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Understanding the Impact of Information and Communication Technology on Travel Behavior

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Abstract

Information and Communication Technology (ICT) is an important factor in the advancement of transportation. This paper aims to explore the importance of various ICT mediums and their impact on travel behavior by various segments of the society. For the purposes of this study, a data set obtained from Seattle, USA from the year 2014 courtesy of the Puget Sound Regional Council (PSRC) has been used with a Multinomial Logit Model to determine answers to the questions that this paper aims to address. Several research studies that have been undertaken to show the correlation between ICT and Transport behavior have also been reviewed and taken into consideration. A clear relationship between ICT and travel behavior patterns is established in the findings of this paper, with notable differences in age groups, gender and the usage of different ICT mediums are being registered.

Research Topic

Understanding the impact of travel information acquired through various ICT mediums on the travel behaviour patterns of different user groups.

Research Questions

1. What are the characteristics of people who use ICT to acquire travel information and what is the impact of the acquired information on their travel behaviour?
2. What are the different methods of acquiring travel information?
3. What are the differences in the ways of procuring travel information between various age groups? (Age Vs Methods of acquiring information)
4. What is the impact of different mediums of acquiring travel information on the travel behaviour of commuters?

These are the main questions that the paper aims on focussing by using different methods of statistical analysis. According to the results in the end, the paper comes up with conclusions and possible recommendations to make it more inclusive and user friendly.

It also comes up with various ways in which this ICT can be widely used to encourage people into taking public transportation and reduce the use of private vehicles. This would help in saving a lot of road space which would result in reducing traffic congestion levels, and saves up a lot of time and money for the people giving them the benefit of a seamless connectivity from the origin to the destination.

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Introduction

Transport plays a major role in the day to day lives of the general populace. Improvements, enhancements and advancements in the world of transport continue to be devised and implemented on a regular basis. As a result, cities and urban spaces have been in a constant state of expansion. The radius or the size of human activities has increased with time (M. Aljoufie, 2011).

Due to advancements in technology, ease of travel has greatly increased with time. This paper primarily focuses on the impact of information and communication technology (ICT) on urban mobility.With the introduction of smart technology, people can get access to information for their trip in a faster and convenient way. Technology in terms if ICT combined with transportation has made so many things easier (Matti Kutila, 2013).

Most urban commuters in this day and age are equipped with smartphones and have internet connectivity. They can, therefore, acquire information about shortest routes of travel, monitor the traffic situation etc. with relative ease.

Commuters can also decide their mode of travel and determine the approximate cost of their trip in advance. With the introduction of ICT to transport, commuters can save a lot of time and money in travelling or planning trips.

Several studies have been undertaken in the past in order to define ICT and to determine its' impact on travel behaviour. This paper, focuses on how different methods of acquiring travel information from different mediums impact the travel behaviour of people. Has ICT in transportation really affected the travel patterns of the people? How is it different from the times when they did not use any smart technologies?

It also emphasizes on the demographic divide and the differences in the patterns of the people's decision making behaviour to choose a mobility related decision. It tries to understand the characteristics of the people who use these travel information and how different classes of people get affected in terms of travel behaviour.

With the wide spread use of the new technology, people use the internet in various ways to acquire various types of information. So many people use different mediums like computers, smart phones and tablets to gain information about travel, tourism plans, online shopping, weather updates etc. Now, ICT is an inevitable and addictive medium as it is cost effective, and also, saves a immense time as the physical presence of the person is not required for any of the above mentioned work
(Bert van Weea, 2013).

(Eran Ben-Elia, 2014) Now, a trend of work from home has also been emerging, and this has reduced the number of trips all through as networking is so much easier via the internet. Traditionally travel behaviour was an impact of the land use, geographical aspects and many more other physical components (Fariya Sharmeen, 2017).

However, now there are studies that shows ICT can replace or substitute many trips, because things can be done in an easier way, but also can generate whole new location based trips which were not at all planned in the first place. It can stimulate the demand for new location based trips and hence increase the amount of travel (Patricia L. Mokhtarian, 2006).

Before getting into details regarding the impact of ICT in travel behaviour, several studies done in the past have been reviewed to understand what kind of studies had been done in the past reading the impacts of ICT. There has been also literature review done on different ways of explain what ICT actually means or rather to define it in a more formal manner. Studies have also been looked into about the user groups or the demographic divide that uses these kind of new technologies to acquire this information (Scottish Qualifications Authority, 2013).

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Literature Review

Several studies were reviewed for the analysis of online travel trends, focuses on the behaviour of the people who use these online mediums to acquire any kind of transport information. It states that the consumer behaviour has a strong relationship between the demographic factors and the attitude towards using their products.
A study for a sample size of 692 respondents were used and all the models have been performed in the statistical software SPSS. These respondents showed about their interaction in social media to gain information for travel.
It explains that majority of the people who use ICT are of 21-34 years and the people who are aged between 55-60 years prefer travel information provider websites. These are almost 40% of the people compared to the young ones who are 47%. Also, among the young users, Facebook of social media, influenced their decision making to a considerable extent (75%) (Narayan B. Prabhu M, 2014).
It also discussed about the methods by which they acquire such information. If they used computers or mobile phones and most of them interacted to information for travel agencies to email via mobile phones upto 19%. Downloaded applications in the mobile phones listed upto 21% and the least being alerts through SMS which was about 15%. This resulted in the highest being Facebook of 90%, twitter 30%, and google plus 10% in the age group of 22-34 years. However, in the age group of 45-60 years there were 48-49% respondents who did not involve or engage themselves in any kinds of social media activities.

Several studies were also done regarding the benefits of online platforms and tried to explain the meaning of ICT in a holistic manner. It describes about the variety of platforms that consumers use and why. It talks about maximising the growth of digital economy. The authors struggle to give a proper definition of the online platform. They have used various references that could summarise or give a proper definition. In the end they come up with the conclusion that there is no single definition that could summarise the plurality of the online market. It is a very broad term.

Some of the key findings that are driven from these studies explains that it saves a lot of time and costs. There are more choices for the consumers and increase in the quality of the goods and services. Online comparisons websites also have a lot of impact on the consumer purchasing choices. There have been other social benefits too and a considerable increase in the market platform. There has been cost reduction in terms of travel expenses as well. There can be a lot of information exchange and expansion seen in this online platform as there are so many peer comments for a particular service or good used by various customers. Hence it impacts the customer choices.

Different studies discuss about the traveller's road to decisions. A study was done where a sample size of 5000 US citizens was surveyed who used online platforms to make personal/ business travel decisions. It described that 69% people involved with business trips made online search before going anywhere followed by 65% of leisure trip travellers. 42% of these people used travel apps/sites and 31% used destination specific apps and sites. 80% of the business travellers used the internet for these information and 78% of the leisure travellers used the internet for the same (Google, 2014) Surprisingly both the business and leisure travels used information from the phone equally up to 44%, however, 86% of the business travellers, 55% used from website and 63% from apps. For the leisure travellers, it is 71% who use online platforms being 45% for website and 40% for apps.
This changes for people who are on leisure trips, like the decision to make for an excursion is influenced by the use of apps by 56% and in computers by 49%. Majority of the people almost 65% were inspired by the internet for the travel decision makings (Ulrike Gretzel, 2006).

The other aspects for the literature review covered on studying the relationship between socio demographic factors and ICT use which impacts travel behaviour. Numerous studies were done to understand the relationship between gender, employment, age and usage of ICT.

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Studies based on a technology survey on the people who were between the age of 65 to 100 years were done and explains that internet is not optional now a days and it is just a requirement or a way of life. However, the older group has limