders (Windmiller et al., 2014). The same study also revealed that among the metro riders, students and full-time and part-time employed persons usually own a smartphone. Internet use and online activity (for maintenance purpose) participation increases with the increase in income level (Srinivasan and Athuru 2004). A similar trend is also noted by Bhat et al. (2003) and Mondschein (2011) who showed that the possibility of cell-phone ownership rises with income. However, Windmiller et al. (2014) depicted income as a less dominant indicator for smartphone ownership.

Literature related to trip planning activities and ICT use is emerging. Trip planning activities considered in this study include decisions regarding departure time, destination choice, mode choice, coordinating trips, and performing virtual (e.g. online) activity. Virtual activity (e.g. online banking) has a possible effect (can be substitution, indirect generation or modification) on physical travel (Wang and Law, 2007). A recent study on American travellers showed that online planning and purchasing activities (e.g. air tickets and accommodation) has increased significantly over the past several years (Xiang et al., 2015). Srinivasan and Athuru (2004) explored the virtual activity (e.g. online banking and browsing) participation (using Internet) in maintenance and discretionary activities using the data of 4,214 respondents from the San Francisco Bay Area. Findings suggested that internet use reduces travel duration, but increases maintenance activities and travel frequency. Corpuz and Peachman (2003) revealed strong influence of internet use on shopping, personal business (e.g. banking, etc.), and educational trips. Bhat et al., (2003) suggested that an increase in mobile phone and home computer use can reduce the number of individual trips for non-maintenance related shopping activities. On the contrary, studies of Casas et al., (2001) and Farag et al. (2007) showed a positive relationship between online buying and the frequency of shopping trips. Females are found to be less involved in online shopping in the study by Farag et al. (2007).

Mixed findings were observed in relation to the effects of ICT on travel outcomes. Wang and Law (2007) have identified that the use of ICT generates recreation activities, trip

frequency, and longer travel time. The authors explored the impacts of using e-mail, internet service, video conferencing, and videophone on time use and travel behaviour using travel characteristic survey data from Hong Kong. Viswanathan and Goulias (2001) suggested that internet use is negatively correlated, whereas mobile phone use is positively correlated, with travel time. Hjorthol (2002) argued that "after controlling for gender, age, household income, and number of cars, using a home computer for work with or without Internet connection both have a small but statistically significant positive effect on daily distance traveled and total trips". A study on the Chicago area, suggested a positive relationship between cellphone use and number of social trips (Mondschein, 2011). Berg et al. (2013) showed that ICT use whether has a substitutional (decrease) or neutral effect on social travel. The study also indicated a negative effect of Internet interactions on social travel distance, whereas analysis of Carrasco (2011) confirmed a mediated complementary effect. Studies on mobile tour guides done by Kramer et al. (2007) showed no difference between different mobile applications and traditional guided tours regarding tour duration, walking distance, and number of sights visited.

Recent studies, such as the work of Wang and his colleagues (Wang et al., 2014a; Wang et al., 2014b; Tussyadiah and Wang, 2014) explored the adoption and use of Smartphones and their impact on travel experience of tourists. Following a qualitative approach, after interviewing 24 participants, they suggested that the use of a smartphone can influence travel route, duration, and walking distance (Wang et al., 2011). Meng et al., (2015) explored the role of some factors such as ease of use, compatibility, result demonstrability, etc. of smartphone applications on tourists' decision on adopting smartphone technologies/applications. Wang and Fesenmaier (2013) explored the impacts of four purposes of smartphone use including communication, entertainment, facilitation, and information search on travel experience. Findings suggested that a smartphone can influence tourists travel planning, provide convenience in information search, and change travel decision making. However, how smartphone applications are influencing day to day travel was never explored.

Overall, there is a gap in exploring the impact of smartphone use on travel. While previous studies focused mainly on generation or substitution effects of travel characteristics due to use of ICT, investigation of smartphone use on daily trip planning activities and how they influence travel outcomes were limited, except some studies regarding touristic experiences. Hence, this study offered an in-depth analysis of the recent survey on smartphone applications' usage for day to day trip planning activities as well as travel outcome.

2.3 Sample Characteristics of Smartphone Use and Travel Choice Survey – 2015

Findings from Smartphone Use and Travel Choice Survey - 2015 provides an idea about the characteristics of the smartphone users along with their smartphone and its applications usage pattern for trip planning. It also reveals how use of smartphone applications influence travel outcomes. This section provides the sample characteristics such as socio-demographic characteristics and preliminary investigation of the travel behaviour of the respondents. The next section will describe an exploratory analysis on how smartphone use is influencing trip planning and travel outcomes.

2.3.1 Socio-Demographic Characteristics of the Survey Respondents

2.3.1.1 Age

Findings reveal that 34.84% of the survey respondents belong to 20-24 years old and 20.21% of the respondents belong to 25-29 years old age group (Figure 3). One fourth of the respondents (74%) belong to less than 34 years old and 26% belong to more than 34 years age group. On the other hand, retired persons are the least smartphone users as only 1% of respondents belong to that group. This is expected for smartphone users as several studies found younger people as main ICT adopters. Smartphone is becoming highly popular among the younger generation. In 2012, 69% of the 18 -34 years old people own a smartphone (CWTA, 2012). This sample from Smartphone Use and Travel Choice Survey - 2015 shows that 66.49% of the respondents are between 20 -34 years old which assumed to be a reasonable representation of Canadian smartphone users.

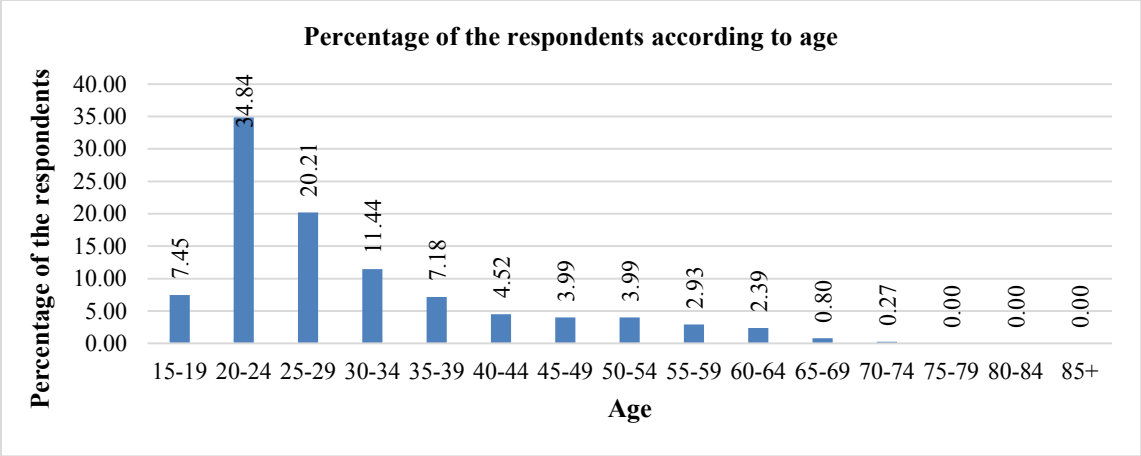

Figure 3: Percentage of the Respondents according to Age Group

2.3.1.2 Gender

54.62% of the respondents represent female and 44.59% represent male population of Halifax in Smartphone Use and Travel Choice Survey - 2015 (Figure 4).

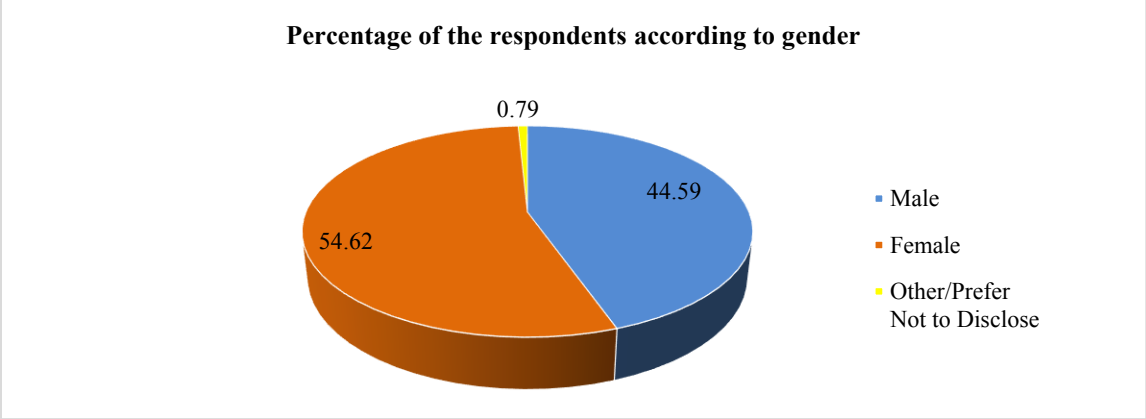

Figure 4: Percentage of the Respondents according to Gender

2.3.1.3 Studentship Status

65.17% of the respondents are full-time students and 28.76% of the respondents belong to non-student group (Figure 5).

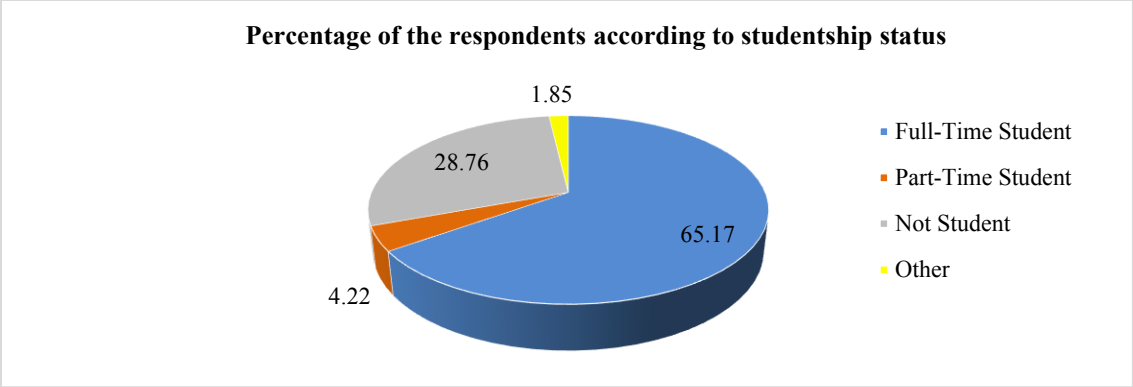

Figure 5: Percentage of the Respondents according to Studentship Status

2.3.1.4 Employment Status

Among the respondents, 43.01% are full-time employed and 24.80% are part-time employed (Figure 6). However one fourth (26.12%) of the respondents are found unemployed. Probably, because of the presence of high percentage of young people as well as high full-time studentship (which is still a good representation of Canadian smartphone users), this survey contains a significant percentage of non-working population of smartphone users.

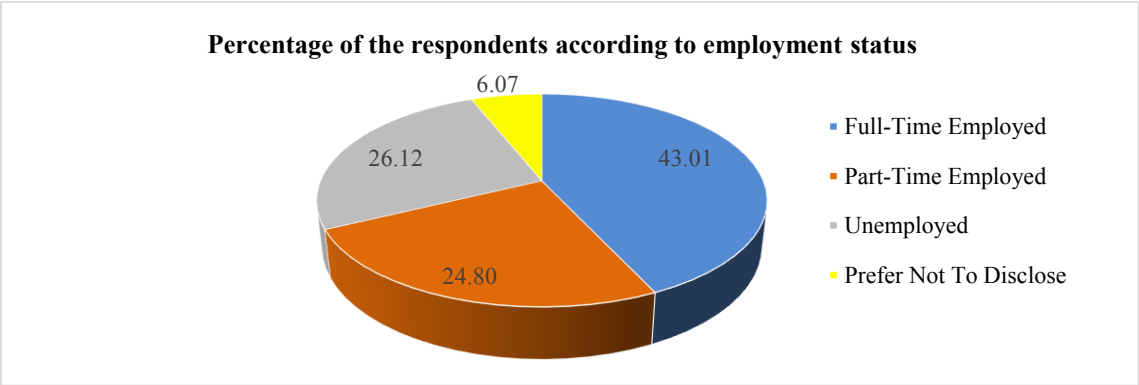

Figure 6: Percentage of the Respondents according to Employment Status

2.3.1.5 Annual Individual Income

As majority of the respondents belong to young and full-time students group, low income is supposed to represent the majority. Accordingly, Figure 7 shows that 65.96% of the respondents belong to below $30,000 individual income group.

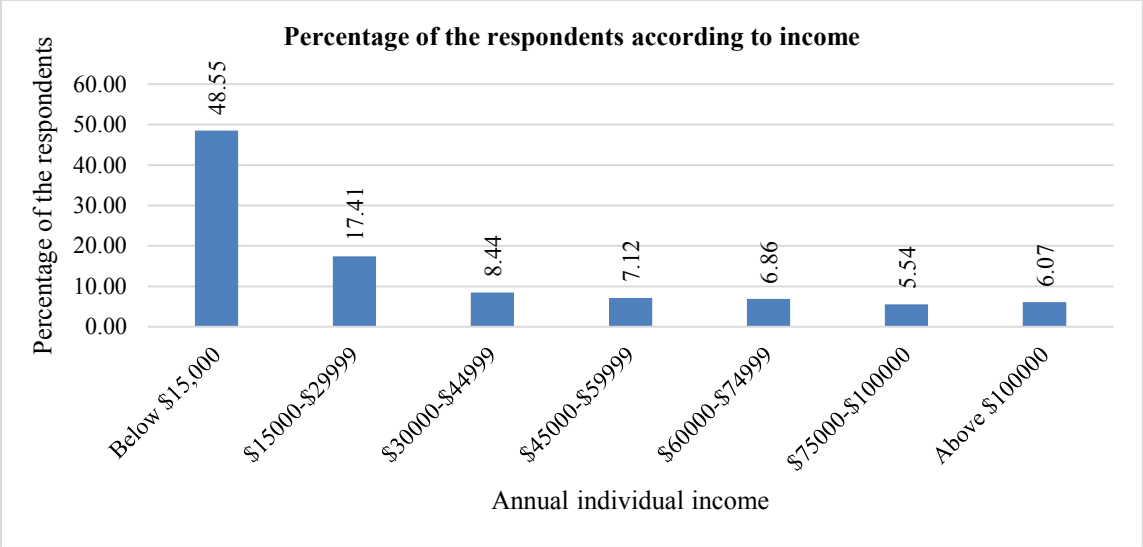

Figure 7: Percentage of the Respondents according to Annual Individual Income Group

2.3.2 Preliminary Investigation on Travel Behaviour of the Survey Respondents

2.3.2.1 Weekly round trip by purpose

Figure 8 represents the frequency of weekly round trips made by the respondents according to the purpose of the trip. Around 30% of the work and 19% of the school related round trips are made 5 times a week. Moreover, around 28% of the respondents make only one and around 33% of the respondents make two shopping related round trips per week. In contrast, recreation and entertainment related round trips are low among the respondents as 40% and 62% do not make any recreation and entertainment related round trips per week. Around 29% and 24% of the respondents make one and two weekly social trips respectively. For personal errands, 31% of the respondents make one and 21% of the respondents make two weekly round trips. For further understanding, the survey also collected the daily travel log of the respondents.

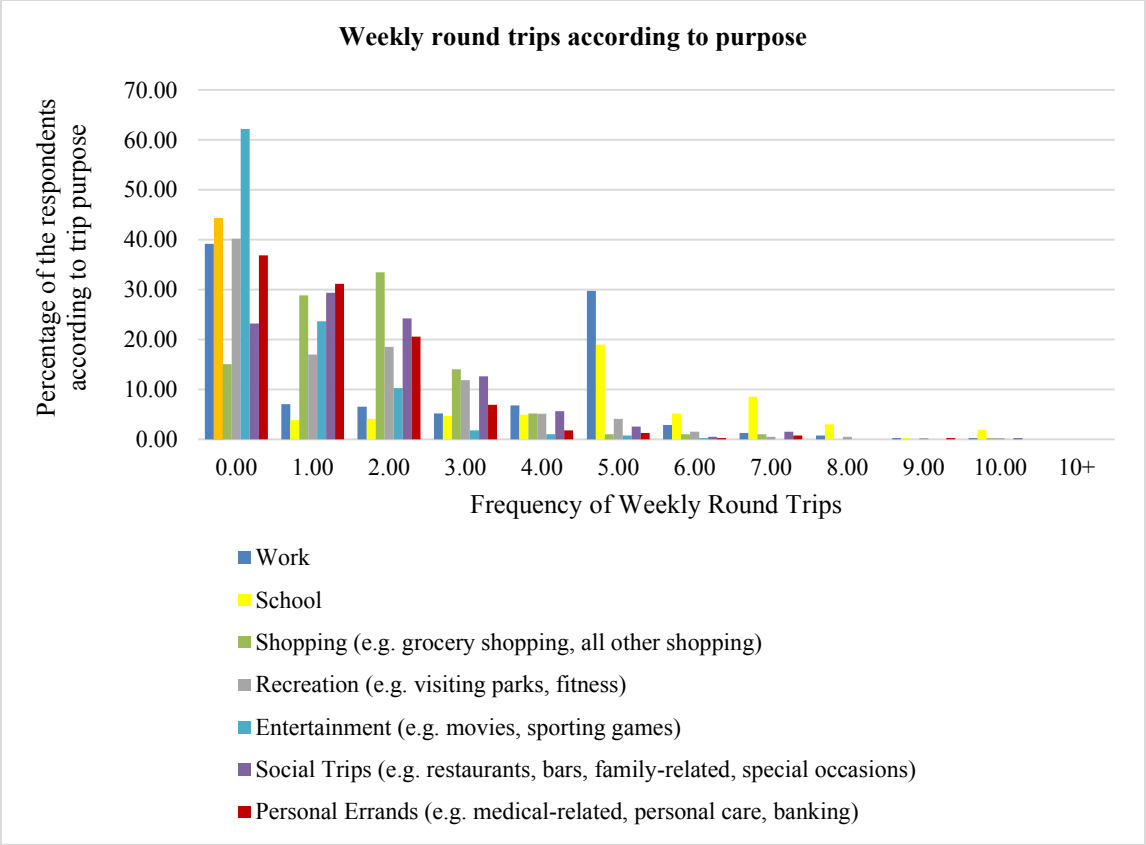

Figure 8: Percentage of the Respondents according to Trip Purpose and Frequency of Weekly Round Trips

Table 1 shows the average number of weekly round trips made by the respondents. Highest number of round trips among the respondents are made for school (3.33) or work (2.62) related trips and lowest value (0.59) stands for entertainment purposes.

Table 1: Average Frequency of Round Trips in a Week

Purpose	**Average**
Work	2.62
School	3.33
Shopping (e.g. grocery shopping, all other shopping)	1.89
Recreation (e.g. visiting parks, fitness)	1.55
Entertainment (e.g. movies, sporting games)	0.59
Social Trips (e.g. restaurants, bars, family-related, special occasions)	1.70
Personal Errands (e.g. medical-related, personal care, banking)	1.19

2.3.2.2 Number of Daily Trips, Trip Duration and Trip Distance

Respondents are asked to report a travel log for the last weekday and last weekend. Figure 9 show the percentage of the respondents according to the number of trips made in a typical weekday and weekend. For weekday trips, 34% of the respondents make 1- 2 trips per day and 35% make 3 - 4 trips per day. 32% of the respondents make 5 or more trips per day. The average number of trips made per day is 3.7 (Table 2).

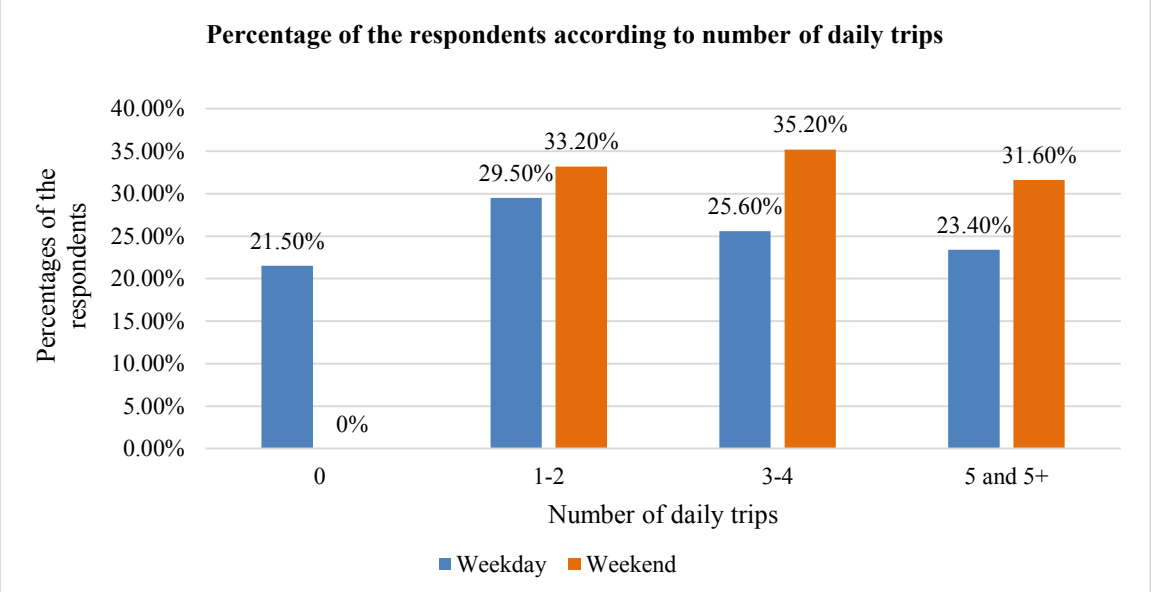

Figure 9: Percentage of the Respondents according to Number of Daily Trips

However, in weekends, around 22% of the respondents do not make any trips. Around 30% of the respondents make 1-2 trips, 35% make 3-4 trips and 32% make 5 or more trips in a day.

Table 2: Average of Number of Trips, Duration and Distance Travelled in a Day

	Average	
	Weekday	**Weekend**
Average number of trips in a day (all purposes)	3.7	3.5
Average duration of total trips made in a day (all purposes)	66.72	50.60
Average total distance travelled in a day (all purposes)	25.75	27.28

Figure 10 and 11 show the total travel time and total distance travelled in typical weekday and weekends according to the percentage of the respondents. The survey results show that in weekday, only 7.5% of the respondents travel for less than 20 minutes in a day. Most of the respondents travel more than half an hour in a day. In addition, 26% of the respondents travel half an hour to 1 hour, 21% of the respondents travel 1 hour to 1.5 hour and 24% of the respondents travel more than 1.5 hour in a day.

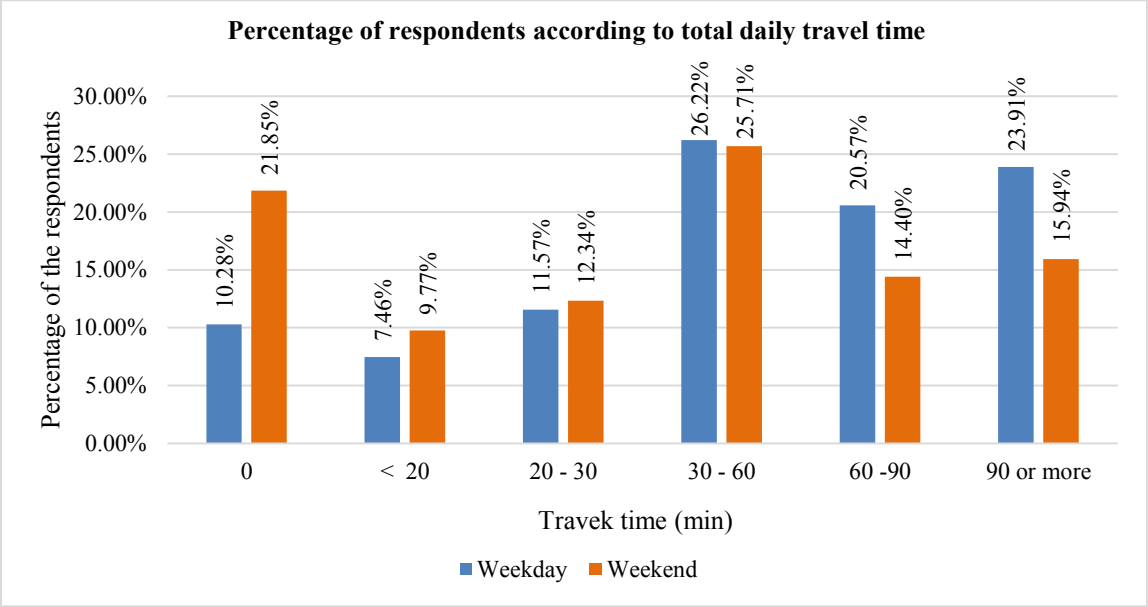

Figure 10: Percentage of the Respondents according to Daily Total Travel Time

In a typical weekend, one fourth (around 26%) of the respondents travel between half an hour to 1 hour in total. Only 14% travel between 1 hour to 1.5 hour and 16% travel more than 1.5 hours. The average of weekday and weekend travel duration of smartphone users are 66.72 minutes and 50.60 minutes respectively. The findings are also similar with the results of Nova Scotia Travel Activity (NovaTRAC) Survey – 2015, where average daily travel time was found to be 61 minutes for Nova Scotians (Habib, 2016).

While considering distance travelled, the survey analysis suggest that most of the respondents (28%) usually travel between 10 to 30 km in a weekday (Figure 11). On the other hand, 19% travel less than 5 Km a day. In weekends, 20% of the respondents travel

between 10 -30 Km per day. 16% of them travel less than 5 Km and 14% of them travel 5 - 10 Km per weekend. On average, smartphone users travel 25.75km in weekday and 27.28 km in weekends. In the NovaTRAC survey, the average vehicle kilometer travelled was found 27 Km per day.

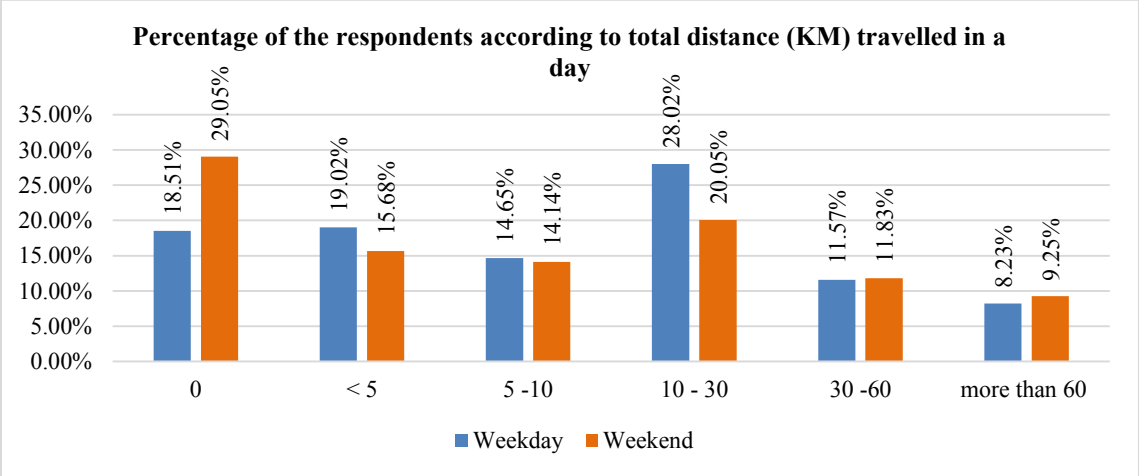

Figure 11: Percentage of the respondents according to daily total distance travelled (Km)

2.3.2.3 Trip Purpose, Mode Choice and Accompany Arrangement

Figure 12 represents mode choice according to the purpose of the daily trips. It is very promising that around 48% of the school trips are made by walking/biking and 32% are made by transit. Only 20% of the school trips are made by auto. In contrast, for work trips, auto (46%) is more likely to be used compared to transit (29%) and walk/biking (25%). However, except school trips, auto is the most prominent mode choice for all purposes. Highest use of auto (around 63%) has been seen for social trips. Similarly, transit use is very low (12 -16%) for shopping, social trips, recreation, entertainment and personal errands. However, half of the respondent usually walk/bike for personal errands.

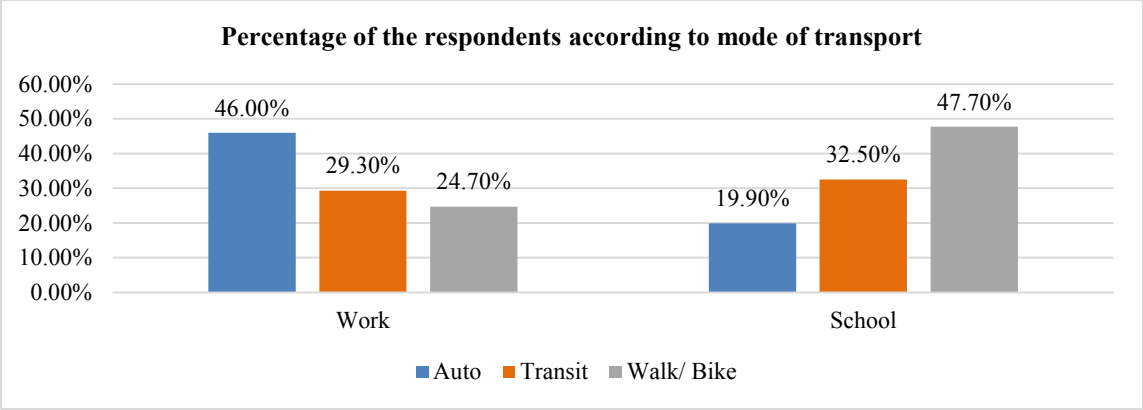

Figure 12a: Percentage of the Respondents according to Mode of Transport by Weekday Work and School Travel

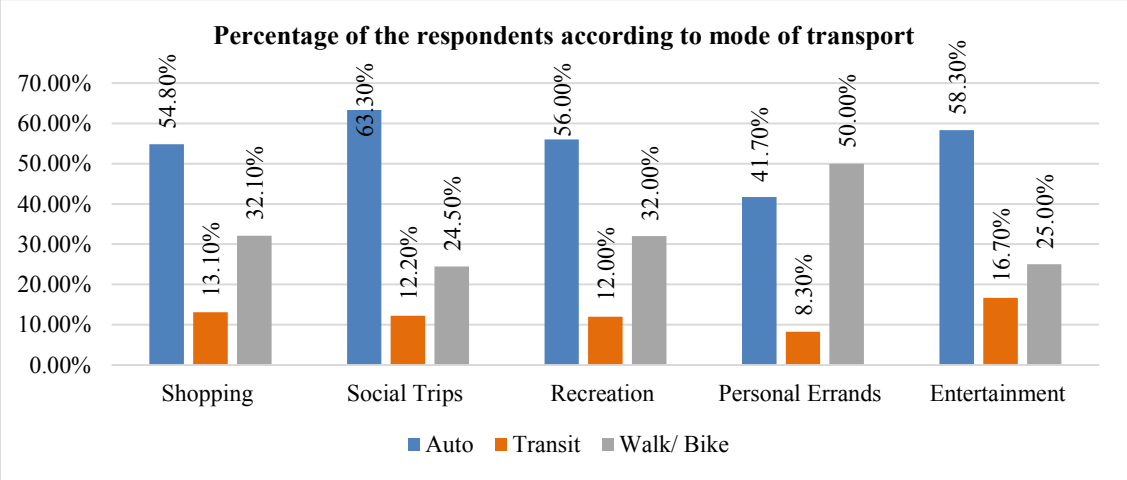

Figure 12b: Percentage of the Respondents according to Mode of Transport by Weekend Non-work Travel

Figure 13 shows type of accompany arrangement according to the purpose of the trip. It is very interesting that, for both work and school trips, more than 80% of the travel are made alone. However, for other non-work trips, the percentage of making trips alone is decreasing. For example: in case of shopping trips, 52% are made alone and around 33% are made with the family members. 35% of the social trips are made with family members and 37% with friends and relatives. Half of the entertainment related trips are made with the family members. However, more than two thirds (68%) of the personal errand trips are made alone.

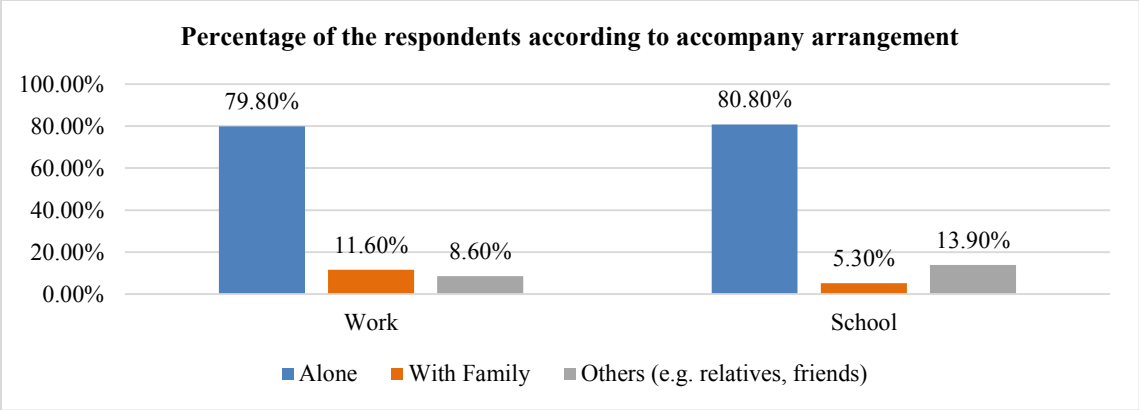

Figure 13a: Percentage of the Respondents according to Travel Accompany by Weekday Work and School Travel

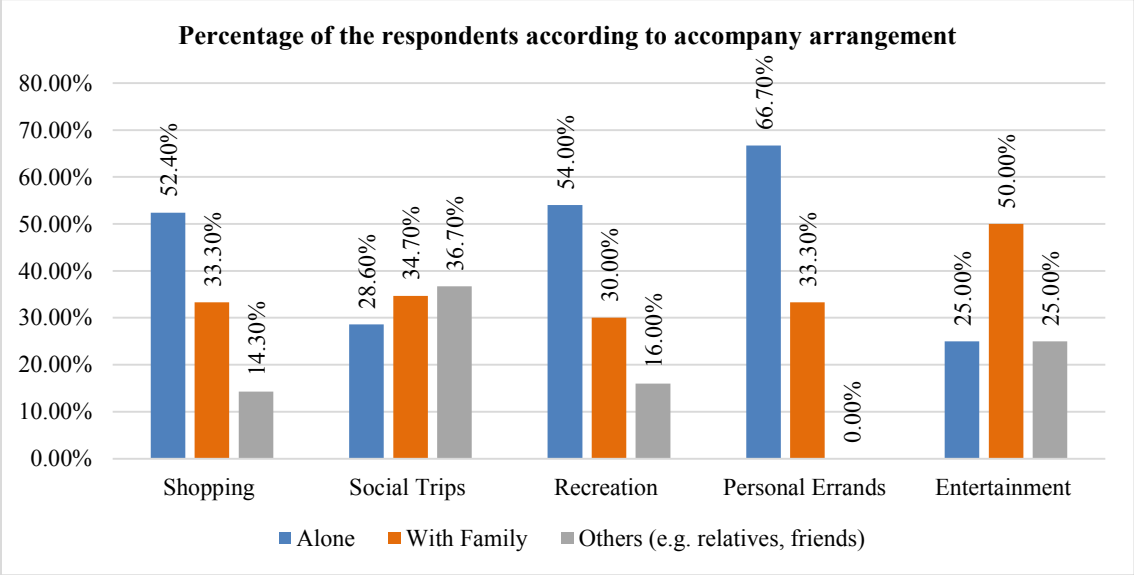

Figure 13b: Percentage of the Respondents according to Travel Accompany by Weekend Non-work Travel

2.3.2.4 Mobility Tool Ownership

2.3.2.4.1 Number of Vehicles in the Household

Surprisingly, 36.76% of the respondent do not own any vehicles in the household (Figure 14). Arguably, because of high percentage of young people and student group's presence in this smartphone users' sample, most of the respondents are living as a single person household and thus their household don't own any vehicle. Regarding vehicle owners, 36.76% of the respondents have one and 18.25% own two vehicles in the household.

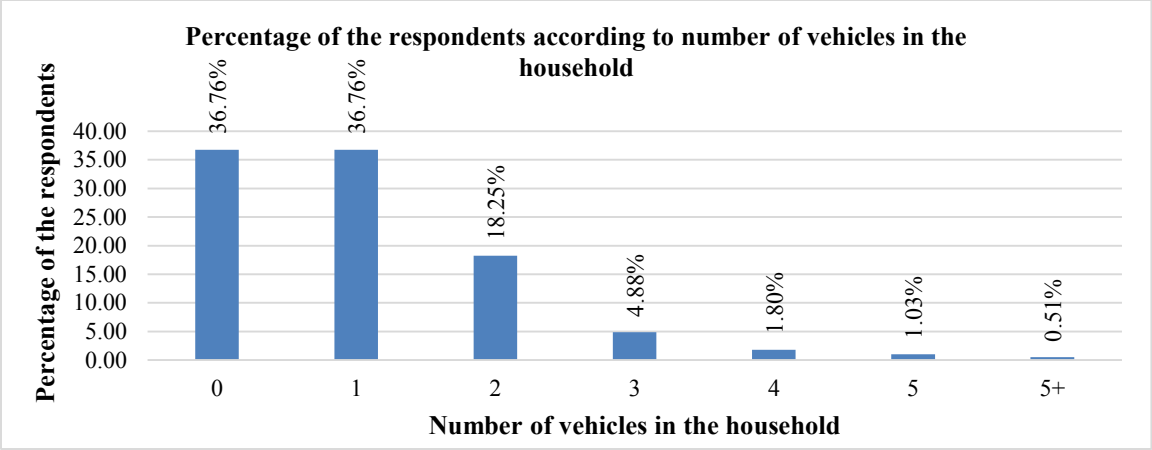

Figure 14: Percentage of the Respondents according to Number of Vehicles in the Household

2.3.2.4.2 Number of Bicycles in the Household

Bicycle ownership is also low among the respondents (Figure 15). More than one third (36.76%) of the respondents doesn't own any bicycle and 23.65% of the respondents' household own one bicycle.

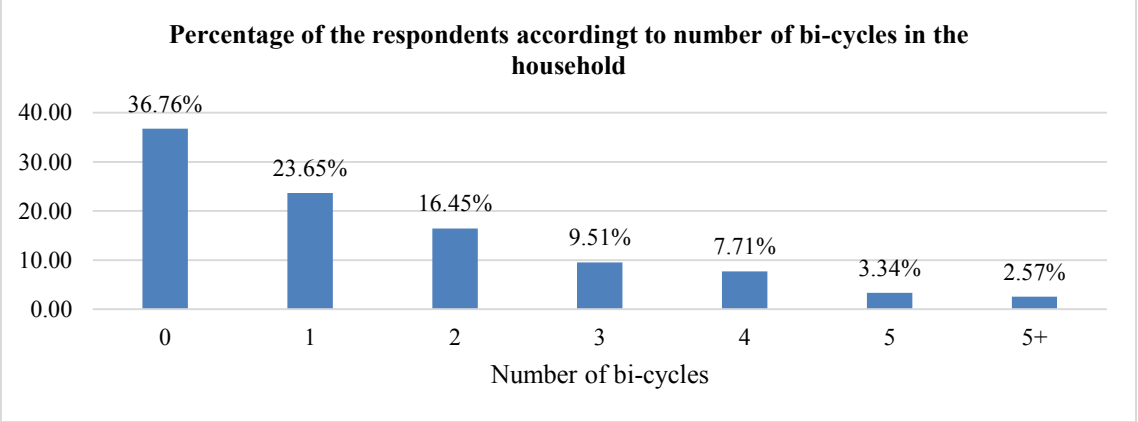

Figure 15: Percentage of the Respondents according to Number of Bi-cycles in the Household

2.3.2.4.3 Transit Pass Ownership

Transit pass ownership is higher among the respondents (67.87%). Only 32.13% of the respondents did not own transit pass for the last month of the survey period (Figure 16).

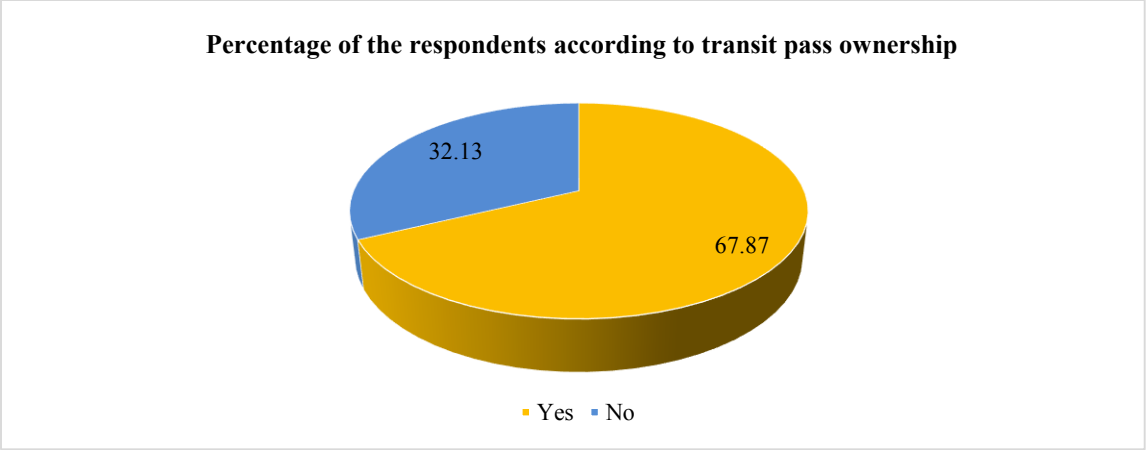

Figure 16: Percentage of the Respondents according to Transit Pass Ownership

2.3.3 Attitudes and Life-Style Choice Preference

Figure 17 presents seven attitudinal and life-style choice related attributes considered in the survey. Overall the responses show that smartphone users can easily adapt to new technologies. More than 80% acknowledge that they can easily adapt new technologies. Moreover, around 70% agreed on improvement of daily life due to smartphone use. Proximity to shops and services are important to more than 90% of the respondents. Though smartphone users have the opportunity to perform online tasks, accessibility to necessary facilities is also important to them. Smartphone users hold positive attitudes towards environment. More than 80% agree that they make sustainable life-style choices whenever possible. On the other hand, around 55% have took initiatives like limiting their driving because of environmental concern. Possibly, they are performing online tasks rather than travelling. More than half of the respondents agree on implementation of policies such as fining households for emitting greenhouse gas above a daily set limit. Half of the respondents (58%) also agree that to them travel time is generally a wasted time.

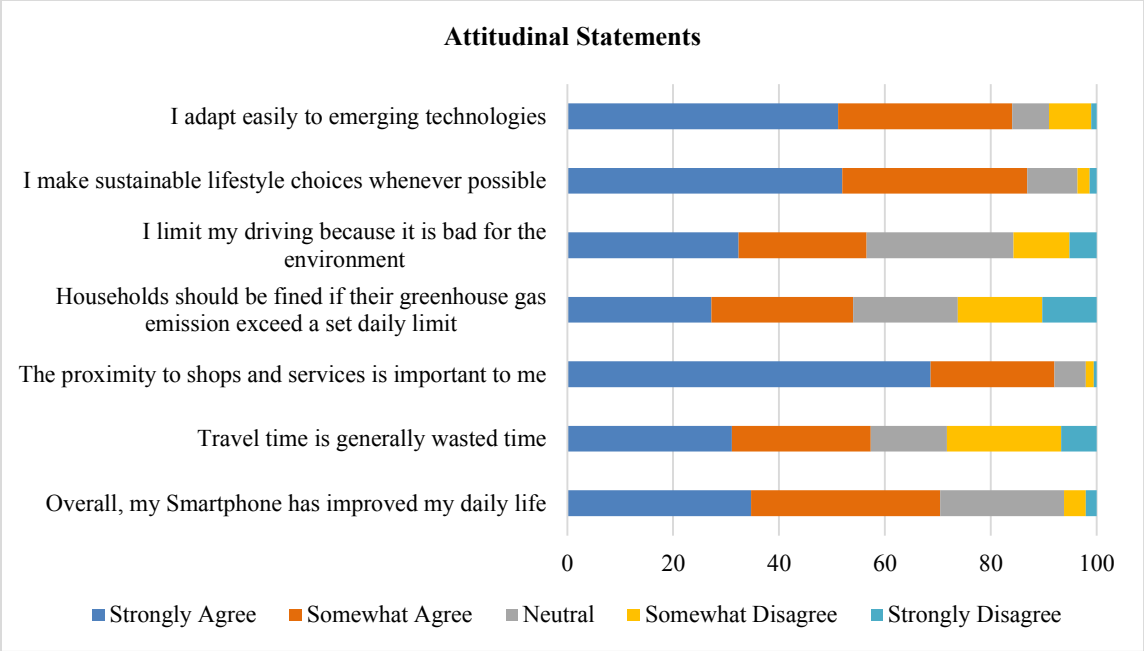

Figure 17: Respondents' Level of Agreement on Attitudinal Statements

2.4 Smartphone Usage Pattern of the Respondents

2.4.1 Years of Smartphone Use

Figure 18 suggests that around two thirds (65.81%) of the respondents are using smartphones for more than 3 years whereas only 6.43% are the novice users of smartphones.

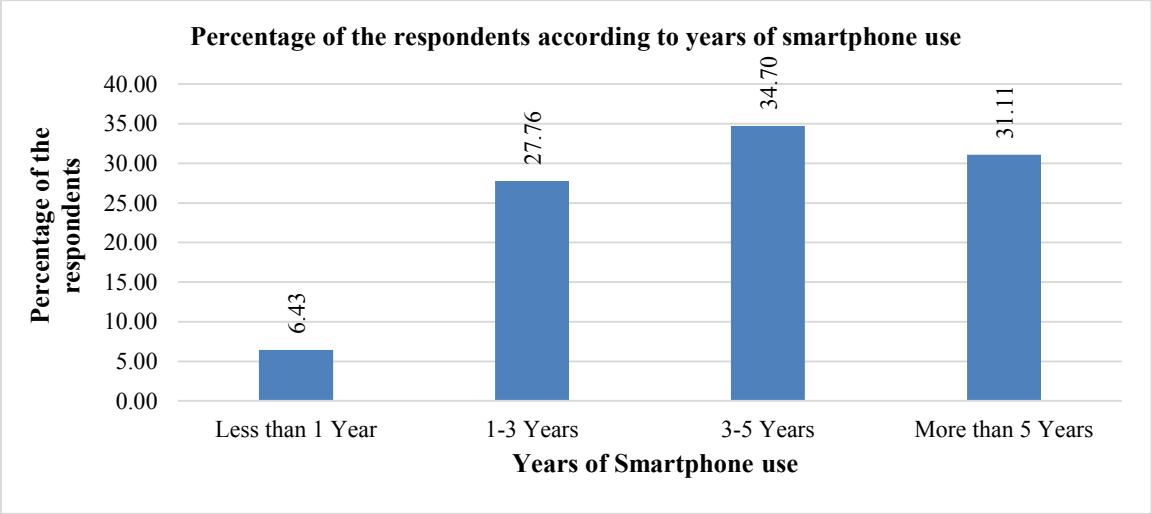

Figure 18: Percentage of the Respondents according to Years of Smartphone Use

2.4.2 Impact of Smartphone on Frequency of Trips

Figure 19 depicts how respondents perceive the impact of smartphone use on their frequency of trips according to trip purpose. Around 43% feel that smartphone use has increased their frequency of social trips. More than one fourth (29%) think that smartphone has increased entertainment related trips and around one third of the respondents (33%) agreed that smartphone use has increased their recreation related trips. Nevertheless, around 29% of the respondents think that smartphone use has decreased their personal errands trips and 19% of the respondents have observed decrease in shopping related trips. It is interesting that more than half of the respondents think that smartphone use has no impact on frequency of trips. Highest percentage of respondents reported 'No Impact' for shopping (74.29%) and personal errands (61.44%) related trips.

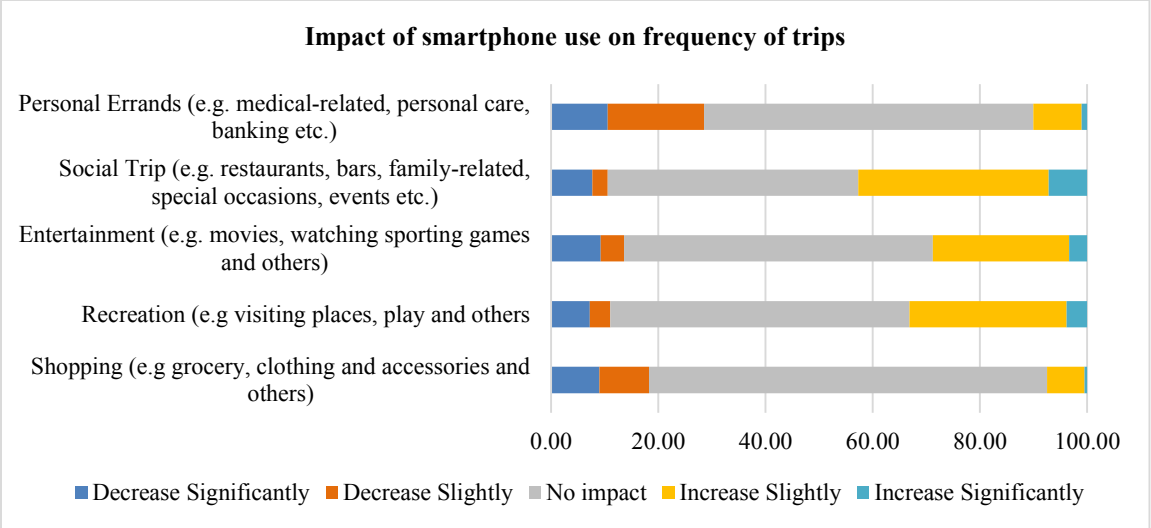

Figure 19: Extent of Impact of Smartphone Use on Frequency of Trips by Purpose

39.59% of the respondents didn't buy anything online in the last month (Figure 20). 45.24% of them purchased 1-2 times in the last month and rest of the 14.17% purchased 3 or more times in the last month. Respondents are also asked specifically about the impact of smartphone use on e-shopping. Figure 21 shows that around 35% of the respondents think that smartphone use has decreased their shopping related trips. In contrast very few (less than 2%) mentioned increase in shopping trips due to online purchase. However, more than 60% of the respondents mentioned e-shopping do not have any impact on shopping related trips.

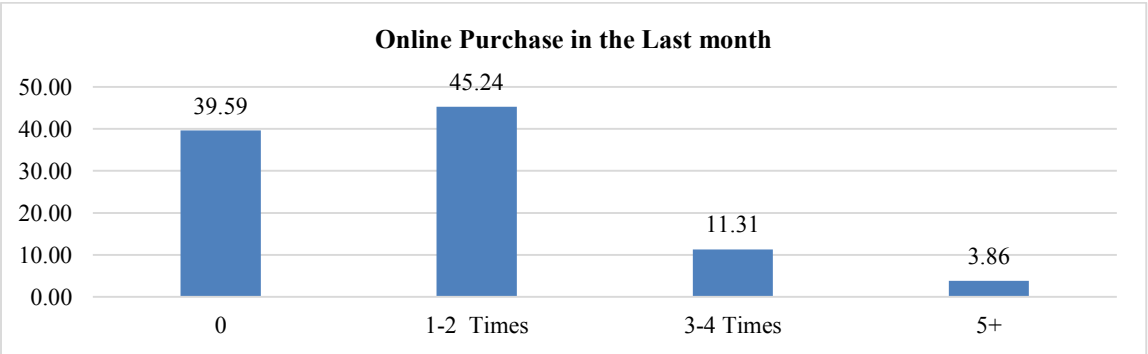

Figure 20: Percentage of the Respondents according to Number of Online Shopping

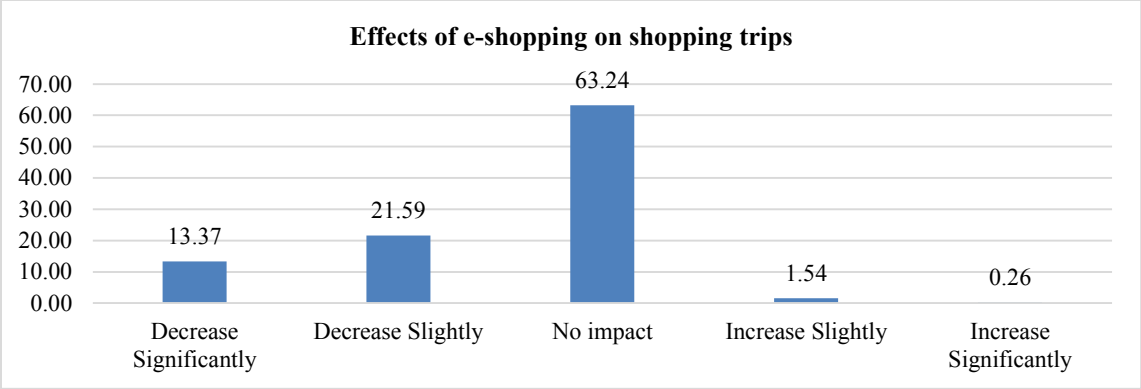

Figure 21: Percentage of the Respondents according to Effects of e-shopping on Shopping Trips

2.5 Exploratory Analysis of Smartphone Applications Use and Travel Choices

This section provides an exploratory analysis of the smartphone applications usage data collected through the survey. Responses on smartphone applications use for trip planning and travel outcomes are analysed using chi-square test to explore the inherent relationship between the variables. All socio-demographic and travel attributes are examined and variables that are found significant are included here for discussion.

2.5.1 Use of Smartphone Applications by Purpose

Respondents are asked about their level of dependency on smartphone applications for several purposes on a 5 point Likert Scale ranging from Not Dependent to Highly Dependent. Figure 22 illustrates the summary of their responses. The result reveals that smartphone users are highly dependent on smartphone applications for communication purposes (around 55%). In contrast, more than 40% of the respondents are not dependent on smartphone applications for shopping, recreation and entertainment related activities.

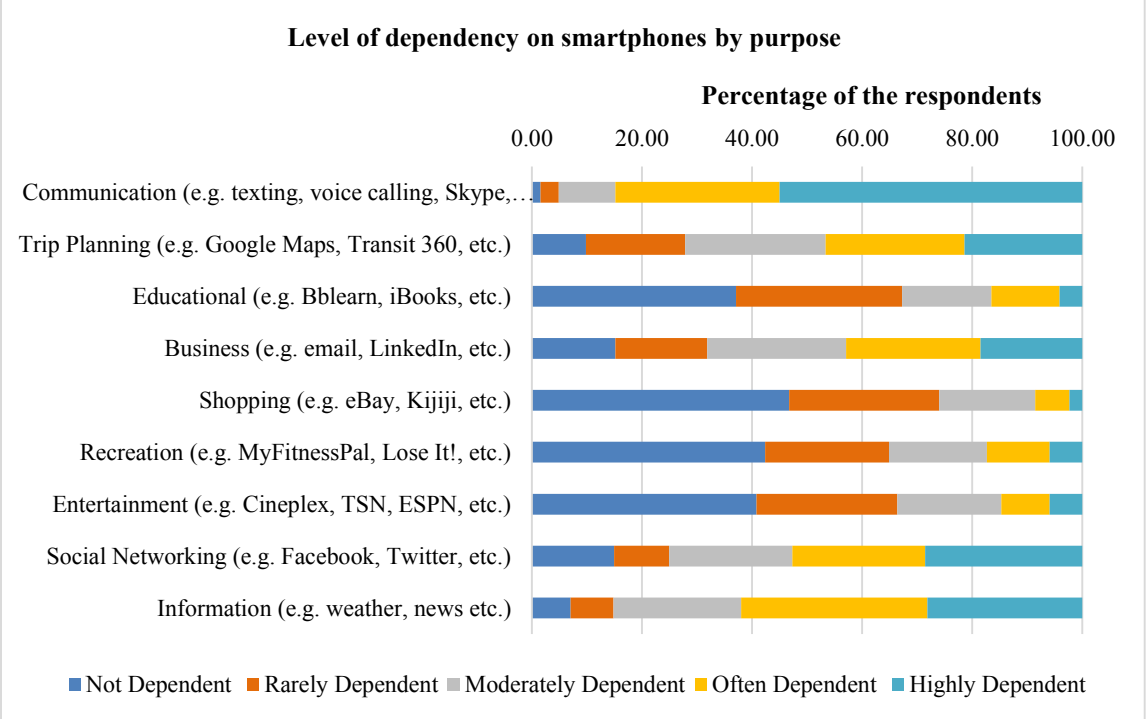

Figure 22: Percentage of the Respondents according to Level of Dependency on Smartphones by Purpose

For a better understanding, responses are converted into a numeric scale such as: 0 = Not Dependent, 1 = Rarely Dependent, 2 = Moderately Dependent, 3 = Often Dependent, 4 = Highly Dependent and their mean value of dependency on smartphone applications according to age group is presented in Figure 23. The respondents are categorized into three groups according to age: 15 - 24 years (likely students), 25- 34 years (likely professional) and 34 - 65+ years (likely workforce). This figure depicts some interesting findings. For example: in Halifax, trip planning was found in the fourth position (Moderately to Often Dependent) among the purposes considered for smartphone use. Communication (Often Dependent to Highly Dependent), information search and social networking (Moderately to Often Dependent) are top three purposes of using smartphone applications. Note that, these activities also assist trip planning. The findings are consistent with the previous studies discussed in the literature section. Nevertheless, results show that the mean value for entertainment, recreation, online shopping, and education are relatively low, which suggests lower use of smartphone applications for these purposes in Halifax. In addition to commonly cited purposes, about forty respondents mentioned some notable 'other' purposes on which they are often dependent. Notable other purposes include gaming applications, clock and alarm, reminders, and scheduling.

Furthermore, results suggest (Figure 23) that young people are the frequent users of smartphone applications. Students (15 - 24 years) and young professionals (25 - 34 years) are more dependent on smartphone applications compared to the mature workforce (35 - 65+ years). In the case of communication, social networking, and trip planning, 15 - 24 years and 25 - 34 years old users have high mean dependency score than the average of the total sample. Young professionals use smartphone applications more frequently for information search and trip planning compared to all other age groups. Their mean score is even higher than the mean score of the total sample. Though the sample mean value is very low, young professionals are showing a higher dependency on smartphone applications among all age groups for entertainment, recreation, and shopping. As expected, the student group uses it for educational purposes more than any other age group.

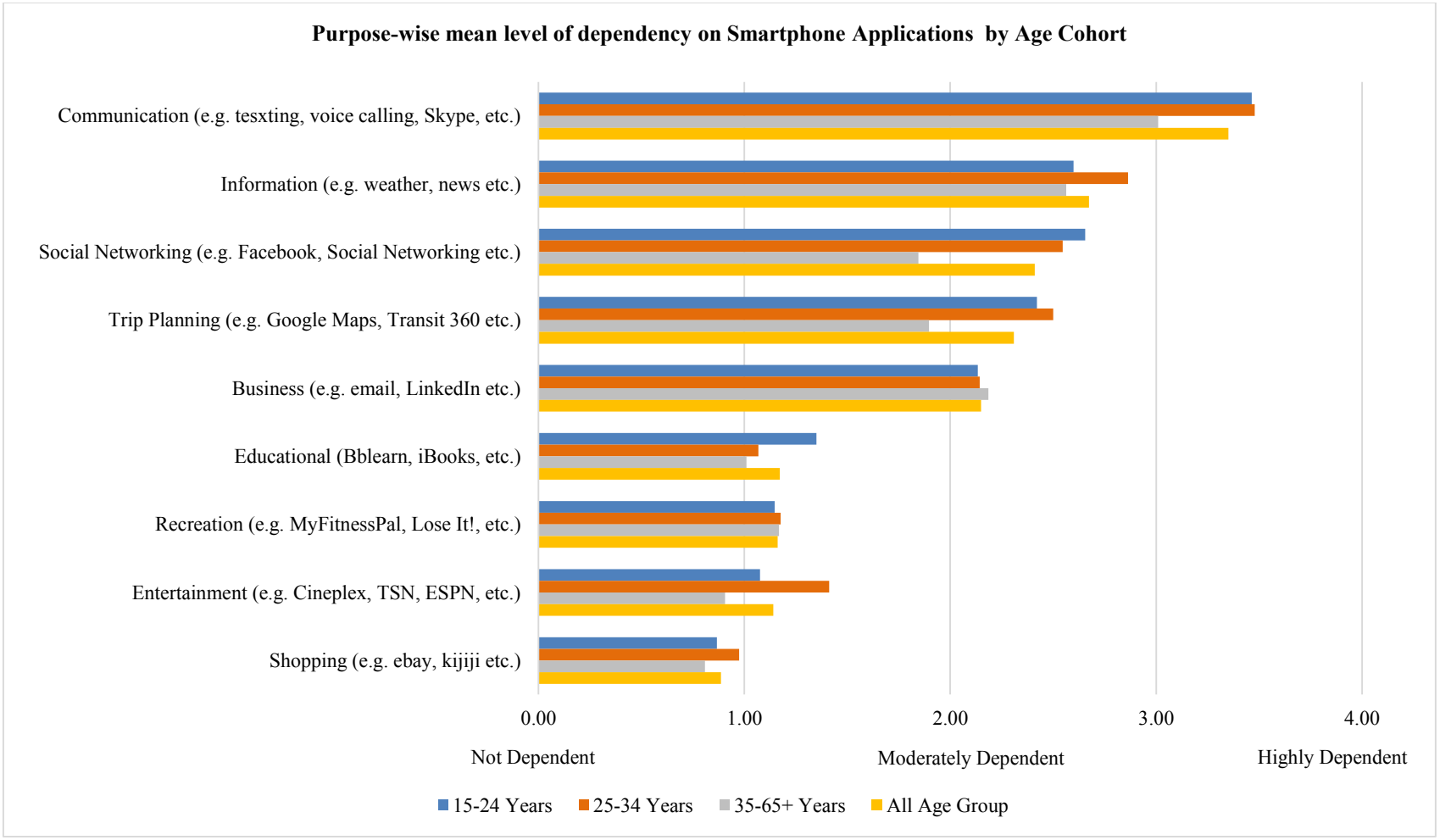

Figure 23: Purpose-wise Mean Level of Dependency on Smartphone Applications by Age Cohort

2.5.2 Use of Smartphone Applications for Trip Planning Activities

Following two Figures 24 and 25 show the dependency on smartphone applications as well as social networking applications for trip planning activities. For smartphone applications, higher dependency (often/always) is seen for communicating and coordinating trips with others (63%) and deciding departure time (48%). However, individuals are very less dependent (Never/Rarely/Sometimes) on smartphone applications for deciding trip destinations (81%).

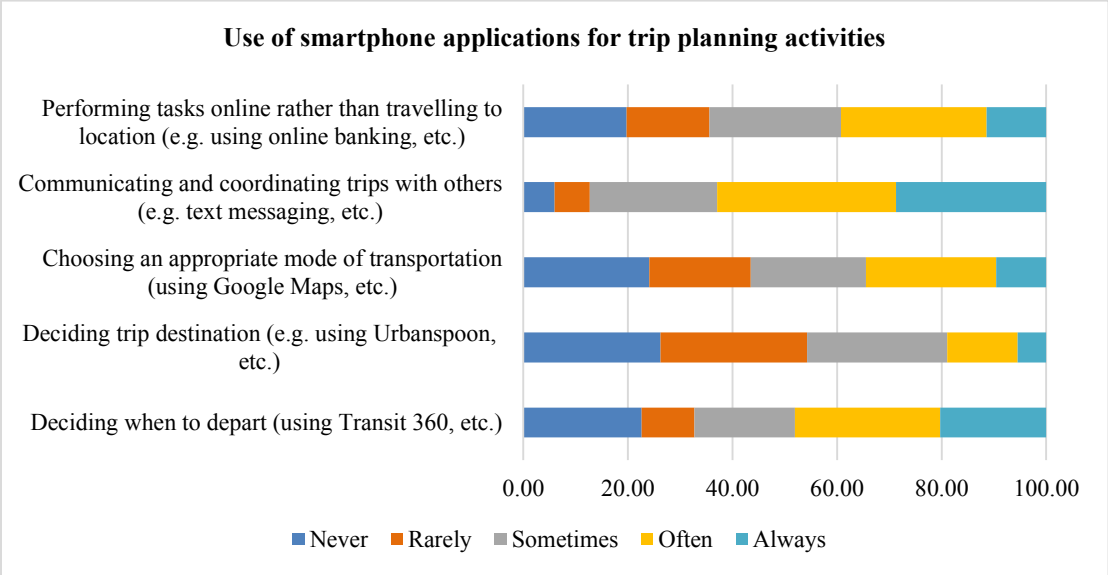

Figure 24: Frequency of Using Smartphone Applications for Trip Planning

On the other hand, dependency on social networking applications for trip planning purposes are very low (Figure 25). The highest use for social networking applications are seen for communicating and coordinating trips with others where percentage for higher use (often/always) is around 35% and medium use (sometimes) is around 30%.

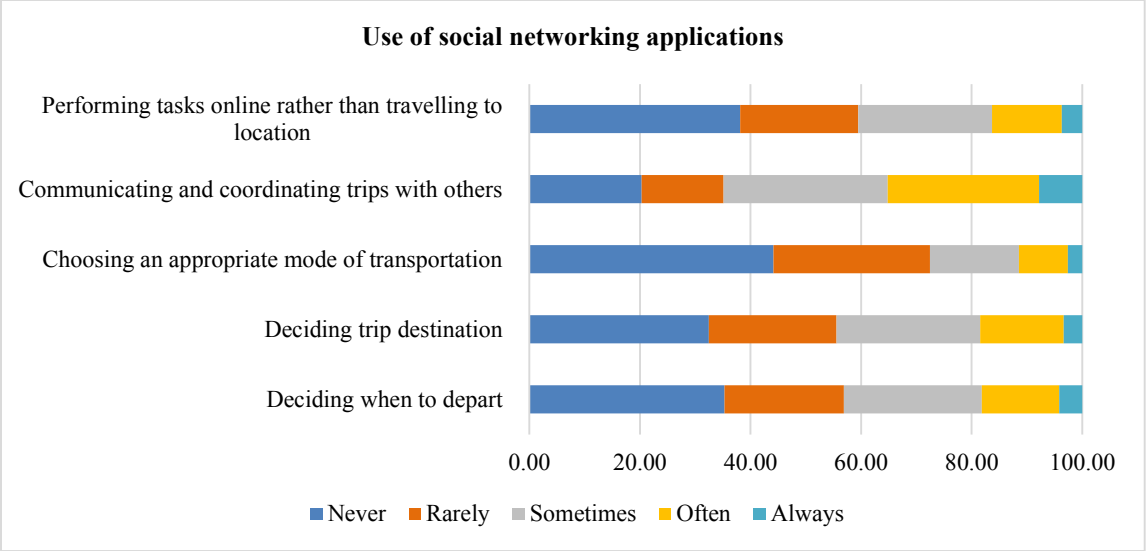

Figure 25: Dependency on Social Networking Applications

The relationship between smartphone application use on trip planning and socio-demographic and travel characteristics (if there is any) will show how the use of smartphone applications vary among several groups. A chi-square test is performed to find out the inherent relationship between variables (Table 3). For this statistical test, the null hypothesis is that there is no relationship between trip planning purposes and other variables considered. For years of smartphone usage, chi-square test rejects the null hypothesis for deciding trip destination, coordinating trips with others, and performing tasks online rather than going to the location which are significant at the 5% level. Among those who are using smartphone for less than 1 year, 56% of them never used a smartphone application for deciding trip destination where the percentage is only 19.30% among those who are using more than 5 years. For coordinating trips and performing online tasks, the change is 36% to 3.30% and 48% to 10.30%, respectively. Based on the analysis, it can be stated that the higher the years of smartphone use, the higher propensity of using smartphone applications for trip planning. Arguably, the longer a person is using a smartphone, the more used to the applications they will become, and thus their probability of using it for daily trip planning will increase.

Table 3: Smartphone Application Use for Trip Planning

Smartphone Application use for trip planning activities		Years of smartphone use				Age (years)			Number of Private Vehicle				Transit Pass Ownership		Row Total
		Less than 1 Year	1-3 Years	3-5 Years	More than 5 years	15-24	25 - 34	35 - 65+	0	1	2	3 or more	Yes	No	
Deciding when to depart (e.g. using Transit 360)	Never	40.00%	25.20%	20.50%	19.20%	15.2%	17.6%	40.2%	12.1%	27.5%	37.1%	16.1%	15.3%	38.2%	22.70%
	Rarely to Sometimes	20.00%	33.60%	28.80%	28.30%	29.7%	26.9%	32.0%	24.1%	31.7%	34.3%	32.3%	27.6%	33.3%	29.40%
	Often to Always	40.00%	41.10%	50.80%	52.50%	55.1%	55.5%	27.8%	63.8%	40.8%	28.6%	51.6%	57.1%	28.5%	47.90%
	Total	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.00%
	Chi-square test	$X^2 = 8.136$, $df = 6$, $p = 0.228$				$X^2 = 30.23$, $df = 4$, $p = 0.000$			$X^2 = 32.24$, $df = 6$, $p = 0.000$				$X^2 = 34.569$, $df = 2$, $p = 0.000$		
Deciding trip destination (e.g. Urbanspoon etc.)	Never	56.00%	30.80%	23.30%	19.30%	21.5%	21.0%	39.2%	15.6%	31.0%	43.5%	15.6%	20.4%	38.7%	26.30%
	Rarely to Sometimes	32.00%	54.20%	54.10%	61.30%	57.6%	60.5%	47.4%	61.0%	53.5%	43.5%	59.4%	56.5%	51.6%	54.90%
	Often to Always	12.00%	15.00%	22.60%	19.30%	20.9%	18.5%	13.4%	23.4%	15.5%	13.0%	25.0%	23.1%	9.7%	18.80%
	Total	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.00%
	Chi-square test	$X^2 = 17.663$, $df = 6$, $p = 0.007$				$X^2 = 12.499$, $df = 4$, $p = 0.014$			$X^2 = 23.501$, $df = 6$, $p = 0.001$				$X^2 = 19.130$, $df = 2$, $p = 0.000$		
Choosing an appropriate mode of transportation (e.g. Google Maps etc.)	Never	48.00%	27.10%	21.80%	19.20%	17.1%	20.2%	40.8%	12.1%	28.9%	42.9%	15.6%	17.2%	38.7%	24.20%
	Rarely to Sometimes	40.00%	38.30%	43.60%	42.50%	44.3%	37.8%	41.8%	43.3%	44.4%	30.0%	46.9%	39.8%	45.2%	41.60%
	Often to Always	12.00%	34.60%	34.60%	38.30%	38.6%	42.0%	17.3%	44.7%	26.8%	27.1%	37.5%	42.9%	16.1%	34.30%
	Total	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.00%
	Chi-square test	$X^2 = 12.456$, $df = 6$ $p = 0.053$				$X^2 = 27.112$, $df = 4$, $p = 0.000$			$X^2 = 31.715$, $df = 6$, $p = 0.000$				$X^2 = 34.198$, $df = 2$, $p = 0.000$		
Communicating and coordinating trips with others (e.g. text messaging etc.)	Never	36.00%	4.70%	3.80%	3.30%	3.8%	4.2%	10.2%	4.3%	7.7%	4.3%	9.4%	4.2%	9.7%	6.00%
	Rarely to Sometimes	24.00%	32.70%	32.30%	30.00%	23.4%	29.4%	45.9%	27.7%	32.4%	35.7%	31.3%	27.2%	39.5%	31.20%
	Often to Always	40.00%	62.60%	63.90%	66.70%	72.8%	66.4%	43.9%	68.1%	59.9%	60.0%	59.4%	68.6%	50.8%	62.90%
	Total	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.00%
	Chi-square test	$X^2 = 43.508$, $df = 6$, $p = 0.000$				$X^2 = 23.312$, $df = 4$, $p = 0.000$			$X^2 = 4.456$, $df = 6$, $p = 0.615$				$X^2 = 12.514$, $df = 2$, $p = 0.002$		
Performing tasks	Never	48.00%	33.30%	11.60%	10.30%	15.5%	16.9%	28.7%	15.2%	22.9%	22.1%	20.0%	16.5%	26.4%	19.70%
	Rarely to Sometimes	24.00%	40.00%	47.30%	38.50%	47.1%	36.4%	38.3%	44.9%	43.6%	33.8%	26.7%	40.0%	43.0%	41.00%

Smartphone Application use for trip planning activities		Years of smartphone use				Age (years)			Number of Private Vehicle				Transit Pass Ownership		Row Total
		Less than 1 Year	1-3 Years	3-5 Years	More than 5 years	15-24	25 - 34	35 - 65+	0	1	2	3 or more	Yes	No	
online rather than travelling to location (e.g. using online banking etc.)	Often to Always	28.00%	26.70%	41.10%	51.30%	37.4%	46.6%	33.0%	39.9%	33.6%	44.1%	53.3%	43.5%	30.6%	39.40%
	Total	100.00%	100.00%	100.00%	100.00%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.00%
	Chi-square test	$X^2 = 42.321$, $df = 6$, $p = 0.000$				$X^2 = 10.656$, $df = 4$, $p = 0.031$			$X^2 = 8.497$, $df = 6$, $p = 0.204$				$X^2 = 7.823$, $df = 2$, $p = 0.020$		

Table 4: Smartphone Application Use for Trip Planning (2)

Smartphone Application use for trip planning		Mode for work/school trips			Number of Daily Trips (Weekday)			Trip Duration of Work/School Trips (min)				Distance between Home and Work/School (km)				Row Total
		Auto	Transit	Walk/ Bike	0-2	3-4	5 and more	10	20	30	More than 30	0 to 1	1+ to 2	2+ to 5	More than 5	
Deciding when to depart (e.g. using Transit 360)	Never	31.4%	16.7%	18.5%	26.0%	17.8%	24.6%	17.9%	26.4%	18.2%	29.9%	20.8%	16.7%	26.0%	33.0%	22.70%
	Rarely to Sometimes	32.1%	18.4%	36.2%	31.5%	25.2%	32.0%	31.6%	24.0%	40.0%	28.4%	32.1%	27.8%	23.3%	32.2%	29.40%
	Often to Always	36.4%	64.9%	45.4%	42.5%	57.0%	43.4%	50.5%	49.6%	41.8%	41.8%	47.2%	55.6%	50.7%	34.8%	47.90%
	Total	100.0 %	100.0%	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.00 %
	Chi-square test	$X^2 = 25.52, df = 4, p = 0.000$			$X^2 = 7.14, df = 4, p = 0.129$			$X^2 = 8.21, df = 6, p = 0.223$				$X^2 = 11.64, df = 6, p = 0.071$				
Deciding trip destination (e.g. Urbanspoon etc.)	Never	26.6%	27.2%	25.2%	28.3%	21.3%	29.8%	22.1%	28.1%	18.2%	38.2%	18.9%	16.7%	35.6%	34.8%	26.30%
	Rarely to Sometimes	57.6%	46.5%	59.5%	52.8%	64.0%	47.1%	58.9%	52.3%	65.5%	45.6%	67.9%	62.5%	46.6%	47.8%	54.90%
	Often to Always	15.8%	26.3%	15.3%	18.9%	14.7%	23.1%	18.9%	19.5%	16.4%	16.2%	13.2%	20.8%	17.8%	17.4%	18.80%
	Total	100.0 %	100.0%	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.00 %
	Chi-square test	$X^2 = 7.22, df = 4, p = 0.125$			$X^2 = 7.94, df = 4, p = 0.094$			$X^2 = 8.72, df = 6, p = 0.190$				$X^2 = 13.66, df = 6, p = 0.034$				
Choosing an appropriate mode of transportation (e.g. Google Maps etc.)	Never	34.3%	20.2%	16.8%	27.6%	18.4%	27.0%	20.0%	25.6%	16.4%	35.3%	17.0%	9.7%	32.9%	32.8%	24.20%
	Rarely to Sometimes	39.3%	32.5%	51.9%	40.9%	44.1%	39.3%	43.2%	38.0%	47.3%	38.2%	47.2%	50.0%	35.6%	34.5%	41.60%
	Often to Always	26.4%	47.4%	31.3%	31.5%	37.5%	33.6%	36.8%	36.4%	36.4%	26.5%	35.8%	40.3%	31.5%	32.8%	34.30%
	Total	100.0 %	100.0%	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.00 %
	Chi-square test	$X^2 = 24.01, df = 4, p = 0.000$			$X^2 = 3.99, df = 4, p = 0.407$			$X^2 = 8.23, df = 6, p = 0.222$				$X^2 = 17.43, df = 6, p = 0.008$				
Communicating and coordinating trips with others (e.g. text messaging etc.)	Never	7.1%	7.0%	3.8%	10.2%	2.9%	4.9%	4.2%	3.9%	1.8%	11.8%	3.8%	5.6%	5.5%	6.9%	6.00%
	Rarely to Sometimes	31.4%	29.8%	32.1%	30.7%	34.6%	27.9%	28.4%	27.1%	30.9%	45.6%	26.4%	36.1%	24.7%	35.3%	31.20%
	Often to Always	61.4%	63.2%	64.1%	59.1%	62.5%	67.2%	67.4%	69.0%	67.3%	42.6%	69.8%	58.3%	69.9%	57.8%	62.90%
	Total	100.0 %	100.0%	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.00 %
	Chi-square test	$X^2 = 1.73, df = 4, p = 0.785$			$X^2 = 7.78, df = 4, p = 0.100$			$X^2 = 18.44, df = 6, p = 0.005$				$X^2 = 4.88, df = 6, p = 0.559$				

Smartphone Application use for trip planning		Mode for work/school trips			Number of Daily Trips (Weekday)			Trip Duration of Work/School Trips (min)				Distance between Home and Work/School (km)				Row Total
		Auto	**Transit**	**Walk/ Bike**	**0-2**	**3-4**	**5 and more**	**10**	**20**	**30**	**More than 30**	**0 to 1**	**1+ to 2**	**2+ to 5**	**More than 5**	
Performing tasks online rather than travelling to location (e.g. using online banking etc.)	Never	19.9%	21.6%	17.8%	21.0%	18.5%	19.7%	12.9%	19.8%	14.5%	35.4%	13.5%	19.7%	26.8%	23.0%	19.70%
	Rarely to Sometimes	36.8%	34.2%	51.2%	41.1%	43.0%	38.5%	45.2%	39.7%	43.6%	33.8%	53.8%	38.0%	43.7%	33.6%	41.00%
	Often to Always	43.4%	44.1%	31.0%	37.9%	38.5%	41.9%	41.9%	40.5%	41.8%	30.8%	32.7%	42.3%	29.6%	43.4%	39.40%
	Total	100.0 %	100.0%	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.00 %
	Chi-square test	X^2 =9.02 , df =4, p = 0.061			X^2 = 0.788 df =4, p = 0.940			X^2 =13.68 , df =6, p = 0.033				X^2 = 9.49, df =6, p = 0.148				

On the other hand, age is negatively related with applications use for trip planning (Table 3). Among the age cohorts, 35-65+ years old are less likely to use a smartphone for deciding departure time, destination, and mode choice, as around 40% of them do not use smartphone applications for these purposes. The proportion, mentioning often to always is very low compared to 15-24 years and 25-34 years. Among 35-65+ years old, usage of smartphone applications is noticeably more for coordinating trips with others and performing task online (from Often to Always: 43.9% and 33% respectively). The percentage of students (15-24 years) and young professionals (25-34 years) are almost similar in often to always for deciding departure time (55.1% and 55.5% respectively) and coordinating trips with others (72.8% and 66.4% respectively). The largest percentage among these groups (57.6% of students and 60.5% of young professional) defined their smartphone application use as rarely to sometimes for deciding trip destination. This result proves that students and young professionals are more dependent on smartphone applications for all trip planning purposes than the workforce. However, the workforce use smartphone applications more for coordinating trips with others and performing a task online, rather than going to the location, compared to other trip planning purposes. Although the age groups are not exactly the same, findings differ with results of Srinivasan and Athuru (2004), where they found that older respondents (50+) prefer to participate in physical rather than virtual activities. Comparing these two studies, it appears that older generations are emerging as the new adopters of smartphone applications.

There are also some interesting findings with respect to vehicle ownership (Table 3). Individuals with no private vehicle in the household rely on smartphone applications more heavily for trip planning decisions compared to vehicle owners. For all types of purposes, the percentage of respondents who never use smartphone applications varies between 4.3% to 15.6% only. The chi-square test confirms the significance (at 5% level) of the relationship between vehicle ownership and departure decision, decision on trip destination, and mode choice. Among vehicle owners (e.g. those who have at least one private vehicle at the household), individuals with one private vehicle in the household show a higher use compared to two private vehicle owned household in case of departure decision, trip destination, and mode choice. For example: for mode choice decision, 71.2%

of the smartphone users whose household has one private vehicle use smartphone applications from rarely to always whereas the percentage drops to 57.1% for two vehicle owners. Individuals belong to households owning 3 or more personal vehicles have the highest percentages compared to both one and two vehicle owned household. Among them, 84.4% of the respondents use smartphone applications (rarely to always) for taking mode choice decision. The same trend is also visible for decision on departure time and trip destination. This exhibits the existence of a possible positive relationship between the number of vehicle in the household and smartphone application use for trip planning related functions. Further investigation, particularly the econometric modeling approach, will be required to confirm the hypothesis.

Additionally, the chi-square analysis shows that transit pass owners are the frequent users of smartphone applications for trip planning decisions (Table 3). Their percentage of never use lies between 4.2% and 20.4%. The chi-square test confirms the significance (at 5% level) of the relationship between transit pass ownership and all activities of trip planning. It has already been noticed that those who do not own any private vehicle are more dependent on smartphone applications for departure decision, deciding trip destination, and mode choice. Results for transit pass holders are also consistent with these observations. Regular transit riders possibly check bus schedules and decide trip destination which is accessible by transit. Also, transit users perhaps have less convenience when coordinating trips with others and going to any location. As a result they are more dependent on smartphone applications for these purposes.

Interestingly, based on chi-square analysis, mode for school/work trip does not have any significant influence on smartphone use for deciding trip destination, coordinating trips with others, and performing tasks online instead of travelling (Table 4). However, transit and active transportation users are the frequent users of smartphone applications in case of deciding departure time (64.9% and 45.4% respectively for often to always) and mode choice (79.9% and 83.2% respectively for rarely to always). Additionally, total number of daily trips does not have any influence on application's usage for trip planning decisions according to chi-square analysis. People who go to school/work routinely have higher

number of daily trips than those who do not. As routine trips do not require much planning, higher number of daily trips does not influence smartphone use for trip planning. In the case of commute travel time/trip duration, no significant relationship is visible for the depart decision, trip destination, or appropriate mode choice. A slight negative relationship is observed in coordinating trips with others and performing tasks online, however, further econometric investigation is required for further hypothesis testing.

2.5.3 Use of Smartphone Applications for Specific Travel Need Activities

Trip planning activities are further analyzed considering six specific activities as travel needs that are served by smartphone applications. Travel needs included for responses are scheduling meetings with friends and family, online banking, e-shopping, finding locations, checking bus schedules and reserving taxis. Only 31 respondents mentioned some other activities such as getting traffic updates and flight booking/check-in. Figure 26 shows the percentage of the respondents according to the specific travel need activities. Higher use (often/always) is noticed for scheduling meetings with friends and family (52%), finding locations (62%) and checking bus schedules (52%).

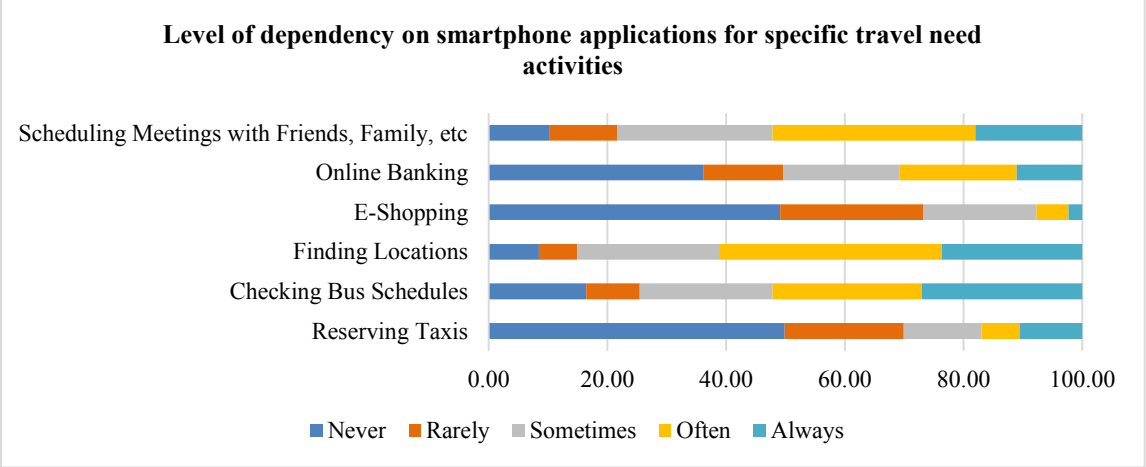

Figure 26: Level of Dependency on Smartphone Applications for Specific Travel Need Activities

To get a better understanding, responses are given numeral values such as 0 = never, 1 = rarely, 2 = sometimes, 3 = often and 4 = always and mean values are used for presenting

the graphs in Figure 27. First of all, it is examined that if there are any trend between years of smartphone use and travel needs related activities. Mean value of all attributes of travel need activities increase with the increase in years of smartphone ownership. The sharpest increase is visible for finding locations and online banking.

As expected, 15-24 years and 25-34 years old users show a high average value of use for all activities of travel needs compared to workforce (35-65+ years) (Figure 27). Among all specific travel need attributes, young professionals (25-34 years) are showing highest mean value (close to often) for finding locations. This supports our assumption in the previous sub-section that young professionals are making more trips and thus using applications to find location. Workforce (35-65+) show less use for checking bus schedule (rarely to sometimes).

As expected, individuals who do not have any private vehicle in the household are more dependent on smartphone applications than the average, for finding a location, checking the bus schedule, and reserving taxis (Figure 27). Except reserving taxi and online shopping, the frequency of using smartphone applications is between sometimes to often in all other attributes of travel needs among those whose household possess 3 or more vehicles. In the case of school/work mode choice, transit riders often (almost) use smartphone applications for checking bus schedule, which is expected. Transit pass owners use smartphone applications more for travel needs than those who do not own it, especially; in the case of checking bus schedule the difference is very high.

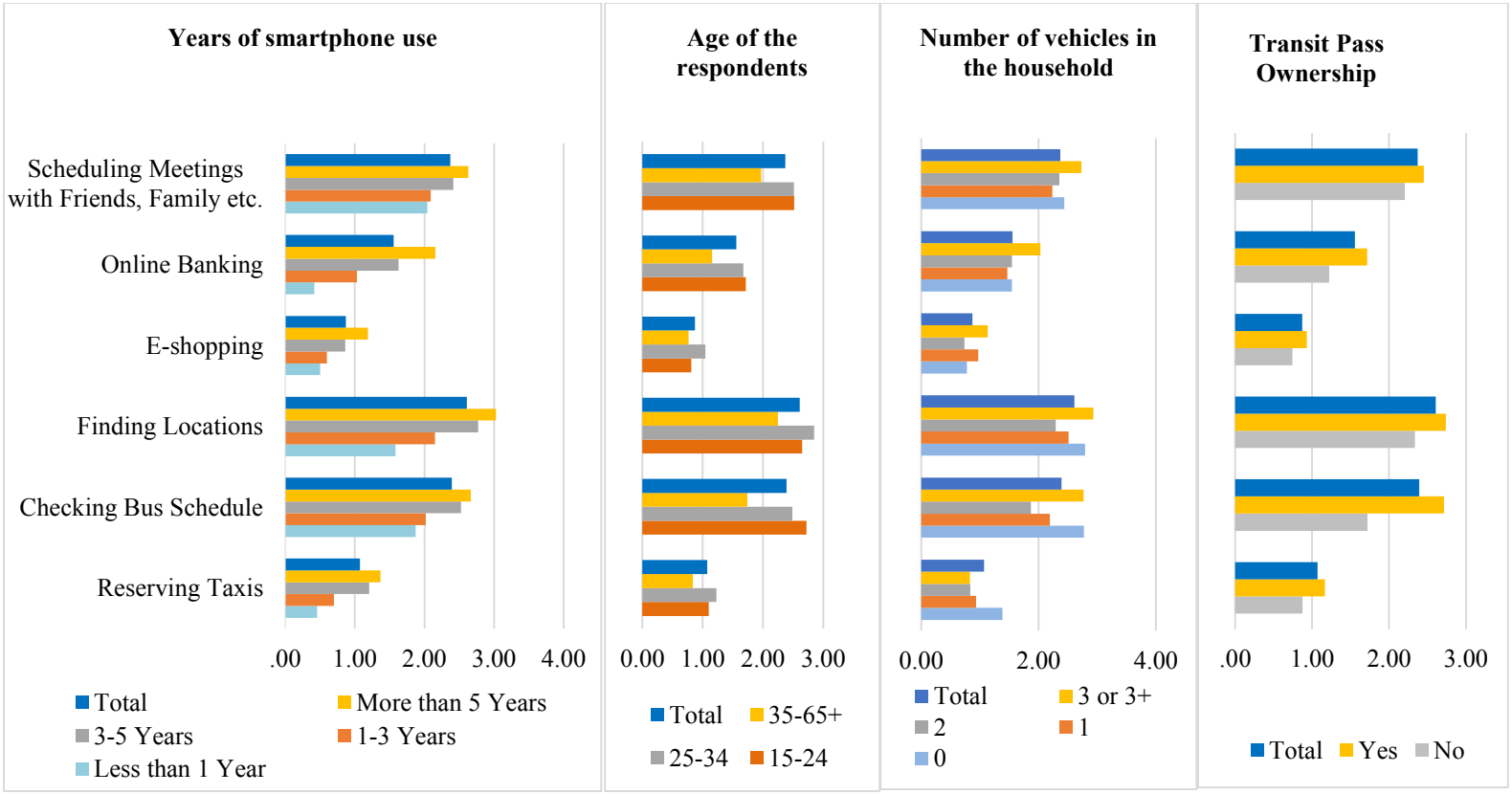

Figure 27: Mean Usage of Smartphone Applications by Different Factor

2.5.4 Impact of Smartphone Applications on Travel Outcomes

This study investigated the impact of using smartphone applications on travel outcomes. The travel outcomes considered in the study are vehicle kilometers travelled, number of new places visited, number of social gatherings attended and number of group planned trips. The highest impact is seen for the increase in number of new places visited (48.8%). However, Kramer et al (2007) found no difference in number of sights visited for using mobile tour guides and traditional guided tours. In Halifax, 40.2% to 43.2% increase is also noticeable for the number of trips planned in groups and number of social gathering attended due to smartphone use. Surprisingly, the reported impact is very low, as 50% or more smartphone users mentioned no impact of smartphone applications for all considered travel outcomes (Figure 28). The use of smartphone application has the lowest impact on vehicle kilometers travelled as 77.9% stated no impact. These results clearly show that, from the respondents' perspective, smartphone application usage does not have much substitution effect on travel outcome. In fact, in most of the cases, smartphone applications have both neutral and complementary effects.

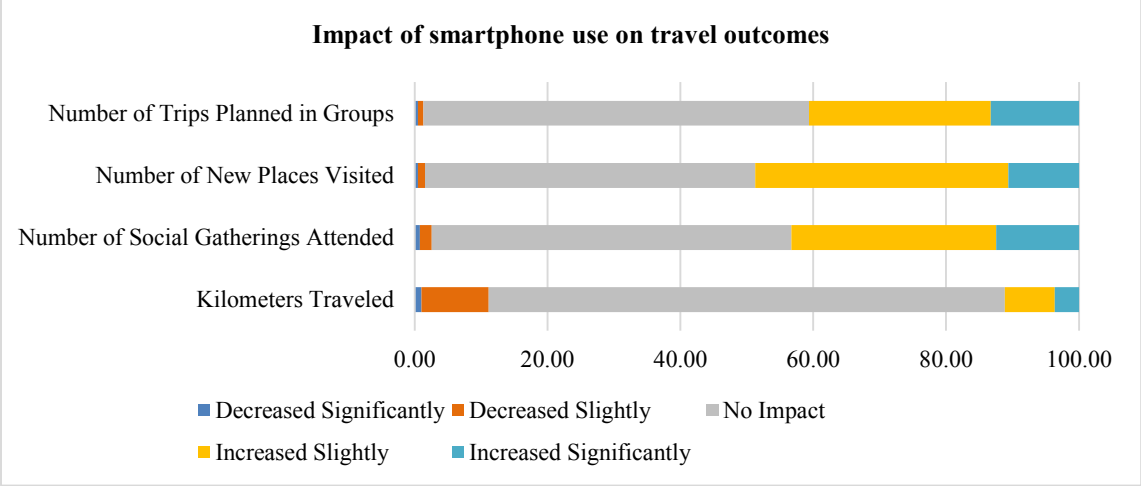

Figure 28: Impact of Smartphone Use on Travel Outcomes

For further investigation, chi-square analysis is performed between travel outcome and other attributes (Table 5). Among all the variables considered in previous sections, age, private vehicle ownership, and transit pass ownership are found to have statistically significant association (at 5% significant level) with usage of smartphone applications for

number of social gatherings attended, number of new places visited and number of trips planned in groups. As expected, the majority of the 35-65+ years age group (77.6%) do not have any impact of smartphone application use on the number of social gatherings attended. Only 18.4% of this age group mentioned slight to significant increase in number of social gatherings attended. On the other hand, 56.3% of the students group (15-24 years) and 46.2% of the young professionals (25-34 years) reported some sort of increase (slight to significant) in number of social gatherings attended due to smartphone use. The same pattern has also been observed for the number of new places visited and number of trips planned in groups. This highlights that except kilometers travelled, increase in age decreases the impact of smartphone application use on travel outcome.

Around half of the respondents who belong to a household with no private vehicle responded that use of smartphone applications has increased (slight to significant) their number of new places visited, number of social gathering attended and number of planned group trips. In contrast, it can be noticed that 38.3% of the respondents whose household own one private vehicle mentioned an increase in the number of new places visited resulting from smartphone application usage. The percentage has increased to 47.8% and 73.3% for two and three vehicle owners, respectively. Similar findings is observed for the number of social gatherings attended and number of trips planned in groups. This indicates that among those individuals, whose household own at least one private vehicle in the household, the number of private vehicles is positively related with impact of smartphone use on number of new places visited, number of social gatherings attended and number of planned group trips. Transit pass ownership is also positively related with travel outcome, except kilometer traveled as 45.8% - 53.1% of the transit pass owners mentioned increase in travel outcome attributes.

Table 5: Impact of Smartphone Application Use on Travel Outcome

Impact of smartphone use on travel outcome		Age			Number of Private Vehicles				Transit Pass Ownership		Row Total
		15-24	25-34	35-65+	0	1	2	3 or more	Yes	No	
Kilometers Travelled	Slight to Significant Decrease	10.1%	12.6%	11.2%	8.8%	12.8%	7.5%	23.3%	12.2%	9.1%	11.2%
	No impact	75.3%	76.5%	83.7%	76.6%	78.7%	88.1%	56.7%	73.6%	86.8%	77.9%
	Slight to Significant Increase	14.6%	10.9%	5.1%	14.6%	8.5%	4.5%	20.0%	14.2%	4.1%	10.9%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Chi-Square Test	$X^2 = 5.904$, $df = 4$, $p = 0.206$			$X^2 = 15.731$, $df = 6$, $p = 0.015$				$X^2 = 10.089$, $df = 2$, $p = 0.006$		
Number of Social Gatherings Attended	Slight to Significant Decrease	1.3%	3.4%	4.1%	2.9%	2.1%	3.0%	3.3%	2.8%	2.5%	2.7%
	No impact	42.4%	50.4%	77.6%	47.4%	66.7%	50.7%	33.3%	48.8%	65.3%	54.1%
	Slight to Significant Increase	56.3%	46.2%	18.4%	49.6%	31.2%	46.3%	63.3%	48.4%	32.2%	43.2%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Chi-Square Test	$X^2 = 36.904$, $df = 4$, $p = 0.000$			$X^2 = 16.995$, $df = 6$, $p = 0.009$				$X^2 = 9.106$, $df = 2$, $p = 0.011$		
Number of New Places Visited	Slight to Significant Decrease	.6%	2.5%	1.0%	1.5%	1.4%	0.0%	3.3%	1.6%	.8%	1.3%
	No impact	43.7%	44.5%	66.3%	43.8%	60.3%	52.2%	23.3%	45.3%	59.5%	49.9%
	Slight to Significant Increase	55.7%	52.9%	32.7%	54.7%	38.3%	47.8%	73.3%	53.1%	39.7%	48.8%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Chi-Square Test	$X^2 = 16.324$, $df = 4$, $p = 0.003$			$X^2 = 18.103$, $df = 6$, $p = 0.006$				$X^2 = 6.723$, $df = 2$, $p = 0.035$		
Number of Trips Planned in Groups	Slight to Significant Decrease	1.3%	.8%	2.1%	.7%	2.1%	0.0%	3.3%	1.2%	1.7%	1.3%
	No impact	47.5%	57.6%	77.3%	52.2%	66.4%	62.7%	40.0%	53.0%	70.0%	58.4%
	Slight to Significant Increase	51.3%	41.5%	20.6%	47.1%	31.4%	37.3%	56.7%	45.8%	28.3%	40.2%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Chi-Square Test	$X^2 = 23.892$, $df = 4$, $p = 0.000$			$X^2 = 13.64$, $df = 6$, $p = 0.034$				$X^2 = 10.392$, $df = 2$, $p = 0.006$		

2.6 Summary and Conclusion

This chapter aims to enhance our understanding of the nature of smartphone application usage on day to day trip planning and travel outcome through an exploratory analysis. Results of this study offer important insights and could be useful for policy discussions. The study suggests that young people (age: 15 - 34 years) are the major users of smartphones. Among the various usages of smartphone applications; communication, information search, social networking and trip planning rank top four. Intensity of using smartphone applications for trip planning functions, such as deciding trip destination, coordinating trips with others, and performing online tasks are increasing with years of smartphone use. Similar trend is also noticed for specific travel needs activities. If we look at the smartphone penetration rate in Canada (mentioned in literature review), it clearly indicates that in future, more people will start using smartphones. These statistics and the findings of this study suggest that in future, impact of smartphone and its applications on travel will be much higher than the present as more people will get used to with the use of smartphones.

Students (15-24 years) and young professionals (25-34 years) are more involved in using smartphone applications for trip planning such as deciding departure time, destination and mode choice. However, a growing interest is noticed among workforce (35-65+ years) in smartphone application use for coordinating trips with others and performing online tasks. This age group is facing less influence of smartphone applications on travel outcomes such as number of social gatherings attended, number of new places visited, and number of trips planned in groups.

Regarding vehicle ownership, 36.76% of the smartphone users do not own a private vehicle. Individuals who do not have any private vehicle in the household rely more on smartphone applications for trip planning decisions compared to vehicle owners. For travel needs, they are more dependent for, checking bus schedule, and reserving taxis compared to vehicle owners. Nevertheless, both vehicle owners and no-vehicle owners are dependent on smartphone applications for finding locations and scheduling meetings with friends,

family, etc. This study also confirms that the transit pass owners are the frequent users of smartphone applications for trip planning specially for checking bus schedule. Transit and active transportation users are the more frequent users of smartphone applications for deciding departure time and appropriate mode for travel.

From the individuals' perspective, usage of smartphone application have a very little substitution effect on travel outcomes. For all travel outcomes, except kilometers travelled, both neutral and positive effects are noticeable. Analysis suggests that almost 90% think that use of smartphone applications do not have any substitution effect on vehicle kilometers travelled. Only 40.2% of the respondents reported increase in the number of trips planned in groups and 43.2% reported increase in number of social gatherings attended due to smartphone use.

However, further investigative analysis is required to determine the extent of influencing factors of smartphone application usage on trip planning. Therefore, the next chapter includes econometric modelling of trip planning activities and travel outcomes. Econometric modelling will reveal the trade-off among different factors that influence trip planning decisions and travel outcomes.

Chapter 3: Smartphone and Mobility: How the Use of Smartphone Applications Affect Travel Decisions[3]

3.1 Introduction

Rapid advancement of technology is continuously shaping our travel behaviour and the environment in which we live. Information and Communication Technology (ICT) in particular is changing the way we travel such as how we choose our destination, what modes we use, etc. (Mokhtarian and Tal, 2013). Smartphone, the most recent addition to ICT, which with its emerging sets of applications is offering unique and powerful travel supporting solutions. Although smartphone and travel related research is fairly new, scholars became increasingly interested in exploring the relationship between ICT and travel behaviour in the last four decades. Literature review suggests that most of the previous research broadly used ICT as a generalized term. Several studies investigated the preference of tele-commuting (e.g. Mokhtarian and Salomon, 1996), use of home computers and internet connection (e.g. Hjorthol, 2002 and Bhat et al., 2003), number of tele-phone calls, number of mobile phones (e.g. Senbil and Kitamura, 2003), email, internet service (Wang and Law, 2007), online shopping (Farag et al., 2007), etc. and how they influenced travel behaviour. Ben-Elia et al. (2014), however argued that to understand the possible impact of ICT on travel, each type of ICT devices and services should be analysed separately as much as possible. No doubt, there is a significant gap in understanding the use of smartphone, its applications and how they shape our movement.

In 2014, 66% of Canadians owned a smartphone (CRTC, 2015) and the penetration rate is increasing. According to Canadian Wireless Telecommunications Associations (CWTA), 69% of the 18-34 years old owned a smartphone in 2012. A more recent study showed that around 94% of the 18 - 34 years old own a smartphone in Canada whereas ownership rate is only 58% among the 34 + years old (Spring 2015 Global Attitude Survey). Compared to

[3] Part of this chapter is adopted from the paper Jamal, S. and Habib, M.A. "Smartphone and Mobility: How the Use of Smartphone Applications Affect Travel Decisions" under review for 96th Annual Meeting of Transportation Research Board, Washington D.C. January, 2017.

baby boomers, millennials are considered as more connected and technology oriented. A study from Catalyst (2015b) confirmed that millennials are shaping the evolving smartphone market. According to the same study, smartphone applications are mainly used for getting direction, finding restaurants, reading emails, social networking and searching for weather information. There are many trip planning and transportation resource applications that provide travel information for a region. Google Maps is one of the top map applications which reached 91.2 percent of iPhone users and 74.5 percent of Android users (ComScor.com, 2016). However, most of the studies only give an idea about the fraction of users of smartphone for several purposes. Empirical evidence is still absent on how smartphone use for trip planning has changed travel and what the impacts of smartphone use on travel outcomes are.

How people adapt to emerging technologies may depend on socio-demographic characteristics. Many studies found that there is difference between age (Windmiller et al, 2014), gender (Srinivasan and Athuru, 2004) and income level of ICT adopters (Bhat et al., 2003) as well as smartphone users (Mondschein, 2011), and thus impact on daily trips might vary according to these socio-demographic groups. On the other hand, online-solutions through smartphone applications such as e-shopping, e-banking, e-ticketing, etc. might influence land use as well as travel patterns.

Accessibility to facilities may have a different impact on individual's travel. For example, people may travel less or not travel at all for work, shopping, banking and bill payment related activities as a result of smartphone use. Changes in travel pattern due to ICT, more specifically due to smartphone applications use is absent in travel and neighbourhood characteristics interactions studies (Wee et al., 2013). Some of the studies considered impact of social attitudes on tele-work (e.g. Mokhtarian and Solomon, 1997; Dam, 2009). However, attitudes toward sustainability and technology use were analysed limitedly with ICT and travel. Under such back drop, this study explored how socio-demographic, neighbourhood characteristics and attitudinal factors affect smartphone use for travel decisions.

Following discrete choice modelling techniques, this chapter analysed the determinants of trip planning and travel outcomes as an influence of smartphone applications usage and how this differentiates across socio-demographic, travel characteristics, neighbourhood characteristics and attitudes. The study used data from a Smartphone Use and Travel Choice Survey, 2015 conducted in Halifax, Nova Scotia. The survey revealed that smartphone is used for five major trip planning activities: performing online tasks rather than going to the location, deciding departure time, mode choice decision, deciding trip destination and communicating/ coordinating trips with others. The travel outcomes, which are considered for modelling include vehicle kilometres travelled, number of new places visited, number of social gathering attended and number of trips planned in groups.

The rest of the chapter is organized as follows. Section 2 begins with a brief overview of the existing literature related to ICT's impact on travel outcomes and trip planning activities. Section 3 illustrates the methodology and data. Following section provides model description and discussion of the results. Finally, the chapter concludes with a summary of findings.

3.2. Literature Review

Previous studies mostly focused on direct supplementary (decrease) or complementary (increase) effect of ICT on travel. However, new insights and methodology in revealing the ICT and travel interrelationship is growing, indicating that rather than direct increase or decrease, ICT has brought modifications in our mobility and activity pattern. Table 6 describes a summary of the existing literature relevant to this study. Based on the extensive literature review, the studies can be grouped into three broad themes: i) ICT and travel outcome; ii) ICT and trip planning and iii) Determinants considered in ICT impact modelling.

3.2.1 ICT and Travel Outcome

A number of studies focused on how ICT affects travel outcomes, for instance vehicle kilometer travelled (VKT), number of total trips, trip duration, etc. Studies such as Mokhtarian and Meenakshisundaram, 1999; Zhang et al., 2007; Choo and Mokhtarian,

2007; Circella and Mokhtarian, 2010, found a complementary relationship between telecommuting and travel. Choo et al. (2005) explored US nationwide data of 1966–1999 to analyse the impact of teleworking on vehicle miles travelled (VMT) and suggested that teleworking reduces VMT by 0.8% or less. However, a recent study of Wee (2015) claimed that there are limited studies that have found substantial net decrease in travel due to ICT use. Mokhtarian (2009) explained some of the reasons behind generation of additional travel due to ICT, which can be summarized as: i) likelihood of time and money saving for other activities , ii) efficiency in travel by providing real time traffic information, iii) increasing productivity and attractiveness of travel, iv) access to information about places, services, etc.

In case of online shopping or tele-shopping, Bhat et al. (2003) suggested that an increased use of mobile phone and home computer reduces the number of individual trips for non-maintenance related shopping activities. Nevertheless, several studies revealed a complementary effect between online buying and the frequency of shopping trips (e.g. Casas et al., 2001; Ward and Morganosky, 2002; Farag et al., 2006 and Rotem-Mindali, 2010). It is evident that online information search (Cao et al., 2010) and online shopping (Lee et al., 2016) tends to increase in-store shopping. Arguably, due to internet marketing, social networking websites and several smartphone applications, consumers are becoming more aware of new retailers and familiarizing themselves with information searching, special deals, product trial and frequent purchase (Ngai and Gunasekaran, 2007; Cao, 2012; Cohen-Blankshtain and Rotem-Mindali, 2013).

Additionally, the use of ICT can alter the number of trips as well as total travel distance which may also vary according to trip purposes. Wang and Law (2007) identified that the experience of using e-mail, internet service, video conferencing, and videophone increases total number of recreational trips. Berg and colleagues (2013) have found higher internet interactions reduces distance of social trips. However, the study of Carrasco (2011) suggested that the use of ICT has the potential to increase social activities. Wang and Law (2007) found an increase in out of home recreational trips and recreational time as a result of ICT use. Le vine et al. (2016) found that using the internet at out of home locations is

positively correlated with the time spent on traveling and out of home activities more compared to using the internet at home. Ren and Kwan (2009a) showed that online maintenance activities substitute women's physical maintenance activities, in contrast, complement men's physical maintenance activities. Furthermore, they suggested that internet use for leisure purposes reduce men's travel demand for leisure activities but increase maintenance activities.

Table 6: Summary of Previous Studies on ICT and Travel Behaviour

Study	Focus and Study Area	Method	Data and Major Findings
Mokhtarian, 1990	**Focus:** Conceptual framework between telecommunication and transportation **Study area:** California, USA	Literature review	Two previous empirical studies are summarized: • Teleconferencing increased travel • Telecommuting decreased travel
Olszewski and Mokhtarian, 1994	**Focus:** Tele-commuting and travel behaviour **Study Area:** California, USA	Descriptive analysis and factor analysis	• No relation between telecommuting frequency and commute distance • No significant impact of demographic variables such as age, gender, or number of children in the household on frequency of telecommuting
Mokhtarian, 1998	**Focus:** Forecasting the demand for telecommuting and the resulting transportation impacts. **Study Area:** California, USA	Synthetic (artificial) multiplicative model	• Telecommuting is estimated to reduce at most 0.6% of household travel • However, due to counteracting forces, the aggregate travel impacts will remain relatively flat in future
Mokhtarian and Salomon, 1997	**Focus:** Tele-commuting and attitudinal factors **Study Area:** City of San Diego, USA	Binary logit model	• Attitudinal factors that drives tele-commuting: disability/ parental leave, stress at work, commute time/stress, independence and leisure drives • Attitudinal factors that discourages tele-commute: workplace interaction, commuting benefit, household distraction
Mokhtarian and Meenakshisundaram, 1999	**Focus:** Relationship among personal travel such as trips, personal meetings, object transfer and various types of electronic communication activities such as phone, fax, email	Disaggregate longitudinal structural equation modeling	• Significant relationship indicates net generation of communication activities over time • Presence of complementary effects across various modes of communication

	Study Area: City of Davis, California, USA		• Relationships between electronic forms of communication and personal meetings or trips were not significant
Hjorthol, 2002	**Focus:** Use of home computer and travel **Study Area:** Norway	Descriptive analysis and Linear regression	• Access to and use of home computer do not have any impact on everyday travel
Bhat et al., 2003	**Focus:** Mobile telephones, computers and out of home non-maintenance shopping activities **Study Area:** Cities of Halle and Karlsruhe, Germany	Hazard based duration model	• Effects of ICTs on activity–travel patterns are mediated by individual socio-demographic and locational factors such as urban, sub-urban, etc.
Farag et al., 2003	**Focus:** E-shopping and personal travel **Study Area:** Netherlands	Logistic regression analysis	• Frequency of online shopping does not vary according to the number of shopping opportunities in that area
Mokhtarian et al., 2004	**Focus:** Telecommuting, residential location and commute distance **Study Area:** California, USA	Descriptive analysis	• One-way commute distances were higher for telecommuters than for non-telecommuters • Average telecommuting frequency declined over time
Krizek et al., 2005	**Focus:** Household related ICT activity and spatial attributes **Study Area**: Seattle, Washington, Kansas City, Missouri, Pittsburgh, Pennsylvania	Survey and descriptive analysis	• Spatial attributes such as accessibility, traffic congestion, etc. do not play a significant role in frequency of ICT use
Choo and Mokhtarian, 2005	**Focus:** Tele-communication and travel **Study Area:** USA	Factor analysis and structural equation modelling	• The relationship between tele-communication and actual amount of travel is complementary
Choo et al., 2005	**Focus:** Impact of tele-commuting on passenger vehicle miles travelled (VMT) **Study Area:** USA	Multivariate time series model	• A reduction in annual VMT on the order of 0.8% or less
Zhang et al., 2007	**Focus:** ICT (Internet and telephone usage) and travel outcomes such as vehicle miles travelled, total daily trips and daily walking trips **Study Area:** Baltimore, USA	Linear and Poisson regression model	• Internet and tele-communication both have a complementary impact on travel
Choo and Mokhtarian, 2007	**Focus:** Relationships among travel, telecommunications, land use, economic activity, and socio-demographics **Study Area:** USA	Structural equation model	• Tele-communication and travel are complementary
De Graaff and Rietveld, 2007	**Focus:** Trade-off between working at home and out-of-	Micro-economic	• Changes in ICT and commuting time display weak substitution effects on working

	home, ICT and commuting time **Study Area:** Netherlands	demand system	out-of-home and at home, respectively • Age and education –is more important for the choice between working at home and out-of-home than ICT availability or commuting time
Weltevreden and Rietbergen, 2007	**Focus:** E-shopping and shopping centres' attractiveness **Study Area:** Netherlands	Multinomial logit model and Binomial logit model	• 20% online buyers made fewer trips to city centre stores • Higher accessibility to shopping centres reduces online shopping
Farag et al., 2006	**Focus:** E-shopping and in-store shopping **Study Area:** Netherlands	Chi-square tests and logistic and ordinary least-squares regressions	• Online buying is influenced by socio-demographic, spatial, behavioural and attitudinal variables
Farag et al., 2007	**Focus:** The relationship among online shopping, in-store shopping, attitudes, behaviour and land use factors **Study Area:** Netherlands	Structural equation modelling	• Searching online increases frequency of shopping trips as well as buying online • Urban residents shop online more often than suburban residents • Shopping opportunities within 10 min by bicycle reduces the possibility of searching online
Wang and Law, 2007	**Focus:** Impact of ICT usage (e.g. e-mail, internet service, video conferencing and video phone) on time use and travel behaviour **Study Area:** Hong Kong	Structural equation model	• Use of ICT generates additional time for out of home recreational activities and increases trip making propensity • Younger individuals and higher income group are the major ICT users • Effect of ICT on travel is complementary
Hjorthol and Gripsrud, 2009	**Focus:** Domestic use of ICT **Study Area:** Norway	Descriptive analysis and Linear regression	• Virtual and physical mobility varies depending of type of activities and social group
Ren and Kwan, 2009a	**Focus:** Internet and human activity travel pattern **Study Area:** Columbus, Ohio, USA	Multi-group structural equation modelling	• Internet use for maintenance purposes impacts women's physical activity and travel • Internet use for leisure purposes affects men's physical travel and activities
Ren and Kwan, 2009b	**Focus:** Effects of accessibility and residential context on adoption of e-shopping **Study Area:** Columbus, Ohio, USA	Regression models: Logistic, Poisson, Negative binomial and Linear	• Shopping opportunities within short distances from home tends to reduce the need for online shopping • Living in areas with white majority has higher likelihood of e-shopping

Circella and Mokhtarian, 2010	**Focus:** Online shopping and store shopping **Study area:** California, USA	Seemingly unrelated regression and structural equation model	• Complementary relationship between online shopping and store shopping • Pro-environmental attitudes reduce number of trips to stores
Rotem-mindali, 2010	**Focus:** E-shopping vs traditional shopping and the influencing factors **Study Area:** Tel Aviv	Ordinal logit model	• Higher preference for in store shopping compared to e-shopping • No substitution between physical and virtual travel and information technology can stimulate or generate physical shopping
Tang et al., 2011	**Focus:** Work at home and residential built environment **Study Area:** California	Multinomial logit model	• Factors positively affect work at home: density, number of eating places and number of institutional establishments with 400 m, pro-bike and pro-transit attitude
Padayhag et al., 2011	**Focus:** Mobile phone and telecommuting **Study Area:** London, UK	Descriptive analysis and ordered probit model	• Mobile phone possession increases total number of trips • Population density effects leisure trips but not work or shopping trips
Wang et al., 2014a	**Focus:** Smartphone and Tourist experience **Study area:** USA	Qualitative Analysis	• Use of smartphone for travel is shaped by the complex interactions between contextual factors, cognitive beliefs, previous experiences and everyday use.
Ben-Elia et al., 2014	**Focus:** ICT, activity fragmentation and travel behaviour **Study Area:** Netherlands	Path analysis modelling	• ICT use facilitate the participation in non-work activities and can replace work and non – work travel
Meng et al., 2015	**Focus:** Factors affecting smartphone adoption for travel **Study Area:** Hong Kong	Factor analysis and Logit model	• Characteristics that positively influence use of smartphone for travel: personal innovativeness, use of smartphone functions, positive attitudes towards smartphone's result demonstrability

3.2.2 ICT and Trip Planning

Recently, there has been a growing interest in examining how ICT shapes our travel. A change in travel patterns such as variation in destination choice, mode of transport, route choice, execution time and duration has been noticed in recent years (Mokhtarian and Tal, 2013). Couclelis (2003) proposed the fragmentation of activities which is defined as the

reorganization of activities at different time and space as a result of ICT use. Lyons (2015) argued that ICT not only substitute or stimulates travel but also allows enhancement, redistribution, enrichment and improvement in the efficiency of travel. Internet offers information on several destination and associated travel. Furthermore, mobile telephones, more recently smartphone applications are used in organizing personal meetings, coordination of meeting times and places even at micro level (Mokhtarian and Tal, 2013). Information relevant to transport mode such as fare, schedule, travel maps, travel time required by each mode are now available via internet. ICT also offers a larger scope for alternative ways of trip planning, for instance rideshare matching (Buliung et al, 2010). Shaheen et al. (2009) claimed that car users may use transit or non-motorized modes for some of the trips if information on cost of each trip is easily available. Several ICT devices offer information on the chosen route while travelling, such as warnings on congestion and delays of public transport. This information allows travellers to have the option to decide to take an alternate route or switch modes (Wee et al., 2013; Mokhtarian and Tal, 2013). Windmiller et al. (2014) conducted a study on transit riders experience on real time information availability due to smartphone applications and how this use may affect riders' experience and ridership generating potential. Their findings suggested that Metro riders who use smartphones report higher levels of satisfaction with service factors, such as the ability to make transfer connections and personal security at transit centres. Nevertheless, there are few instances of looking at the use of smartphones and how that shapes trip planning. This study will add to the existing knowledge of this group, by specifically looking at how smartphone is used for performing online tasks, coordinating trips, mode choice, destination and departure time selection and their determinants.

3.2.3 Determinants Considered in ICT Impact Modelling

Socio-demographic and trip characteristics are mainly used as determinants in ICT impact modelling. Except these, some studies explored neighbourhood characteristics and attitudes in ICT impact modelling. For instance, Tang et al. (2011) studied the relationship between the accessibility and built environment characteristics and tele-work. The study suggested that perceived regional accessibility, numbers of institutional establishments and places to eat out within 400 meters of an individual's home location have a significant

association with tele-work. In the same study, the authors explored several other studies and made a list of neighbourhood/built environment elements hypothesized to influence tele-work/tele-commuting. For example: home size, dwelling type, population density, connectivity, green/open space, land use mix, walkability/bike ability, commute distance, regional accessibility, public transit availability, etc. Padayhag et al. (2011) showed that population density effects the number of leisure trips but does not affect number of work or shopping trips. However, the impact of ICT on neighbourhood characteristics is unexplored in many dimensions. According to Choo and Mokhtarian (2007), a comprehensive framework to analyse linkages between telecommunication and travel, should include land use factors with commonly explored socio-demographic factors. Wee et al. (2013) has provided a broad discussion of available literature on impact of ICT on travel behaviour where some research gaps have been identified such as how ICT influences travel, activity, trip patterns, etc. Wee et al. (2013) predict that land use changes should be expected if ICT started reducing travel related hassles such as congestion, longer travel time, higher fuel cost, etc. The authors identified that the absence of land use components in empirical studies on how ICT is changing in arrangements of individuals' activities as well as destinations.

Regarding online shopping, Farag et al. (2003) indicated that the number of shopping opportunities in an area does not affect buying online in Netherlands. In contrast, another study in the Netherlands showed that better accessibility to shops reduces the frequency of online buying (Farag et al., 2006). The same study found that people living in urbanized areas are more likely to search and buy online than those living in less urbanized areas. Results of Ren and Kwan (2009b) indicated that having shopping opportunities within a 6.25 minute drive reduces the possibility of online buying. However, no influence of shopping accessibility on performing online buying was found by Weltevreden and van Rietbergen (2007). Krizek et al. (2005) concluded that distance from CBD does not have a significant influence on online buying.

Regarding the relationship between ICT and attitudes, Mokhtarian and Solomon (1997) tried to explore the relationship between telecommuting and attitudinal factors. The study

identified that factors such as stress at work, commute stress, leisure drives, etc. encourages tele-commuting for the employees of the City of San Diego. Another study in Hamilton, confirmed that social interactions influence decision to adopt tele-work (Dam, 2009).

Based on the review of this body of literature it can be said that there is a gap in knowledge on how smartphone, a specific mobile ICT device that revolutionised ICT for travellers and its applications are shaping our mobility pattern. It will be interesting to explore how smartphone usage for conducting online tasks, destination choice, departure time, mode choice and coordination of trips are bringing change to how we move. Further insights are also required on how the use of smartphones impact travel outcomes such as kilometres travelled, new places visited, social gatherings attended and number of group trips planned and what their determinants are. Hence, this study would like to contribute by modelling the determinants, more specifically socio-demographic, travel characteristics, neighbourhood characteristics and attitudinal factors that affect the use of smartphone applications for trip planning and its impact on travel outcomes.

3.3. Methodology

3.3.1 Data Used

Smartphone Use and Travel Choice Survey - 2015 in Halifax Nova Scotia was used as the primary source of information on smartphone users in Halifax. As mentioned before, the first part of the questionnaire includes information on the use of smartphone applications for travel choices, such as trip purposes, trip planning activities, and travel outcomes, etc. Five different attributes were considered as trip planning activities and responses were collected on a 5 point Likert Scale: Never - Rarely - Sometimes - Often - Always. For modelling purposes, we coded the responses in 3 point scale such as Never/Rarely as low use, Sometimes as moderate use and Often/Always as higher use. The first attribute performing online task was elaborated in the questionnaire as preference of doing online tasks (e.g. online banking, e-shopping) rather than going to the location. As nowadays, many people use smartphone applications for checking transit schedules, deciding departure time was included as a trip planning activity. Similarly, people use google maps and other directional applications within smartphones to compare routes, distance and

travel time offered by different transport modes, therefore decision on mode choice for the trip was included. The fourth attribute was deciding trip destination. Several applications offer information on restaurants, shopping, recreational and entertainment facilities, so smartphone users can use them to facilitate their discretionary trips. Additionally, smartphones offer carsharing and carpooling applications, and people can coordinate trips with others by simply calling or text messaging. Therefore communicating/coordinating trips with others was considered as the fifth component of trip planning activities.

Questions on whether the respondent feels that their smartphone has impacted their travel outcomes such as vehicle kilometres travelled, number of new places visited, number of social gatherings attended and number of planned group trips were collected on a 5 point Likert scale of Decreased Significantly - Decreased Slightly - No Impact - Increased Slightly - Increased Significantly which was also converted into 3 point Likert scale such as Decrease – No Impact - Increase. Additionally, the survey collected information on individuals' socio-demographic status and travel attributes such as daily trips, mode choice, travel time, vehicle and bicycle number, transit pass ownership and attitudes. A travel log of the respondents activities for last weekday and last weekend were collected by reporting a maximum of 7 trips a day, which was considered a respondent's typical travel pattern in a weekday and weekend. Attitudinal factors were included in the questionnaire to respond in a 5 point Likert Scale: Strongly Agree – Slightly Agree – Neutral – Slightly disagree – Strongly disagree which was also converted to Agree – Neutral - Disagree for modelling purposes.

3.3.2 Sample and Results from Descriptive Analysis

The survey yields a sample of 386 smartphone users residing in Halifax. The data was cleaned and home locations are geocoded using BatchGeo software. For neighbourhood characteristics, additional data sources used in this study include HRM Census Database – 2011 for household size and percentage of apartments, National Land-use Database – 2011 to include land use characteristics in the neighbourhood, National Household Database-2011 for employment rate and dwelling density, and GIS data of Halifax Regional Municipality (HRM) for location information of activity points and transportation services

from Desktop Mapping Technologies Inc. (DMTI). Finally, 358 samples are taken for analysis.

Table 7: Descriptive Statistics

Variables	Percentage	Mean
Age (years)		
15-24	41.2	
25-34	30.8	
35-65+	28.0	
Gender		
Male	43.0	
Female	53.6	
Other/Prefer not to disclose	3.4	
Individual Annual Income		
Below $15,000	46.9	
$15000-$29999	17.1	
$30000-$44999	8.3	
$45000-$59999	7.0	
$60000-$74999	6.7	
Above $75000	11.4	
Studentship Status		
Full-Time	63.2	
Part-Time	4.1	
Not-Student	32.6	
Employment Status		
Full-Time	41.5	
Part-Time	24.4	
Unemployed	34.2	
Trip Attributes		
Number of daily Trips (Weekday)		3.7
Average Commute (Work/School) distance in KM (Weekday)		7.77
Primary Mode of Work/School Trips		
Active Transportation	33.9	
Transit	29.5	
Auto	36.5	
Number of Vehicles in the Household		
0	36.5	
1	36.8	
2	18.4	
3 and 3+	8.3	

Variables	Percentage	Mean
Number of Bi-cycles in the Household		
0	36.3	
1	23.8	
2	16.6	
3 and 3+	23.3	
Transit Pass Ownership		
Yes	67.6	
No	32.4	
Neighbourhood Characteristics		
Distance between home and CBD (m)		5290
Distance between home and nearest bus stop (m)		4436.06
Distance between home and nearest shopping mall (m)		751.536
Distance between home and nearest regional centre (m)		5839.48
Dwelling density (per acre)		3298.75
Average percentage of apartments	21.34	
Average percentage of employment rate	62.34	
Land use Index (mixed land use)		0.16
Average percentage of residential land use	63.30	
Average percentage of commercial land use	8.44	
Average percentage of industrial land use	14.62	

Sample characteristics and descriptive statistics of the variables considered in the model are presented in Table 7. The analysis shows that 72% of the respondents of the smartphone users' survey belong to the 15 - 34 years old group in Halifax. Over half (53.6%) of the respondents are female and 43% are male (3.4% prefer not to disclose). 64% of the respondents belong to 'below $30,000' personal income category. 63.2% of the respondents are full-time students. As per employment status, 41.5% are full-time employed and 24.4% are part-time employed.

In terms of travel behaviour, it is found that the average number of daily (weekday) trips of smartphone users is 3.7. Based on the sample responses, an average one-way commute (home to work/school) distance travelled on a weekday is 7.77 km. Transit pass ownership is high (67.6%) among the respondents and 36.8% of the respondents' household reported owning one motorized private vehicle.

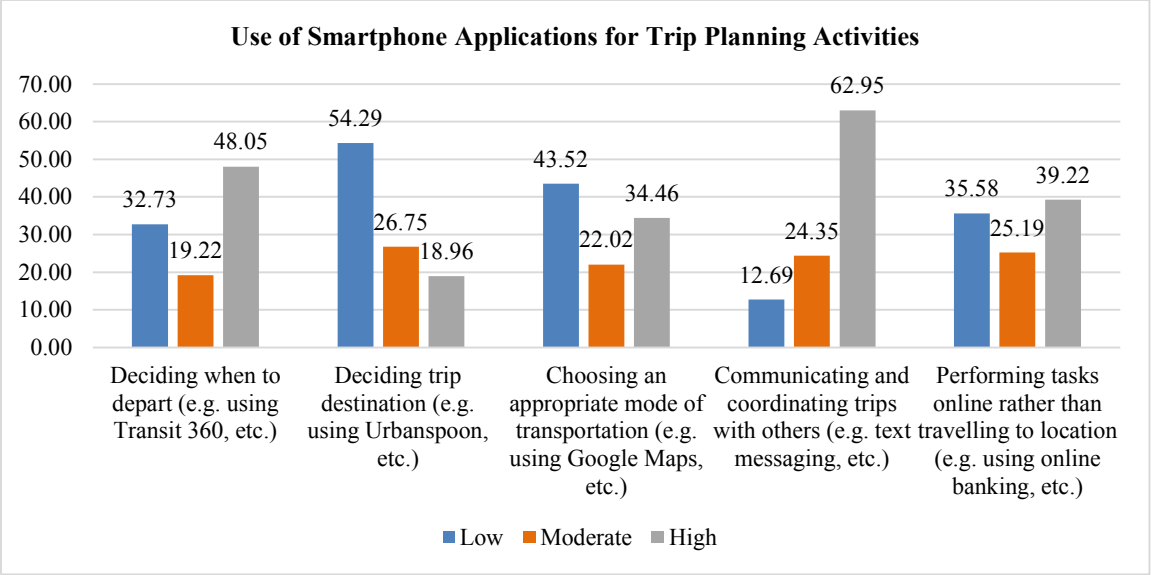

Figure 29: Frequency of Using Smartphone Applications for Trip Planning Activities

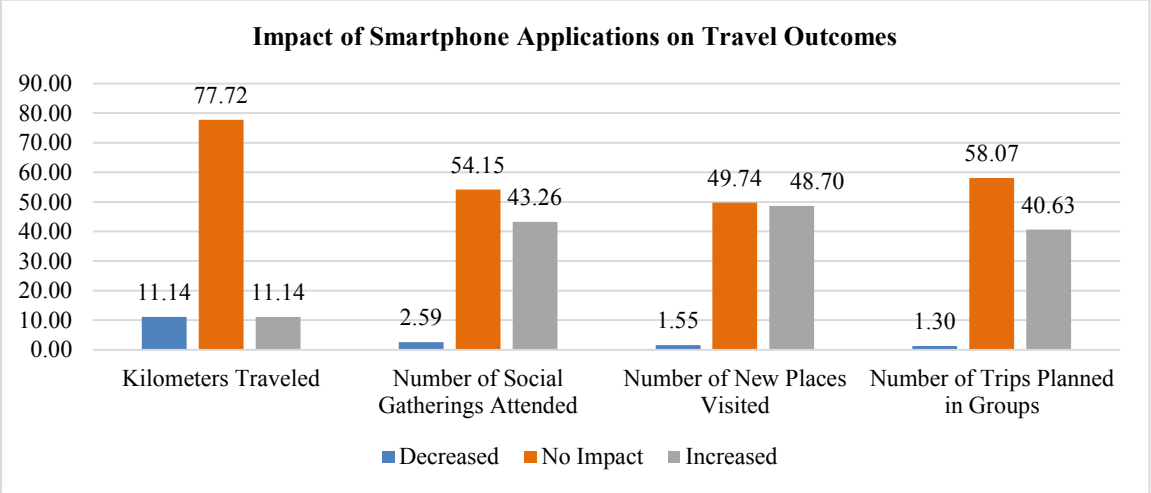

Figure 30: Influence of Smartphone Applications on Travel Outcomes

Responses on trip planning activities are presented in Figure 29. The figure suggest that majority of the respondents are using smartphones for communicating/coordinating trips with others, deciding departure time and performing online tasks. The impact of smartphone use on travel outcomes are presented in Figure 30. The highest impact is seen for the increase in number of new places visited (48.8%). These results clearly show that, from the respondents' perspective, smartphone application usage rarely reduce travel

outcomes. In fact, apart from neutral effects, smartphone applications usually increase travel outcomes.

3.3.3 Discrete Choice Model

3.3.3.1 Binary Choice Model

With the aim of further understanding on how smartphone is shaping our mobility, empirical analyses were conducted on smartphone usage for trip planning activities and impact on travel outcomes. Travel outcomes include vehicle kilometres travelled, number of new place visited, number of social gatherings attended and number of trips planned in groups. The objective was to explore whether smartphone use is increasing travel outcomes or not and what the determinants are. Since it is a binary choice context, binary logit model was developed for each of the travel outcomes. In these models, the individuals were faced with two mutually exclusive alternatives, e.g. "1" if they have reported increase in travel outcomes otherwise "0". If Y is the binary response variable,

$Y_i = 1$ if there is an increase in travel outcome of the respondent i
$Y_i = 0$, otherwise

The probability of the model can be written as:

$$Pr\,[Y_i = 1] = Exp\,(\alpha + \sum \beta X_i) / [1 + Exp\,(\alpha + \sum \beta X_i)] \quad (1)$$

where, β is the coefficient associated with the alternative, α is the constant. The error term assumed to be distributed as standard logistic distribution. X_i is the vector of explanatory variables describing socio-demographic, travel characteristics, neighbourhood attributes and attitudes for respondent i.

The log-likelihood can be written as:

$$LL = \prod_{i=1}^{N} [\, exp\{Y_i\,(\alpha + \beta X_i)\}/\{1 + exp(\alpha + \beta X_i)\}] \quad (2)$$

Nlogit 5.0 was used for parameter estimation of binary logit models.

3.3.3.2 Ordered Response Model

To explore the determinants of smartphone usage for trip planning activities, ordered probit models were estimated for each of the trip planning activities considered in this study. For instance, performing online tasks rather than travelling, communicating/ coordinating trips with others, decision on mode choice, destination choice and departure time. The ordered response model was chosen for analysis as it allows more than two response categories of the dependent variable. Responses on "How often do you use smartphone applications for the trip planning activities" were collected on a five point Likert scale where "0" stands for "Never" and "4" stands for "Always" in the model.

The following specification of an ordered probit model was used:

$$Y_i = \beta X_i + \varepsilon_i \quad (3)$$

Where Y_i is the latent and continuous measure of usage level of smartphone applications for trip planning by individual i, X_i is the vector of explanatory variables describing socio-demographic, travel characteristics, neighbourhood attributes and attitudes. β is the coefficient associated with the explanatory variables and ε_i is the random error term assumed to standard normal distribution.

Y_i takes on values 0 through m generating an ordered portioning of latent level of usage frequency for trip planning activities into the observed categories according to the following scheme:

$$-\infty < \mu_1 < \mu_2 < \ldots\ldots\ldots < \mu_{m-1} < \infty \quad (4)$$

Where μ represents threshold parameters in which $\mu_0 = -\infty$ and $\mu_m = \infty$. The observed level of usage can therefore be represented as:

$Y_i = 0$ if $Y_i \leq 0$

$= 1$ if $0 < Y_i \leq \mu_1$

$= 2$ if $\mu_1 < Y_i < \mu_2$

……

$= m$ if $Y_i > \mu_{m-1}$ (5)

The probability of observing a particular ordinal outcome can be represented generically as:

$$Pr\ (Y_i = m) = \phi\ (\mu_m - \beta X_i) - \phi\ (\mu_{m-1} - \beta X_i) \quad (6)$$

The log likelihood can be written as follows:

$$LL = \sum_{i=1}^{n} \sum_{m=0}^{m} \psi_{im}\ ln\ [\phi\ (\mu_m - \beta X_i) - \phi\ (\mu_{m-1} - \beta X_i)] \quad (7)$$

where, ψ_{im} is an indicator variable, which equals 1 if the individual has a usage frequency, m on smartphone for trip planning activities, and 0 otherwise. This log-likelihood function is maximized to obtain parameter estimation. The goodness of fit of the estimated models are evaluated in terms of *Rho-square*, which is calculated by subtracting ratio of log-likelihood of the full model and the null model (constant only model) from one.

Table 8 and 9 displays the parameter estimation of all the variables for the trip planning and travel outcome models. Interpretation of the model's parameter set, β, is as follows: a positive sign indicates higher use of smartphone applications of the trip planning purposes, while a negative sign suggest lower use. Nlogit 5.0 was used for parameter estimation for both binary logit and ordered probit model. The majority of the variables exhibit statistical significance. In some cases, the *t*-statistic is less than the threshold value. However, those variables are taken in the final model estimation since they offer important behavioural insights, with the assumption that if a larger dataset were available, these parameters might show statistical significance.

3.4. Results of Trip Planning Models

3.4.1 Socio-demographic Characteristics

The parameter estimation (Table 8) results suggest that age, studentship status and employment status are important factors that determine the use of smartphone applications for trip planning activities. Respondents who are between 25 - 34 years old, can be identified as young professionals in this study, are more likely to perform online tasks (e.g. online banking, etc.) rather than going to the location. Similarly, younger people within the age group 15 - 34 years old show a higher dependence on smartphone applications for mode choice for a trip. Alternatively, people within age group 35 - 65 years, show lower probability of using smartphone applications for deciding departure time, deciding trip destination and communicating/coordinating trips with others.

Full-time students and full-time employees both report a high use of smartphone applications for performing online tasks, deciding trip destinations and communicating/coordinating trips with others. Full-time employees and students usually have a fairly rigid daily activity agenda. The use of smartphones perhaps help to manage their time schedule as well as ease trip planning activities, enabling more frequent online tasks instead of travelling, trip destination choice, and communication and coordinating trips with others. In all cases, the coefficient values are higher for students than that of individuals who are employed full-time. A discrepancy is, however observed in the case of departure time choice. While full-time employees are more like to use smartphones for deciding departure-time, students are found to be less likely to use it.

In general, full-time students use smartphone applications more for trip planning. Our model results could not confirm whether smartphone use for trip planning is affected by income or not. Males are found to be less likely to use smartphone applications for performing online tasks, mode choice, destination choice and communicating and coordinating trips with others.

3.4.2. Travel Characteristics

Travel characteristics are also found to be significant predictors of smartphone use for trip planning. For example: the number of total work/non-work daily trips and number of weekly work/school related round trips are positively associated with trip planning activities. That means, a higher number of trips involve a higher use of smartphone applications for trip planning. Interestingly, the study reveals that commute mode choice is a strong predictor of the type of trip planning activities individuals partake in using smartphone applications. Specifically, the likelihood of using smartphones for mode choice is very high for transit users compared to other groups. Similarly, transit users tend to replace travel by performing tasks on line. Auto users, on the other hand, show lower probability of mode choice by using smartphone applications. Auto and active transportation users are less likely to use smartphone applications for destination choice (e.g. restaurants, social gatherings etc.).

Additionally, mobility tool ownership offers some interesting findings. Higher number of vehicle ownership reduces the probability of using smartphone applications for mode choice and deciding departure time. Transit pass ownership is showing higher likelihood of smartphone use for deciding departure time. Higher number of bicycle ownership increases communicating and coordination of trips by using smartphone applications. Moreover, a higher number of bicycles in the household reduces the likelihood of performing online tasks. This indicates that living closer to facilities (within walk/bike distance) could possibly reduce the chance of doing tasks online such as online banking, and grocery shopping, etc. On the other hand, our model results confirm that those who e-shop more, show a higher probability of performing online tasks.

3.4.3 Neighbourhood Characteristics

Model results offer important insights on the effect of neighbourhood characteristics on the use of smartphone applications for trip planning. A variety of accessibility factors such as home to work/school distance and accessibility from downtown, shopping malls, regional business centre, bus stops and neighbourhood characteristics such as land use, density, employment rate, etc. are assessed in the models.

Results suggest that individuals who live farther from the work/school place exhibit a higher likelihood of performing online tasks. This is expected because if people are spending more time on commute travel they will have less time to perform other maintenance activities by going to the location. Additionally, the use of ICT also offers opportunities to avoid trips by tele-commuting, online shopping, etc. (Mokhtarian, 2009). Mokhtarian et al. (2004) also confirm that higher one-way commute distance increases the probability of tele-commute. Besides, living in residential land use as well as having higher dwelling density in the neighbourhood encourages individuals to perform online tasks.

Higher commute distance reduces the probability of using smartphone applications for deciding departure time. Living 10 Km or farther from the workplace increases the likelihood of decision on mode choice by using smartphone applications. Possibly, people use 'Google Maps' and other similar types of smartphone applications to compare the distance and time required by different transport mode and thus choose the most suitable mode for them. Furthermore, individuals who do not have a bus stop near their residence use smartphone applications more for the same purpose. Higher distance between home and CBD tends to reduce the use of smartphone applications for mode choice decision. On the other hand, higher percentage of residential land use and higher dwelling density in the neighbourhood, both increases the likelihood of smartphone use for mode choice.

Smartphone use for destination choice (e.g. restaurants, entertainment) decreases if the nearest bus stop is higher than walking distance (more than 500 m) from home. Individuals who live in a residential neighbourhood show a higher probability of using a smartphone for destination choice. In addition, a higher percentage of apartments in the neighbourhood and a higher dwelling density show the similar trend with smartphone use for discretionary destination choice. In contrast, employment rate in the neighbourhood shows an opposite association.

Table 8: Ordered Response Model for Trip Planning Activities

Variables	Performing Online Tasks rather than Travelling		Deciding Departure Time		Decision on Mode Choice for the Trip		Deciding Trip Destination		Communicating/ Coordinating Trips with Others	
	β	t	β	t	β	t	β	t	β	t
Socio-Demographic Characteristics										
Age: 15 - 24 years (dummy)					.5285	***3.043				
Age: 25 - 34 years (dummy)	.2653	**2.131	.0880	.604	.5713	***3.402				
Age: 34 - 65 years (dummy)			-.3249	-1.545			-.2834	-1.569	-.4128	**-2.295
Gender: Male (dummy)	-.0855	-.729			-.1727	-1.445	-.1114	-.934	-.1670	-1.392
Studentship Status: Full-Time (dummy)	.6718	***3.664	-.2682	-1.326			.5666	***2.778	.2685	1.281
Employment Status: Full-Time (dummy)	.2436	1.411	.1290	.731			.2616	1.521	.2672	1.530
Travel Characteristics										
# of work/non-work daily trips (one-way)	.0327	1.112	.0431	1.455			.0300	1.027	.0510	*1.690
# of weekly round trips (work/school)	.0394	1.506			.0309	1.261	.0558	**2.106	.0324	1.203
Mode for work/school trips: Auto (dummy)					-.3658	**-2.312	-.3318	**-2.110		
Mode for work/school trips: Walk/Bike (dummy)			-.1338	-.960			-.2764	*-1.905		
Mode for work/school trips: Transit (dummy)	.2238	*1.669			1.3690	***9.252				
# of vehicles in the household	.0397	.647	-.0953	-1.585	-.1261	**-2.008				
# of bicycles in the household	-.0536	-1.302			-.0492	-1.160			.0500	1.206
Transit Pass ownership: Yes (dummy)			.1308	.803			.1745	1.110	.1213	.759
Smartphone use related attributes:										
# of e-shopping in the last month	.1914	**2.518								
Dependency on smartphone for trip planning: Not dependent (dummy)					-1.289	***-5.134				

Variables	Performing Online Tasks rather than Travelling		Deciding Departure Time		Decision on Mode Choice for the Trip		Deciding Trip Destination		Communicating/ Coordinating Trips with Others	
	β	t	β	t	β	t	β	t	β	t
Neighbourhood Characteristics										
Home to work/school distance (km)			-.0158	**-2.215					-.0046	-.736
Home to work/school distance (> 5 km) (dummy)	.2579	**2.079								
Home to work/school distance (> 10 km) (dummy)					.1707	1.116				
Distance between home and CBD (m)					-0.00003	**-1.949	0.000009	.749	-0.00002	-.944
Distance between home and CBD (< 1km) (dummy)			.2624	1.202						
Distance between home and CBD (> 500 m) (dummy)	.1504	.588								
Distance between home and nearest Bus stop (m)			0.00002	1.187	0.00007	**2.179				
Distance between home and nearest Bus stop (> 500 m) (dummy)							-.5126	-1.558	-.3350	-1.038
Distance between home and nearest shopping mall (< 1km) (dummy)			.1982	.696	.3083	1.032				
Distance between home and the regional business centre (m)									0.00004	1.374
Land use Index			.3134	.875			.2793	.785	.4405	1.210
Percentage of residential land use in the neighbourhood	.0006	***2.634	.0002	.965	.0003	1.161	.0005	*1.877	.0002	.726
Percentage of apartments in the neighbourhood							.0010	1.522	.0006	1.081
Dwelling density of the neighbourhood (per acre)	.00002	**2.086			0.00004	***3.512	0.00002	**2.067	0.00002	1.225
Employment rate in the neighbourhood			-.0004	-1.042			-.0015	**-2.069	-.0010	-1.570
Percentage of 2 to 4 person family in the neighbourhood					- 0.00005	-1.020				

Variables	Performing Online Tasks rather than Travelling		Deciding Departure Time		Decision on Mode Choice for the Trip		Deciding Trip Destination		Communicating/ Coordinating Trips with Others	
	β	t	β	t	β	t	β	t	β	t
Attitudes										
I easily adapt to emerging technologies: Agree (dummy)	.4048	**2.345	.2727	1.621	.5958	***3.499	.3627	**2.261		
I make sustainable life-style choices whenever possible: Agree (dummy)					-.4581	***-2.592	-.2269	-1.294	-.2892	-1.555
Households should be fined if their greenhouse gas emission exceed a daily set limit: Agree (dummy)									.2151	*1.762
Travel time is generally wasted time: Agree (dummy)			-.2428	**-2.067			-.1919	*-1.641	-.1758	-1.482
Proximity to shops and services are important to me: Agree (dummy)							.9886	***3.850		
Overall, smartphone has improved my daily life: Agree (dummy)	.6360	***4.534	.2033	1.455					.4988	***3.705
Thresholds (μ)										
Mu (1)	.5069	8.982	.3070	6.794	.7389	10.450	.8322	13.360	.4275	6.105
Mu (2)	1.3149	19.122	.8363	14.244	1.7170	20.233	1.7282	21.919	1.3736	19.918
Mu (3)	2.4390	24.672	1.6873	21.210	2.9489	26.491	2.5551	21.136	2.3522	28.949
Constant	-1.2859	***-3.326	.6604	**2.079	.5544	*1.877	-.8614	**-2.152	.9839	***2.927
Model Fit										
Number of Observation	358		358		358		358		358	
Log Likelihood Function	-506.5112		-540.2212		-454.9302		-495.4927		-470.0569	
Restricted Log Likelihood	-554.3747		-557.4142		-560.4035		-531.9466		-501.7831	
Macfadden Pseudo R-squared	.0863377		.0632271		.1882096		.0685291		.0632271	

*** 99% confidence interval, **95% confidence interval, *90% confidence interval

Longer distance between home and work/school reduces the propensity of using smartphone applications for communicating/coordinating trips with others. Perhaps, living far from work place/school reduces the probability of using car sharing or carpooling applications. The relation between distance from home to CBD and communicating/coordinating trips also suggests this assumption. One of the important findings is that living in a higher mixed land use neighbourhood increases smartphone use for communicating/coordinating trips with others. Though residential land use also increases communication/coordination of trips, the influence is very low compared to land use diversity. Higher percentage of apartments in the neighbourhood and higher dwelling density also show positive impact. On the other hand, higher employment rate in the neighbourhood reduces the propensity of communicating/coordinating trips with others by smartphone applications.

3.4.4 Attitudes

We have noticed some important aspects for the attitudes related statements as well. As expected, Tech-Savvy attitude, such as 'I easily adapt to emerging technologies' and 'Overall, smartphone has improved my life' is positively influencing smartphone use for trip planning. On the other hand, individuals who claimed to follow sustainable life-style choices show a lower propensity to communicate/coordinate trips with others. Agreement on 'Travel time is a waste of time' show less likelihood of using smartphone applications for deciding departure time, destination, communicating and coordinating trips. Putting importance on proximity of shops and services has a significant positive association with the use of smartphones for deciding trip destination.

3.5. Results of Travel Outcome Models

3.5.1 Socio-demographic Characteristics

Male respondents show a higher likelihood of increase in all travel outcomes considered in this study (Table 9). The workforce (age 34 – 65 years) tend to have an increase in travel outcomes except number of trips planned in groups. Additionally, 15 - 24 years old age group show a higher probability of an increase in number of new places visited and number of planned group trips due to smartphone use. In contrast, individuals with a higher income

show a lower likelihood of increase in kilometres travelled, new places visited and social gatherings attended. Individuals who are employed full-time show a lower likelihood of planning group trips. Full-time students show the highest increase in kilometres travelled among all the factors considered in the model. In addition, full-time students show an increase in the number of new places visited and number of social gatherings attended.

3.5.2 Travel Characteristics

All considered travel outcomes show a higher probability of increase with the number of total round trips made in a week. That means, making more round trips will increase travel outcomes. However, a higher number of total work/non-work daily trips is decreasing the likelihood of increase in vehicle kilometres travelled and number of new places visited. Apparently, individuals make more trips on shorter distances, thus, they do not show an increase in vehicle kilometres travelled in total. Having a larger number of vehicles increases the number of new places visited, social gatherings attended and planned group trips. This indicates existence of a strong social network among the vehicle owners. On the other hand, having a higher number of bicycles in the household reduces the probability of an increase in kilometres travelled, number of social gatherings attended and planned group trips.

Among smartphone use related attributes, the amount of e-shopping increases vehicle kilometres travelled. Besides, most of the explored literature suggested complementary effects (Table 6) of e-shopping on travel. As expected, a higher use of smartphones for trip planning increases the number of new places visited. In addition, a positive association has been found between higher use of social networking applications and number of new places visited as well as number of social gatherings attended.

3.5.3 Neighbourhood Characteristics

The relationship between neighbourhood characteristics and the impact of smartphone use on travel outcomes offer some interesting results. Higher home to work/school distance is decreasing the probability of an increase in vehicle kilometres travelled (VKT). Smartphone users might tele-commute, as Mokhtarian et al. (2004) indicates that tele-

commuters can have reduction in kilometres travelled. Another assumption could be that individuals who travel more for work/school, perform their maintenance related activities within their commute trip. Thus they make less maintenance trips, and therefore their vehicle kilometres travelled is less. Another important probability is that they might be using smartphones applications for maintenance and discretionary activities. That means they are performing online tasks and therefore obtaining reduction in their VKT. On the other hand, home location within 1 km of downtown reduces the likelihood of an increase in kilometres travelled. This finding is obvious as living closer to most of the facilities and points of interest will reduce the need for travel as well as trip distance.

Living in a neighbourhood with a higher dwelling density and higher employment rate show higher likelihood of increase in kilometres travelled. However, hypothesized positive relationship between high land use mix and reduced vehicle kilometres travelled could not be confirmed through the model result. Nevertheless, model results suggest that living in residential or industrial prone areas both reduces the probability of increase in kilometres travelled as a result of smartphone use. This means the use of smartphone applications can promote decentralized living without increasing VKT.

In the same way as VKT, those who commute a greater distance show a lower probability of an increase in new places visited, social gatherings attended and planned group trips. This indicates that individuals living nearer to workplace/school (i.e. lower commute distance) have more chance to visit new places, attend social gatherings and make more group trips. On the other hand, living within 1 km of downtown increases the probability of increase the number of planned group trips as the downtown area offers higher opportunity for meeting in restaurants, clubs, etc. Propensity of social gatherings attended decreases with the increase in distance between home and the nearest bus stop. Individuals who do not have any bus stop within walking distance (500 m) of their residence are highly plausible of an increase in number of new places visited.

Table 9: Binary Choice Model for Travel Outcomes

Variables	VKT (Increase)		New Places Visited (Increase)		Social Gathering Attended (Increase)		Planned Group Trips (Increase)	
	β	t	β	t	B	t	β	t
Socio-Demographic Characteristics								
Age: 15 - 24 years (dummy)			.4870	*1.649			.5507	**1.966
Age: 34 - 65 years (dummy)	1.1925	1.566	.8802	**2.150	.7072	*1.765		
Gender: Male (dummy)	.9278	**2.291	.4581	*1.808	.1930	.780	.7456	***2.936
Income: More than 75K (dummy)	-1.2850	-.999	-.6779	-1.467	-1.4587	***-2.876		
Studentship Status: Full-Time (dummy)	**2.3766	***2.779	.4939	1.423	.3399	.988		
Employment Status: Full-Time (dummy)							-.7808	***-2.733
Travel Characteristics								
# of work/non-work daily trips	-.1773	*-1.727	-.0915	-1.450				
# of total weekly round trip (all purpose)	.0634	***2.690	.0741	***3.473	.0621	***3.164	.0746	***3.737
Mode for work/school: Auto (dummy)					.4221	1.293	.3016	.886
# of vehicles in the household			.1699	1.430	.2176	*1.766	.1622	1.321
# of bicycles in the household	-.2423	-1.429			-.1501	*-1.709	-.1143	-1.294
Transit pass ownership: Yes (dummy)	1.3004	**2.226	.2342	.876			.6653	**2.351
Smartphone use related attributes:								
# of e-shopping in the last month	.3417	1.395						
Dependency on smartphone for trip planning: Highly (dummy)			1.0662	***3.346				
Dependency on smartphone for social networking: Highly (dummy)			.9112	***3.183	1.3329	***4.779		
Neighbourhood Characteristics								
Distance between home and work/school (km)	-.0201	-.653	-.0193	-1.137	-.0466	**-2.061	-.0716	***-2.843
Distance between home and CBD (m)					0.00003	.737		
Distance between home and CBD (< 1km) (dummy)	-1.2199	-.813	.4090	.950			.4838	1.102
Distance between home and nearest bus stop (m)					-.0002	*-1.708	0.00002	.508
Distance between home and nearest bus stop (> 500m) (dummy)			1.1622	**2.389				

Variables	VKT (Increase)		New Places Visited (Increase)		Social Gathering Attended (Increase)		Planned Group Trips (Increase)	
	β	t	β	t	B	t	β	t
Distance between home and regional growth centre (m)	-0.00003	-.753			0.00005	.703		
Distance between home and regional growth centre (<1km) (dummy)			.9637	.852			.8592	.809
Dwelling density of the neighbourhood (per acre)	0.00003	.932	0.00005	**1.980			0.00004	*1.724
Percentage of apartments in the neighbourhood	-.0022	-1.395						
Percentage of residential land use in the neighbourhood	-.0015	-.994			.0008	1.519		
Percentage of commercial land use in the neighbourhood	.0005	.850			-.0004	-.954	.0004	.995
Percentage of industrial land use in the neighbourhood	-.0006	-1.540						
Land use Index			.7817	1.027	.8159	1.053	-.6451	-.799
Employment rate in the neighbourhood	.0019	1.035	.0008	1.036	-.0011	-1.413		
Attitudes								
I make sustainable life-style choices whenever possible: Agree (dummy)	-1.1638	**-2.233	.8763	**2.215	.6886	*1.830		
I limit my driving because it is bad for the environment: Agree (dummy)	.7326	*1.689					.2783	1.059
Households should be fined if their greenhouse gas emission exceed a daily set limit: Agree (dummy)			.2536	.984				
Travel time is generally wasted time: Agree (dummy)					-.3348	-1.367	-.5733	**-2.291
I easily adapt to emerging technologies: Agree (dummy)							.3367	.959
Constant	-5.5747	***-3.739	-3.5083	***-4.836	-2.8406	***-3.663	-1.6112	**-2.315
Model Fit								
Number of Observation	358		358		358		358	
Restricted Log Likelihood	-125.3433		-248. 1467		-244.3568		-240.8569	

Variables	VKT (Increase)		New Places Visited (Increase)		Social Gathering Attended (Increase)		Planned Group Trips (Increase)	
	β	t	β	t	B	t	β	t
Macfadden Pseudo R-squared	.2521507		.1607245		.1549046		.1628545	

*** 99% confidence interval, **95% confidence interval, *90% confidence interval

A higher dwelling density increases the number of new places visited and planned group trips as a result of smartphone use. Higher employment rate in the neighbourhood increases the number of new places visited and reduces the number of social gatherings attended. As expected, a higher percentage of residential land use increases the number of social gatherings attended because living in a residential area gives the opportunity to connect with more people in the community. For the same reason, having a higher percentage of commercial land use in the neighbourhood displays the opposite relation. Furthermore, mixed land use promotes number of new places visited and social gatherings attended as a result of using smartphone applications.

3.5.4 Attitudes

This study also give some interesting understanding on the attitudes of the respondents. Those who agreed on 'I make sustainable life-style choices whenever possible' show a lower likelihood to increase in kilometres travelled. They also show a higher tendency of increase in the number of new places visited and social gatherings attended. Individuals who agreed on 'Travel time is generally a wasted time' tend to be less probable to make group trips. They also show a lower probability of social gatherings attended. Individuals who mentioned 'I limit my driving because it is bad for the environment' show a higher probability of planning group trips. However, it is interesting that individuals with agreement on limiting driving for environment's sake are more likely of showing increase in VKT. Ewert and Galloway (2004) mentioned that environmental concern and pro-environmental attitudes often show inconsistency with actual behaviour. They identified the reason as 'Socially desirable response bias' which they further elaborated as individual's tendency to respond on pro-environmental attitudes which are consistent with socially acceptable views.

3.6. Summary and Conclusion

This chapter presents key findings based on models of smartphone applications' use for trip planning and its impact on travel outcomes. The main objective is to explore what are the determinants of mobile ICT use and how they affect travel decisions. As such, it adds to a growing body of mobile ICT research by exploring how the use of smartphones and

its applications are shaping our movements. Along with socio-demographic and travel characteristics, this study includes neighbourhood attributes. Furthermore, by including attitudes toward technology and sustainability, this study is offering some new insights. Trip planning attributes considered in the study are: performing online tasks rather than traveling, deciding departure time, mode choice, decision on trip destination and communicating/coordinating trips with others. Impact on the number of new places visited, number of social gatherings attended and number of planned group trips are considered as travel outcomes.

Several empirical findings on socio-demographic characteristics have emerged through this study which can be summarized as:

- Young individuals (15 - 24 years old) are highly dependent on smartphone applications for mode choice decision. Their number of planned group trips are highly likely to increase as a result of smartphone use. On the other hand, 25 - 34 years old smartphone users show a higher likelihood of performing online tasks and deciding mode choice by using smartphone applications.
- 34+ years old individuals display a lower likelihood of smartphone use for communicating/coordinating trips with other. However, their number of new places visited increases as a result of smartphone use
- Men display a higher likelihood of increase in travel outcomes such as vehicle kilometres travelled, number of new places visited and number of planned group trips as a result of smartphone use.
- Full-time studentship confirms a higher probability of using a smartphone for performing online tasks and deciding trip destination; and increase in vehicle kilometres travelled.
- Full-time employees are less likely to make higher number of planned group trips as a result of smartphone use.

Attitudinal variables also significantly affect trip planning and travel outcomes as a result of smartphone use. Tech-Savvy attitudes are highly associated with use of smartphone

applications for trip planning activities. This indicates that individuals with more exposure to ICT, usually use smartphone applications. Among pro-environment attitudes, a sustainable life-style increases the number of new places visited and number of social gatherings attended among the smartphone users.

Neighbourhood characteristics affect trip planning and travel outcomes, but their relative influence is very low compared to other variables. Regarding travel characteristics, individuals who make more round trips (work/non-work) in a week tend to use smartphone applications more for trip planning purposes and their travel outcomes also increase for weekly total trips as a consequence of smartphone use. Transit users show a higher likelihood of using smartphone applications for mode choice compared to auto users.

Although this study includes the reported impact of smartphone use on travel outcomes, it will be very interesting to explore the impact of actual usage of smartphone applications on travel outcomes. Future research may include collecting big data by tracking application usage information and then analysing how this is influencing travel. Nonetheless, this study offers in-depth insights on the use of smartphone applications for trip planning and how they are shaping travel outcomes. The results could be useful to develop policies to promote development of mobile ICT applications that can enhance trip planning experiences and positively influence sustainable travel behaviour.

Chapter 4: Conclusion

This study aimed to explore the use of smartphone applications for trip planning and travel outcomes. This study specifically investigated the determinants which shape our mobility choices as a result of smartphone usage. To achieve the objective, this study conducted a survey titled Smartphone Use and Travel Choice Survey - 2015 on smartphone users of Halifax. The survey collected information on smartphone usage pattern for trip planning and travel outcomes along with socio-demographic characteristics, travel characteristics and attitudes. An exploratory analysis of the information collected were conducted to have a general idea about the smartphone users' characteristics in Halifax. Next, this study examined the determinants and how they affect smartphone applications use for trip planning and their impact on travel outcomes. Trip planning activities considered in this study are performing online tasks rather than travelling, communicating/coordinating trips with others, deciding trip destination, mode choice and departure time. Travel outcomes included are impact on vehicle kilometres travelled, number of new places visited, number of social gatherings attended and number of trips planned in groups. The findings from this study are summarized below.

4.1 Summary and Policy Implications from Exploratory Analysis

This study aimed to enhance our understanding of the nature of smartphone application usage on day to day trip planning and travel outcome through an exploratory analysis. Results of this study offers important insights about the smartphone users which could be useful for policy discussions. The results of the exploratory analysis can be summarized as:

- Young people (age: 15 - 34 years) are the major users of smartphones.
- 15-34 years are more involved in using smartphone applications for trip planning.
- Regarding vehicle ownership, the most significant relationship is seen for decision on departure time, trip destination, and mode choice. Individuals with no private vehicle in the household rely more on smartphone applications for trip planning decisions compared to vehicle owners.

- Among vehicle owners (e.g. those possess at least one private vehicle at home), use of smartphone applications of departure decision, trip destination, and mode choice increases with number of private vehicles in the household.
- Transit pass owners are the frequent users of smartphone applications for trip planning.
- In case of primary mode choice, transit and active transportation users are the more frequent users of smartphone applications for deciding departure time and mode choice.
- From the individuals' perspective, usage of smartphone applications show both neutral and positive effects for all other travel outcomes except vehicle kilometres travelled.
- Higher percentage of younger people (15 - 34 years) are showing increase in travel outcomes such as number of social gatherings attended, number of new places visited, and number of trips planned in groups as a result of smartphone use.
- Transit pass ownership increases the number of social gatherings attended, number of new places visited, and number of trips planned in groups. Similar results have been found for the number of vehicles in the household (among the vehicle owners).

The review of literature and the findings of the exploratory analysis suggest that in future, impact of smartphone and its applications on travel will be much higher than the present as more people will get used to with the use of smartphones. So, now, it is a need to develop user friendly travel support applications. This can be boosted through initiatives similar to 'Apps4Halifax - Halifax Open Data Application Contest' (www.apps4halifax.ca) by developing free applications. This contest has already gathered 237 ideas on application development given by the Halifax residents and 38 smartphone applications was submitted for this contest. Ideas that came through this contest mainly focused on getting real-time transit schedule, traffic update, local recreation and entertainment facility and finding nearest facility, etc. This study also suggest similar findings. For example: Applications are most often used for checking bus schedule and finding locations. In Halifax, a smartphone version of current AVL (Automatic Vehicle Location) based transit schedule is needed to maximize the benefits of this service. Smartphone use is seen far less for

online shopping, recreation and entertainment compared to other activities such as trip planning, business etc. in Halifax. Transportation Planners should generate the idea of need on the development of smartphone applications which will enhance local online shopping, virtual meetings, online banking, etc. and thus reduce the need of travel for these purposes.

Individuals between 15 -34 years are more involved in using smartphone applications for trip planning such as deciding departure time, destination and mode choice. However, a growing interest is noticed among 35-65+ years in smartphone application use for coordinating trips with others and performing online tasks. This age group is facing less influence of smartphone applications on travel outcomes such as number of social gatherings attended, number of new places visited, and number of trips planned in groups. This gives an indication that smartphone applications need to be user specific based on socio-demographic characteristics and purpose.

Individuals with no private vehicle in the household rely more on smartphone applications for trip planning decisions compare to vehicle owners. For travel needs, they are more dependent for, checking bus schedule, and reserving taxis compare to vehicle owners. Nevertheless, both vehicle owners and non-vehicle owners are dependent on smartphone applications for finding locations and scheduling meetings with friends, family, etc. Our study also confirms that the transit pass owners are the frequent users of smartphone applications for trip planning specially for checking bus schedule. Transit and active transportation users are the more frequent users of smartphone applications for deciding departure time and appropriate mode for travel. Developing smartphone applications that makes transit and active transportation easier can be a good initiative as it will encourage people to switch modes of transportation.

From the individuals' perspective, usage of smartphone application have a very little substitution effect on travel outcome. For all travel outcomes, except vehicle kilometers travelled, both neutral and positive effects are noticeable. Applications that provide updates on surrounding sights and tour guides of places, can also be introduced as around 50% of the respondents think smartphones have no impact on their number of new places visited.

This can be validated by the ideas that came through the 'Apps 4 Halifax' contest where lots of ideas emphasized digital tour of the city of Halifax sites, going on's, parks, trails, restaurants, pubs, bars, movies, etc. Analysis suggests that almost 90% think that use of smartphone applications do not have any substitution effect on vehicle kilometers travelled. That means, more attention is needed to reduce vehicle kilometres travelled. The Provincial Government along with the Municipal Agencies should take initiatives and promote innovative social-marketing as well as Travel Demand Management (TDM) measures such as e-commuting and other initiatives with incentives to achieve the goals of 2013 Sustainable Transportation Strategy that aims to reduce total distance travelled. This will need joint engagement of public agencies, local communities and application developers. 40.2% of the respondents reported increase in the number of trips planned in groups and 43.2% reported increase in number of social gatherings attended due to smartphone use. Transportation planners should advocate for high quality and affordable services. They should also advocate for free Wi-Fi at all points of interest (e.g. bus stops, parks, trails, shopping malls etc.) as a government provided facility to create an open platform to use smartphone applications.

4.2 Summary of Model Results and Future Studies

This study offers unique contribution on investigating the determinants of mobile ICT use and how they affect travel decisions. To explore the determinants of smartphone use for trip planning and its impact on travel outcome, four binary choice models were estimated for travel outcomes and five ordered response models were estimated for trip planning activities. This study adds to a growing body of mobile ICT research by exploring how the use of smartphones and its applications are shaping our movements. Along with socio-demographic and travel characteristics, this study includes neighbourhood attributes. Furthermore, by including attitudes toward technology and sustainability, this study is offering some new insights. The model results reveal that socio-demographic and attitudes play a significant role in smartphone use for trip planning and travel outcome whereas relative influence of neighbourhood characteristics is low. Young individuals (15 - 24 years old) are highly dependent on smartphone applications for mode choice decision. Along with mode choice decision, 25 - 34 years old smartphone users show a higher likelihood

of performing online tasks by using smartphone applications. On the other hand, 34 - 65 years old individuals show a lower likelihood of smartphone use for communicating and coordinating trips with other. Although, male respondents display a higher likelihood of increase in travel outcomes, they are less likely to use smartphone applications for trip planning purposes. Full-time student status confirms higher probability of using a smartphone for performing online tasks and deciding trip destination. Full-time students also show a higher likelihood of increase in VKT as a result of smartphone use.

Individuals who make more round trips (work/non-work) in a week tend to use smartphone applications more for trip planning purposes and their travel outcomes also increase as a consequence of smartphone use. Transit users are more dependent on smartphone applications for mode and destination choice compared to auto users.

Attitudinal variables significantly affect trip planning and travel outcomes as a result of smartphone use. Tech-Savvy attitudes are highly associated with use of smartphone applications for trip planning activities. It is expected as individuals with more exposure to ICT, will use smartphone applications more frequently. Among pro-environment attitudes, sustainable life-style choice reduces VKT and increases number of new places visited and number of social gatherings attended.

Neighbourhood characteristics affect trip planning and travel outcome, but their relative influence is very low compared to other variables. Still it can give some important insights. For example: the results presented show that compared to mixed land use, a higher percentage of residential land use in the neighbourhood increases smartphone use for trip planning and in the same time, decreases VKT. Another important finding is that living far from the workplace/school reduces the likelihood of increasing group trips as well as communicating/coordinating trips with others. This indicates low carpooling/car sharing tendency among the smartphone users. Higher dwelling density also ensures higher use of smartphone applications both for trip planning and travel outcomes.

Neighbourhood attributes suggest that smartphone use can enable VKT reduction despite living in a non-mixed land use area. Alternatively, from the land-use policy perspective, we can say smartphone use for trip planning can promote more decentralized living. The assumption that ICT may enable decentralized living was also mentioned by Mokhtarian (2009) and Wee et al. (2013). Use of smartphone permits online activities along with easily attainable information on shortest routes, time, quickest modes, etc. This indicates that some facilities can be established farther if a smartphone version of an online solution is available. This is how individuals can make less trips and reduce their VKT simultaneously, which will ensure less emission from the transportation sector.

By developing mapping along with real time information providing applications, individuals can be encouraged to reduce VKT and use public transportation. As commuters are less likely to use smartphone applications for communicating and coordination of trips, some policy implications need to be developed to encourage carpooling or carsharing. However, Buliung et al. (2012) states that although internet provides opportunities to carpool, the most important point is to make the commuters willing to rideshare. Along with development of local carpool/car sharing applications, financial incentives (e.g. credit on tax returns in State of Washington) could be introduced to encourage reduction in commute trips in Halifax. Employers can be encouraged to introduce Travel Demand Management (TDM) Strategies to reduce distance travelled as Buliung et al. (2010) find it effective in Toronto and Hamilton.

One of the limitation of this study is that attitudinal statements are used directly in the model estimation. Future research includes to conduct a factor analysis of the attitudinal statements and include that in the model analysis. Factor analysis is a statistical method used to define variability among observed, correlated variables in terms of a potentially lower number of unobserved variables. This study did not capture the impact of unobserved latent variables. Latent variables are variables that are not directly observed but are rather inferred from other variables that are observed. It would be interesting to explore how the frequency of using social networking and transport-support applications along with other variables such as attitudes and neighbourhood characteristics are directly and indirectly

affecting travel decisions. Structural equations model (SEM) would be a good methodology to follow as this method will explore the interrelationship among different variables and how they directly and indirectly affect travel decisions. From the study it was seen that smartphone use has increased number of social gatherings attended and planned group trips. There might be an impact of smartphone and social networking applications usage on social trips of individuals in Halifax which can be explored using the existing data. Another limitation of the study is that the frequency of smartphone applications usage for trip planning and how they influence travel outcome are not observed rather they are reported on a Likert scale by the respondents. Future studies should collect actual recording of travel-support and social networking application usage data along with travel characteristics to have a better understanding on the smartphone usage for trip making.

Nevertheless, the current study offers some important policy direction as well as enriches the growing literature on the relationship between smartphone use and travel decisions making. The study provides strong evidences that socio-demographic and attitudes highly influence smartphone use for trip planning and travel outcomes. Our study and available literature show that along with the young generation, middle aged and older generation are emerging as new adopters of smartphones. This huge diffusion of technology is also bringing change to our life-style. It is our understanding that the impact of ICT or smartphones on travel is needed to be considered while formulating strategies and policies. This type of study will give a better understanding on smart city planning. Smart city is an urban planning concept based on the idea of reducing greenhouse gas emissions by means of fundamental changes in urban infrastructure where information and communication technology play the central role (WWF, 2012). European cities such as Amsterdam and Barcelona have adopted the smart city concepts. The Amsterdam Smart City initiative includes 79 projects collaboratively developed by local residents, government and businesses. Under this initiative, they developed some useful smartphone applications, one of which is Mobypark, which allows owners of parking spaces to rent them out to people for a fee (www.mobypark.com). The data generated from this application can then be used by the City to determine parking demand and traffic flows in Amsterdam (amsterdamsmartcity.com). Other than Europe, smart city concept is also becoming

popular in Dubai, Singapore, San Francisco, Chicago, New York, Miami etc. (Maddox, 2015). For Halifax, one good idea could be developing a mashup, more specifically, one-stop application that include all travel-support applications. With the increasing use of smartphones, urban planners can also think to develop smart city concept where smartphone could be a major integrating tool for virtual activities such as e-commute, travel-support solutions, e-commerce, e-governance etc. This can help to achieve the goals of sustainable travel behaviour to build next generation cities and towns in Canada.

Bibliography

Amsterdam Smart City, http://amsterdamsmartcity.com/#/en accessed on July 17, 2016.

Ben-Elia, E.; B. Alexander; C. Hubers, and D. Ettema. 2014. Activity fragmentation, ICT and travel: An exploratory Path Analysis of spatiotemporal interrelationships. *Transportation Research Part A*, 68, 56-74.

Berg, P.V.D., T. Arentze and H. Timmermans. 2013. A Path Analysis of Social Networks, Telecommunication and Social Activity–Travel Patterns. *Transportation Research Part C*, 26, 256-268.

Bhat, R. C., A. Sivakumar, and K.W. Axhausen. 2003. An Analysis of the Impact of Information and Communication Technologies on Non- Maintenance Shopping Activities. *Transportation Research Part B*, 37 (10), 857-881.

Buliung, N.B., R. Bui, and R. Lanyon. 2012. When the Internet is not enough: Toward an Understanding of Carpool Services for Service Workers. *Transportation*, 39, 877 -893.

Buliung, R.N., K. Soltys, R. Bui, C. Habel, and R. Lanyon. 2010. Catching a Ride on the Information Super-highway: Toward an Understanding of Internet-based Carpool Formation and Use. *Transportation*, 37, 849–873.

Canadian Wireless Telecommunication Association (CWTA). 2012. *2012 Cell Phone Consumer Attitudes Study*. Prepared by Quorus Consulting Group. http://cwta.ca/wordpress/wp-content/uploads/2011/08/CWTA-2012ConsumerAttitudes1.pdf . Accessed on July 2, 2015

Cao, X. and P. L. Mokhtarian. 2005. "The Intended and Actual Adoption of Online Purchasing: A Brief Review of Recent Literature". Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-05-07.

Cao, X. J.; F. Douma; F. Cleaveland and Z. Xu. 2010. *Final Report on the Interactions between E-Shopping and Store Shopping: A Case Study of the Twin Cities*. The Intelligent Transportation Systems, Institute Center for Transportation Studies, University of Minnesota.

Cao, X. 2012. The Relationships Between E-shopping and Store Shopping in the Shopping Process of Search Goods. *Transportation Research Part A: Policy and Practice*, 46 (7), 993–1002.

Carrasco, J.A. 2011. Personal Network Maintenance, Face to Face Interaction, and Distance: Studying the Role of ICT Availability and Use. *Transportation Research Record*, 2231, 120-128

Casas, J., J. Zmud., and S. Bricka. 2001. Impact of Shopping via Internet on Travel for Shopping Purposes. Presented at the 80th Annual Meeting of the Transportation Research Board, Washington, D.C.

Catalyst. 2015a. *Infographic: The 2014 Canadian Smartphone Market.* http://catalyst.ca/infographic-2014-canadian-smartphone-market/ . Accessed on July 2, 2015.

Catalyst. 2015b. *With Growth Comes Change: The Evolving Mobile Landscape in 2015*. http://catalyst.ca/2015-canadian-smartphone-market/ . Accessed on June 1, 2016.

Choo, S. and P. L. Mokhtarian. 2007. Telecommunications and Travel Demand and Supply: Aggregate Structural Equation Models for the US. *Transportation Research Part A*, 41, 4–18

Choo, S. and P.L. Mokhtarian. 2005. Do Telecommunications Affect Passenger Travel or Vice Versa? Structural Equation Models of Aggregate U.S. Time Series Data Using Composite Indexes. *Transportation Research Record*, 1926, 224–232.

Choo, S., P.L. Mokhtarian, and I. Salomon. 2005. Does Telecommuting Reduce Vehicle Miles Traveled? An Aggregate Time Series Analysis for the US. *Transportation*, 32 (1), 37–64

Circella G. and P. L. Mokhtarian. 2010. Complementarity or Substitution of Online and In-Store Shopping: An Empirical Analysis from Northern California, Presented at 89th Annual Meeting of Transportation Research Board, Washington D.C.

Cohen-Blankshtain G. and O. Rotem-Mindali. 2013. Key Research Themes on ICT and Sustainable Urban Mobility, International Journal of Sustainable Transportation. DOI: 10.1080/15568318.2013.820994.

ComScore.com, 2016. ComScore Reports December 2015. *U.S. Smartphone Subscriber Market Share*. https://www.comscore.com/Insights/Rankings/comScore-Reports-December-2015-US-Smartphone-Subscriber-Market-Share. Accessed on June 25, 2016.

Corpuz, G. and J. Peachman. 2003. "Measuring the Impacts of Internet Usage on Travel Behaviour in the Sydney Household Travel Survey". Presented at the 26th Australasian Transport Research Forum, Wellington, New Zealand, 2003.

Couclelis, H., 2003. Housing and the new geography of accessibility in the information age. *Open House Int.* 28 (4), 7–13.

CRTC (Canadian Radio-Television and Telecommunication Commission). 2015. Communications Monitoring Report 2015. http://www.crtc.gc.ca/eng/publications/reports/policymonitoring/2015/cmrre.htm. Accessed on June 15, 2016.

Dam, I. 2009. Exploring the Relationship between Social Interaction and Tele-commuting. Master's thesis, submitted to Mcmaster University.

De Graaff, T. and P. Rietveld. 2007. Substitution between working at home and out-of home: the role of ICT and Commuting Costs. *Transportation Research A*, 41 (2), 142 – 160.

Ewert, A. and G. Galloway. 2004. Expressed Environmental Attitudes and Actual Behaviour: Exploring the Concept of Environmentally Desirable Response. Proceedings of the International Conference on Outdoor Education. Latrobe University, Australia.

Farag, S., M. Dijst and M. Lanzendorf. 2003. Exploring the use of E-Shopping and Its Impacts on Personal Travel Behaviour in the Netherlands. *Transportation Research Record*, 1858, 47-54.

Farag, S., K. J. Krizek, and M. Dijst. 2006. E-shopping and its Relationship with in Store Shopping: Empirical Evidence from the Netherlands and the U.S. *Transport Reviews*, 26, 43-61.

Farag, S., T. Schwanen, M. Dijst, and J. Faber. 2007. Shopping Online and/or In-Store? A Structural Equation Model of the Relationships between E-Shopping and In-Store Shopping. *Transportation Research A*, 41 (2), 125-141.

Ferrel, C.E. 2004. Home-based Teleshoppers and Shopping Travel: Do Teleshoppers Travel Less? *Transportation Research Record,* 1894: 241-248.

Gretzel, U. 2010. Travel in the Network: Redirected Gazes, Ubiquitous Connections and New Frontiers. In: M. Levina and G. Kien (Ed.) *Post-global Network and Everyday Life*. New York: Peter Lang, 41-58.

Habib, M.A. 2016. Working Report on Travel Choice and Behaviour: Nova Scotia Travel Activity (NovaTRAC) Survey 2015 -2016. Prepared for Halifax Regional Municipality and Province of Nova Scotia.

Hjorthol, R. J. 2002. The Relation between Daily Travel and Use of the Home Computer. *Transportation Research Part A*, 36 (5), 437-452.

Hjorthol, R. J. and M. Gripsrud. 2009. Home as a Communication Hub: The Domestic Use of ICT. *Journal of Transport Geography*, 17, 115-123.

Irvine, J.D.A. 2014. The Impact of the Use of Smartphone Technologies on Travel Choices. Undergraduate thesis, submitted to School of Planning, Dalhousie University.

Jain, J. and G. Lyons. 2008. The Gift of Travel Time. *Journal of Transport Geography* 16 (2): 81-89.

Kramer, R., M. Modsching, K. T. Hagen and U. Gretzel. 2007. Behavioural Impacts of Mobile Tour Guides. In *Information and Communication Technologies in Tourism 2007*, edited by M. Sigala, L. Mitch and J. Murphy, 109-118, Springer Vienna.

Krizek, K. J., Y. Li, and S. L. Handy. 2005. Spatial attributes and patterns of use in household related information and communications technology activity. Transportation Research Record, 1926, 252-259.

Lee, R.J., I.N. Sener., P.L. Mokhtarian, and S. Handy. 2016. Relationship between the Online and In-Store Shopping Frequency of Davis, California Residents. Presented at 95th Annual Meeting of Transportation Research Board, Washington D.C.

Le Vine, S., C. Latinopoulos, and J. Polak. 2016. Analysis of the Relationship between Internet Usage and Allocation of Time for Personal Travel and Out of Home Activities: Case Study of Scotland in 2005/6. *Travel Behaviour and Society,* 4, 49-59.

Lilaa P.C. and M.V.L.R. Anjaneyulu. 2013. Modeling the Choice of Tele-work and its Effects on Travel Behaviour in Indian context. *Procedia - Social and Behavioral Science* 104: 553-562.

Lyons, G. 2002. Internet: Investigating New Technology's Evolving Role, Nature and Effects on Transport. *Transport Policy*, 9 (4), 335-346.

Lyons, G. 2015. Transport's Digital Age Transition. *The Journal of Transport and Land Use*, 8 (2), 1-19.

Maddox, T. 2015. The World's Smartest Cities: What IoT and Smart Government Will Mean for You, TechRepublic, November 10. 2015.

Meng, B., M. Kim. and Y. Hwang. 2015. Users and Non-Users of Smartphones for Travel: Differences in Factors Influencing the Adoption Decision. *Asia Pacific Journal of Tourism Research*, 20 (10), 1094-1110.

Mokhtarian, P. L. 2009. If Telecommunication is Such a Good Substitute for Travel, Why does Congestion Continue to Get Worse? *Transportation Letters*, 1(1), 1–17.

Mokhtarian, P.L. and I. Salomon. 1996. Modeling the Choice of Telecommuting: A Case of the Preferred Impossible Alternative. *Environment and Planning A*, 28, 1859– 1876.

Mokhtarian, P.L. and I. Salomon. 1997. Modelling the Desire to Telecommute: The Importance of Attitudinal Factors in Behavioural Models. *Transportation Research Part A*, 31 (1), 35–50.

Mokhtarian, P. L., I. Salomon, and S. L. Handy. 2006. The Impacts of ICT on Leisure Activities and Travel: A Conceptual Exploration. *Transportation,* 33 (3), 263-289.

Mokhtarian, P.L. and G. Tal. 2013. Impacts of ICT on Travel Behavior: a Tapestry of Relationships. In: Rodrigue, J.-P., Notteboom, T., Shaw, J., (Eds.). *Handbook of Transport Studies,* Sage.

Mokhtarian, P.L. 1990. A Typology of Relationships between Telecommunications and Transportation. *Transportation Research A*, 24 (3), 231–242

Mokhtarian, P.L. 1998. A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel. *Urban Studies* 35 (2), 215–241

Mokhtarian, P.L., G. O. Collantes, and C. Gerzt. 2004. Telecommuting, Residential Location, and Commute-Distance Travelled: Evidence from State of California Employees. *Environment and Planning A*, 36 (10), 1877 – 1897.

Mokhtarian. P.L. and R. Meenakshisundaram. 1999. Beyond Tele-substitution: Disaggregate Longitudinal Structural Equations Modeling of Communication Impacts. *Transportation Research Part C*, 7 (1), 33–52.

Mondschein, A. 2011. PasseggiataNuova: Social Travel in the Era of Smartphone. Working Paper. Rudin Center for Transportation Policy and Management, New York University, USA, 2011.

Ngai, E.W.T. and A. Gunasekaran. 2007. A review for mobile commerce research and applications. *Decision Support Systems*, 43, 3–15.

Olszewski, P. and P.L. Mokhtarian. 1994. Telecommuting Frequency and Impacts for State of California Employees. *Technological Forecasting and Social Change*, 45 (3), 275 – 286.

Padayhag, G.U., J. D. Schmocker, and D. Fukuda. 2011. Mobile Phones and Telecommuting: Effects on Trips and Tours of Londoners, *Journal of Transport and Land Use*, 4 (3), 23 - 41.

Ren, F. and M. P. Kwan. 2009a. The Impact of the Internet on Human Activity Travel Patterns: Analysis of Gender Differences Using Multi-Group Structural Equation Models. *Journal of Transport Geography*, 17 (6), 440 – 450.

Ren, F. and M. P. Kwan. 2009b. The Impact of Geographic Context on E-Shopping Behaviour. *Environment and Planning B*, 36 (2), 262-278.

Rotem-Mindali, O. 2010. E-tail versus retail: The effects on shopping related travel empirical evidence from Israel. *Transport Policy* 17(5): 312-322.

Senbil, M. and R. Kitamura. 2003. The Use of Telecommunications Devices and Individual Activities Relationships. Presented at 82nd Annual Meeting of Transportation Research Board.

Shaheen, S. A., A. P. Cohen, and M. S. Chung. 2009. North American Carsharing: 10-Year Retrospective, *Transportation Research Record*, 2110, 35-44.

Spring 2015 Global Attitude Survey. Conducted by Pew Research Center in 2015. http://www.pewglobal.org/

Srinivasan, K. K., and S. R. Athuru. 2004. Modelling Interaction between Internet Communication and Travel Activities: Evidence from Bay Area, California, Travel Survey 2000. *Transportation Research Record,* 1894: 230-240.

Tang, W. L., P. L. Mokhtarian, and S. L. Handy. 2011. The Impact of the Residential Built Environment on Work at Home Adoption and Frequency: An example from Northern California, *Journal of Transport and Land Use*, 4 (3), 3-22.

The Nielsen Company. 2015. *So Many Apps, So Much More Time for Entertainment*. http://www.nielsen.com/us/en/insights/news/2015/so-many-apps-so-much-more-time-for-entertainment.html . Accessed on July 2, 2015.

Tussyadiah, L. P and D. Wang. 2014. Tourists' Attitudes toward Proactive Smartphone Systems. *Journal of Travel Research,* 1-16. doi: 10.1177/0047287514563168.

Viswanathan, K., and K. G. Goulias. 2001. Travel Behavior Implications of Information and Communications Technologies (ICT) in the Puget Sound Region. Presented at the 80th Annual Meeting of the Transportation Research Board, Washington, D.C.

Wang, D. and D. R. Fesenmaire. 2013. Transforming the Travel Experience: the Use of Smartphones for Travel. In *Information and Communication Technologies in Tourism 2013*, edited by L. Cantoni and Z. Xiang, 58-69, Springer-Verlag Berlin Heidelburg.

Wang, D. and F. Y. T. Law. 2007. Impacts of Information and Communication Technologies (ICT) on Time Use and Travel Behaviour: A Structural Equations Analysis. *Transportation*, 34 (4), 513-527.

Wang, D. S. Park and D. R. Fesenmaier. 2011. The Role of Smartphones in Mediating the Touristic Experience. *Journal of Travel Research* 51 (4): 371-387.

Wang, D., Z. Xiang and D. R. Fesenmaier. 2014a. Smartphone Use in Everyday Life and Travel. *Journal of Travel Research* 1-12. doi: 10.1177/0047287514535847.

Wang, D., Z. Xiang and D. R. Fesenmaier. 2014b. Adapting to the Mobile World: A model of Smartphone Use. Annals of Tourism Research, Vol. 48, 11-26

Ward, M.R. and M. Morganosky. 2002. Consumer Acquisition of Product Information and Subsequent Purchase Channel Decisions, in *Advances in applied microeconomics: The economics of the Internet and E-Commerce*. In M R Baye (Ed.), Elsevier Science, Amsterdam, 231-255.

Wee, B.V. 2015. Peak car: The first signs of a shift towards ICT-based activities replacing travel? A discussion paper. *Transport Policy*, 42, 1-3.

Wee, B.V., K. Geurs and C. Chorus. 2013. Information, Communication, Travel behaviour and Accessibility. *The Journal of Transport and Land Use*, 6 (3), 1-16.

Weltevreden, J. W. J. and T. van Rietbergen. 2007. E-shopping versus City Centre Shopping: the Role of Perceived City Centre Attractiveness. *Journal of Economic & Social Geography*, 98 (1), 68-85.

Windmiller, S., T. Hennessy, and K. E. Watkins. 2014. Accessibility of Communication Technology and the Rider Experience: A Case Study of St. Louis Metro. *Transportation Research Record*, 2415, 118-126.

WWF (World Wildlife Foundation), 2012. Amsterdam Smart City. http://wwf.panda.org/wwf_news/?204657 accessed on July 16, 2016.

www.mobypark.com. accessed on August 13, 2016

Xiang, Z., D. Wang, J. T. O'Leary, and D. R. Fesenmaier. 2015. Adapting to the Internet: Trends in Travelers' Use of the Web for Trip Planning. *Journal of Travel Research,* 54 (4): 511–527

Zhang, F., K. J. Clifton, and Q. Shen. 2007. Reexamining ICT Impact on Travel using the 2001 NHTS data for Baltimore Metropolitan Area. In Miller, H.J ed. *Societies and Cities in the Age of Instant Access*. 153-166. Springer Netherlands.

Appendix A: Survey Questionnaire

Smartphone Use and Travel Choice Survey 2015

Dear Survey Participant:

Dalhousie Transportation Collaboratory (DalTRAC) of Dalhousie University is conducting this survey titled "**Smartphone Use and Travel Choice Survey 2015**". The objective of the survey is to investigate how the use of information and communication technology (ICT), in particular the use of Smartphones and social networking applications are influencing travel choices, such as trip planning, destination choice, departure time and mode choice. The survey will take approximately 15-20 minutes to complete. The survey will ask questions about your use of Smartphones and social networking applications and whether these technologies affect your travel choices. The survey will be open to respondents until April 30, 2015.

Participation in this survey is voluntary. However the quality of this survey depends highly on the number and diversity of respondents. Therefore, it is, extremely important that we receive a response from each person contacted. Respondents may withdraw from the study at any point if he/she no longer wishes to participate.

Individuals' responses are confidential and will be used to produce statistical analysis only. Any potentially identifying information will be stripped from the data set early on. Data will be accessed by the DalTRAC researchers only.

UPON THE CLOSING OF THE SURVEY, THERE WILL BE A DRAW FOR ONE $100 AND TWO $50 BEST BUY GIFT CARDS FOR BUYING SMARTPHONE RELATED ACCESSORIES.

If you have any questions or require further information please contact: Shaila Jamal, Research Assistant, DalTRAC. email: sh462990@dal.ca. The research is being supervised by Dr. Ahsan Habib, Director of DalTRAC (email: ahsan.habib@dal.ca).

Thank you very much for your time and cooperation.

PART 1: PLEASE TELL US ABOUT YOUR SMARTPHONE USE.

1. How many years have you been using a Smartphone?
   - Less than 1 Year
   - 1-3 Years
   - 3-5 Years
   - More than 5 Years
   - I do not currently own a Smartphone (If yes, then go to PART 4)

2. How dependent are you on your Smartphone applications for the following purposes? Please insert/specify other purposes (if any) in the blank box below

	Not Dependent	Rarely Dependent	Moderately Dependent	Often Dependent	Highly Dependent
Communication (e.g. texting, voice calling, Skype, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Trip Planning (e.g. Google Maps, Transit 360, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Educational (e.g. BbLearn, iBooks, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Business (e.g. email, LinkedIn, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Shopping (e.g. eBay, Kijiji, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Recreation (e.g. MyFitnessPal, Lose It!, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Entertainment (e.g. Cineplex, TSN, ESPN, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Social Networking (e.g. Facebook, Twitter, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Information (e.g. weather, news etc.)					
Other [ ]	[ ]	[ ]	[ ]	[ ]	[ ]

3. How often do you use Smartphone applications for the following travel needs:
   Please insert/specify other purposes (if any) in the blank boxes below

	Never	Rarely	Sometimes	Often	Always
Reserving Taxis	[ ]	[ ]	[ ]	[ ]	[ ]
Checking Bus Schedules	[ ]	[ ]	[ ]	[ ]	[ ]
Finding Locations	[ ]	[ ]	[ ]	[ ]	[ ]
E-shopping	[ ]	[ ]	[ ]	[ ]	[ ]
Online Banking	[ ]	[ ]	[ ]	[ ]	[ ]
Scheduling Meetings with Friends, Family, etc.	[ ]	[ ]	[ ]	[ ]	[ ]
Other 1 [ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other 2 [ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other 3 [ ]	[ ]	[ ]	[ ]	[ ]	[ ]

PART 2: PLEASE TELL US ABOUT YOUR TRAVEL BEHAVIOUR.

4. In the **PAST WEEK**, how many **ROUND TRIPS** (a trip from point A to B and back) did you take for the following purposes?
   Please insert/specify other purposes (if any) in the blank box below

	Amount
Work	(Drop Down Menu 0-10+)
School	(Drop Down Menu 0-10+)
Shopping (e.g. grocery shopping, all other shopping)	(Drop Down Menu 0-10+)
Recreation (e.g. visiting parks, fitness)	(Drop Down Menu 0-10+)
Entertainment (e.g. movies, sporting games)	(Drop Down Menu 0-10+)
Social Trips (e.g. restaurants, bars, family-related, special occasions)	(Drop Down Menu 0-10+)
Personal Errands (e.g. medical-related, personal care, banking)	(Drop Down Menu 0-10+)
Other [ ]	(Drop Down Menu 0-10+)

5. Beginning in the morning, list all of your **ONE-WAY TRIPS** (a trip from one point to another) taken **last WEEKDAY**. Record up to 7 trips.

	Origin of the Trip	Destination/ Purpose of the Trip?	What mode did you choose for this trip?	How long did it take you to travel for this trip (one-way) in minutes?	Approximate Kilometer travelled (one way)	With whom did you travel?
Trip 1	(Drop Down Menu) i. Home ii. School iii.Work iv. Other	(Drop Down Menu) i. Work ii. School iii. Home iv. Shopping (e.g. grocery shopping, all other shopping) v. Recreation (e.g. visiting places, fitness) vi. Entertainment (e.g. movies, watching sporting games) vii. Social Trips (e.g. restaurants, bars, family-related, special occasions) viii. Personal Errands (e.g. medical-related, personal care, banking) ix. Other	(Drop Down Menu) i. Auto-Driver ii. Auto-Passenger iii. Transit (e.g. Bus, Ferry etc.) iv. Cycling v. Walking vi. Other (e.g. Taxi, Motor Cycle, Rental Car etc.)			(Drop Down Menu) i. Alone ii. With Family iii. Friends iv. Relatives v. Colleague vi. Other
Trip 2		"	"			"
Trip 3		"	"			"
Trip 4		"	"			"
Trip 5		"	"			"
Trip 6		"	"			"
Trip 7		"	"			"

6. Beginning in the morning, list all of your **ONE-WAY TRIPS** (a trip from one point to another) taken **last WEEKEND**. Record up to 7 trips

	Origin of the Trip	Destination/ Purpose of the Trip?	What mode did you choose for this trip?	How long did it take you to travel for this trip (one-way) in minutes?	Approximate Kilometer travelled (one way)	With whom did you travel?
Trip 1	(Drop Down Menu) i. Home ii. School iii. Work iv. Other	(Drop Down Menu) i. Work ii. School iii. Home iv. Shopping (e.g. grocery shopping, all other shopping) v. Recreation (e.g. visiting places, fitness) vi. Entertainment (e.g. movies, watching sporting games) vii. Social Trips (e.g. restaurants, bars, family-related, special occasions) viii. Personal Errands (e.g. medical-related, personal care, banking) ix. Other	(Drop Down Menu) i. Auto-Driver ii. Auto-Passenger iii. Transit (e.g. Bus, Ferry etc.) iv. Cycling v. Walking vi. Other (e.g. Taxi, Motor Cycle, Rental Car etc.)			(Drop Down Menu) i. Alone ii. With Family iii. Friends iv. Relatives v. Colleague vi. Other
Trip 2		"	"			"
Trip 3		"	"			"
Trip 4		"	"			"
Trip 5		"	"			"
Trip 6		"	"			"
Trip 7		"	"			"

7. How many private vehicles (e.g. car, motor bike etc.) are there in your household? (Drop Down Menu: 0-5+)

8. How many bicycles are there in your household? (Drop Down Menu: 0-5+)

9. Do you own a monthly transit pass? (Drop Down Menu: Yes/No)

PART 3: PLEASE TELL US ABOUT YOUR USE OF SMARTPHONES FOR TRIP PLANNING.

10. How has the use of Smartphones impacted your behavior in the following categories?
Please insert/specify other purposes (if any) in the blank box below

	Decreased Significantly	Decreased Slightly	No Impact	Increased Slightly	Increased Significantly
Kilometers Travelled	[ ]	[ ]	[ ]	[ ]	[ ]
Number of Social Gatherings Attended	[ ]	[ ]	[ ]	[ ]	[ ]
Number of New Places Visited	[ ]	[ ]	[ ]	[ ]	[ ]
Number of Trips Planned in Groups	[ ]	[ ]	[ ]	[ ]	[ ]
Other [ ]	[ ]	[ ]	[ ]	[ ]	[ ]

11. How frequently do you use your **SMARTPHONE APPLICATIONS** (e.g. Google Maps, Transit 360, etc.) for the following:
Please insert/specify other purposes (if any) in the blank box below

	Never	Rarely	Sometimes	Often	Always
Deciding when to depart (e.g. using Transit 360, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Deciding trip destination (e.g. using Urbanspoon, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Choosing an appropriate mode of transportation (e.g. using Google Maps, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Communicating and coordinating trips with others (e.g. text messaging, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Performing tasks online rather than traveling to location (e.g. using online banking, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Other [ ]	[ ]	[ ]	[ ]	[ ]	[ ]

12 . How frequently do you use **SOCIAL NETWORKING APPLICATIONS** (e.g. Facebook and Twitter, **excluding** text messaging) for the following:

Please insert/specify other purposes (if any) in the blank box below

	Never	Rarely	Sometimes	Often	Always
Deciding when to depart	[ ]	[ ]	[ ]	[ ]	[ ]
Deciding trip destination	[ ]	[ ]	[ ]	[ ]	[ ]
Choosing an appropriate mode of transportation	[ ]	[ ]	[ ]	[ ]	[ ]
Communicating and coordinating trips with others	[ ]	[ ]	[ ]	[ ]	[ ]
Performing tasks online rather than traveling to location	[ ]	[ ]	[ ]	[ ]	[ ]
Other [ ]	[ ]	[ ]	[ ]	[ ]	[ ]

13.
a. To what extent do you agree with the following statement?
Information communication technology substitutes (replaces) the need for your trips

- Strongly Agree
- Somewhat Agree
- No impact
- Somewhat Disagree
- Strongly Disagree

b. To what extent do you agree with the following statement?
Information communication technology compliments (increases) the need for your trips

- Strongly Agree
- Somewhat Agree
- No impact
- Somewhat Disagree
- Strongly Disagree

14. Which method do you use **most** to choose the destination of your discretionary trips (i.e. shopping, recreation, entertainment etc excluding work and school)?

- Personal Contacts and Recommendations
- Proximity or Habits
- Printed Tools: Maps, Brochures, Newspaper
- Media: Television, Radio
- Internet on Computers (excluding Smartphones)
- Smartphone and Applications
- Other (e.g. in-vehicle GPS)

15 To what extent does your use of Smartphones affect the frequency of trips in performing the following activities?

	Decrease Significantly	Decrease Slightly	No Impact	Increase Slightly	Increase Significantly
Shopping (i.e. grocery, clothing and accessories and others)	[ ]	[ ]	[ ]	[ ]	[ ]
Recreation (e.g visiting places, play and others	[ ]	[ ]	[ ]	[ ]	[ ]
Entertainment (e.g. movies, watching sporting games and others)	[ ]	[ ]	[ ]	[ ]	[ ]
Social Trip (e.g. restaurants, bars, family-related, special occasions, events etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
Personal Errands (e.g. medical-related, personal care, banking etc.)	[ ]	[ ]	[ ]	[ ]	[ ]

16 During the past month, how many times have you purchased goods from online (e-shopped)?
- 0 Times
- 1-2 Times
- 3-4 Times
- 5+ Times

17 How has e-shopping affected the frequency of shopping trips you have taken in the **LAST MONTH**?
- Significantly Decreased
- Slightly Decreased
- No Impact
- Slightly Increased
- Significantly Increased

PART 4: PLEASE TELL US ABOUT YOUR LIFESTYLE CHOICE

18 Please indicate whether or not you agree with the following statements:

I adapt easily to emerging technologies.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

I make sustainable lifestyle choices whenever possible.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

I limit my driving because it is bad for the environment.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

Households should be fined if their greenhouse gas emissions exceed a set daily limit.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

The proximity to shops and services is important to me.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

Travel time is generally wasted time.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

Overall, my Smartphone has improved my daily life.
- Strongly Agree
- Somewhat Agree
- Neutral
- Somewhat Disagree
- Strongly Disagree

PART 5: RESPONDENT INFORMATION

Age:
- Under 15
- 15-19
- 20-24
- 25-29
- 30-34
- 35-39
- 40-44
- 45-49
- 50-54
- 55-59
- 60-64
- 65-69
- 70-74
- 75-79
- 80-84
- 85+

Gender:
- Male
- Female
- Other/Prefer Not To Disclose

Annual Personal/Individual Income before Tax:
- Below $15,000
- $15000 - $29999
- $30000 - $44999
- $45000 - $59999
- $60000 - $74999
- $75000 - $100000
- Above $100000

Home Postal Code:

_____

Home Street Address:

_____

Primary Workplace' Postal Code or Street Address:

_____

School's Postal Code or Street Address (If applicable):

_____

Employment:
- Full-Time Employed
- Part-Time Employed
- Unemployed
- Prefer not to Disclose

Student Status:

- Full-Time Student
- Part-Time Student
- Not Student
- Other

20. If you have any additional comments, please provide them in the space below:

_____

21. If you wish to be considered for the prize, please provide your email address to be entered into the draw: _____

22. Would you be interested to participate in a Smartphone based NovaTrac Survey?

- Yes
- No

Thank you for your time.
Your response is very important for us!

Appendix B: Online version of Smartphone Use and Travel choice Survey -2015

Close preview

Smartphone Use and Travel Choice Survey 2015

Dear Survey Participant:
Dalhousie Transportation Collaboratory (DalTRAC) of Dalhousie University is conducting this survey titled "**Smartphone Use and Travel Choice Survey 2015**". The objective of the survey is to investigate how the use of information and communication technology (ICT), in particular the use of Smartphones and social networking applications are influencing travel choices, such as trip planning, destination choice, departure time and mode choice. The survey will take approximately 15-20 minutes to complete. The survey will ask questions about your use of Smartphones and social networking applications and whether these technologies affect your travel choices. The survey will be open to respondents until April 12, 2015.

Participation in this survey is voluntary. However the quality of this survey depends highly on the number and diversity of respondents. Therefore, it is, extremely important that we receive a response from each person contacted. Respondents may withdraw from the study at any point if he/she no longer wishes to participate.

Individuals' responses are confidential and will be used to produce statistical analysis only. Any potentially identifying information will be stripped from the data set early on. Data will be accessed by the DalTRAC researchers only.

"UPON THE CLOSING OF THE SURVEY, THERE WILL BE A DRAW FOR ONE $100 AND TWO $50 BEST BUY GIFT CARDS FOR BUYING SMARTPHONE RELATED ACCESSORIES. "

If you have any questions or require further information please contact: Shaila Jamal, Research Assistant, DalTRAC. email: sh462990@dal.ca. The research is being supervised by Dr. Ahsan Habib, Director of DalTRAC (email: ahsan.habib@dal.ca).

Thank you very much for your time and cooperation.

Start

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Smartphone Use and Travel Choice Survey 2015

Please Tell Us About Your Smartphone Use (Part 1)

1. How many years have you been using a Smartphone?

- Less than 1 Year
- 1-3 Years
- 3-5 Years
- More than 5 Years
- I do not currently own a Smartphone

Back Next

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Close preview

Smartphone Use and Travel Choice Survey 2015

Please Tell Us About Your Smartphone Use (Part 2)

2. How dependent are you on your Smartphone applications for the following purposes?

   Please insert/specify other purposes (if any) in the blank box below

	Not Dependent	Rarely Dependent	Moderately Dependent	Often Dependent	Highly Dependent
Communication (e.g. texting, voice calling, Skype, etc.)	○	○	○	○	○
Trip Planning (e.g. Google Maps, Transit 360, etc.)	○	○	○	○	○
Educational (e.g. Bblearn, iBooks, etc.)	○	○	○	○	○
Business (e.g. email, LinkedIn, etc.)	○	○	○	○	○
Shopping (e.g. eBay, Kijiji, etc.)	○	○	○	○	○
Recreation (e.g. MyFitnessPal, Lose It!, etc.)	○	○	○	○	○
Entertainment (e.g. Cineplex, TSN, ESPN, etc.)	○	○	○	○	○
Social Networking (e.g. Facebook, Twitter, etc.)	○	○	○	○	○
Information (weather, news etc.)	○	○	○	○	○
	○	○	○	○	○

3. How often do you use Smartphone applications for the following travel needs:

   Please insert/specify other purposes (if any) in the blank boxes below.

	Never	Rarely	Sometimes	Often	Always
Reserving Taxis	○	○	○	○	○
Checking Bus Schedules	○	○	○	○	○
Finding Locations	○	○	○	○	○
E-Shopping	○	○	○	○	○
Online Banking	○	○	○	○	○
Scheduling Meetings with Friends, Family, etc.	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

Close preview

Smartphone Use and Travel Choice Survey 2015

Please Tell Us About Your Travel Behaviour

4. In the **PAST WEEK**, how many **ROUND TRIPS** (a trip from point A to B and back) did you take for the following purposes?

Please insert/specify other purposes (if any) in the blank box below

	Round Trips
Work	0
School	0
Shopping (e.g. grocery shopping, all other shopping)	0
Recreation (e.g. visiting parks, fitness)	0
Entertainment (e.g. movies, sporting games)	0
Social Trips (e.g. restaurants, bars, family-related, special occasions)	0
Personal Errands (e.g. medical-related, personal care, banking)	0
	0

5. Beginning in the morning, list all of your **ONE-WAY TRIPS** (a trip from one point to another) taken **last WEEKDAY**. Record up to 7 trips.

	Origin Place of the Trip	Destination/Purpose of the Trip	What mode did you choose for this trip?	How long did it take you to travel for this trip (one way) in minutes?	Approximate kilometer traveled (one way)	With whom did you travel?
Trip 1	Home	Work	Auto-Driver			Alone
Trip 2	Home	Work	Auto-Driver			Alone
Trip 3	Home	Work	Auto-Driver			Alone
Trip 4	Home	Work	Auto-Driver			Alone
Trip 5	Home	Work	Auto-Driver			Alone
Trip 6	Home	Work	Auto-Driver			Alone
Trip 7	Home	Work	Auto-Driver			Alone

6. Beginning in the morning, list all of your **ONE-WAY TRIPS** (a trip from one point to another) taken **last WEEKEND**. Record up to 7 trips.

	Origin Place of the Trip	Destination/Purpose of the Trip	What mode did you choose for this trip?	How long did it take you to travel for this trip (one way) in minutes?	Approximate kilometer traveled (one way)	With whom did you travel?
Trip 1	Home	Work	Auto-Driver			Alone
Trip 2	Home	Work	Auto-Driver			Alone
Trip 3	Home	Work	Auto-Driver			Alone
Trip 4	Home	Work	Auto-Driver			Alone
Trip 5	Home	Work	Auto-Driver			Alone
Trip 6	Home	Work	Auto-Driver			Alone
Trip 7	Home	Work	Auto-Driver			Alone

7. How many motorized private vehicles (e.g car, motor bike etc.) are there in your household?
0

8. How many bicycles are there in your household?
0

9. Do you own a monthly transit pass?
Yes

Back | Next

Close preview

Close preview

Smartphone Use and Travel Choice Survey 2015

Please Tell Us about Your Use of Smartphone for Trip Planning

10. How has the use of Smartphones impacted your behavior in the following categories?

Please insert/specify other reasons (if any) in the blank box below

	Decreased Significantly	Decreased Slightly	No Impact	Increased Slightly	Increased Significantly
Kilometers Traveled	○	○	○	○	○
Number of Social Gatherings Attended	○	○	○	○	○
Number of New Places Visited	○	○	○	○	○
Number of Trips Planned in Groups	○	○	○	○	○
	○	○	○	○	○

11. How frequently do you use your **SMARTPHONE APPLICATIONS** (e.g. Google Maps, Transit 360, etc.) for the following purposes?

Please insert/specify other tasks (if any) in the blank box below:

	Never	Rarely	Sometimes	Often	Always
Deciding when to depart (using Transit 360, etc.)	○	○	○	○	○
Deciding trip destination (e.g. using Urbanspoon, etc.)	○	○	○	○	○
Choosing an appropriate mode of transportation (using Google Maps, etc.)	○	○	○	○	○
Communicating and coordinating trips with others (e.g. text messaging, etc.)	○	○	○	○	○
Performing tasks online rather than travelling to location (e.g. using online banking, etc.)	○	○	○	○	○
	○	○	○	○	○

12. How frequently do you use **SOCIAL NETWORKING APPLICATIONS** (e.g. Facebook and Twitter, excluding text messaging) for the following:

Please insert/specify other tasks (if any) in the blank box below

	Never	Rarely	Sometimes	Often	Always
Deciding when to depart	○	○	○	○	○
Deciding trip destination	○	○	○	○	○
Choosing an appropriate mode of transportation	○	○	○	○	○
Communicating and coordinating trips with others	○	○	○	○	○
Performing tasks online rather than travelling to location	○	○	○	○	○
	○	○	○	○	○

13. To what extent do you agree with the following statements?

Information and communication technology substitutes (replaces) the need for your trips.	Strongly Agree ▼
Information and communication technology complements (increases) the need of your trips	Strongly Agree ▼

14. Which method do you use **MOST** to choose the destination of your discretionary trips (i.e. shopping, recreation, entertainment etc. excluding work and school)?

Personal Contacts and Recommendations ▼

15. To what extent does your use of Smartphones affect the frequency of trips in performing the following activities?

	Drop-Down List
Shopping (e.g grocery, clothing and accessories and others)	Decrease Significantly ▼
Recreation (e.g visiting places, play and others)	Decrease Significantly ▼
Entertainment (e.g. movies, watching sporting games and others)	Decrease Significantly ▼

Social Trip (e.g. restaurants, bars, family-related, special occasions, events etc.)	Decrease Significantly
Personal Errands (e.g. medical-related, personal care, banking etc.)	Decrease Significantly

16. During the **PAST MONTH**, how many times have you purchased goods from online (e-shopped)?

0

17. How has e-shopping affected the frequency of shopping trips you have taken in the **LAST MONTH**?

Decrease Significantly

18. Please indicate whether or not you agree with the following statements:

I adapt easily to emerging technologies	Strongly Agree
I make sustainable lifestyle choices whenever possible	Strongly Agree
I limit my driving because it is bad for the environment	Strongly Agree
Households should be fined if their greenhouse gas emission exceed a set daily limit	Strongly Agree
The proximity to shops and services is important to me	Strongly Agree
Travel time is generally wasted time	Strongly Agree
Overall, my Smartphone has improved my daily life	Strongly Agree

Back Next

Close preview

Close preview

Smartphone Use and Travel Choice Survey 2015

Personal Information

19. Respondent's Information

Age	Under 15
Gender	Male
Annual Personal/Individual Income before Tax	Below $15,000
Home Postal Code (e.g. B4B 080)	
Home Street Address (e.g. 5162 Spring Garden Road, Halifax)	
Primary Workplace's Postal Code or Street Address	
School's Postal Code or Street Address (if applicable)	
Employment	Full-Time Employed
Student Status	Full-Time Student

20. If you have any additional comment, please provide here:

21. If you wish to be considered for the prize, please provide your email address to be entered into the draw:

22. Would you be interested to participate in a provincial travel survey (NovaTRAC Survey)?

Yes
No

Back Finish

Close preview

Appendix C: Promotional Leaflet for Survey Distribution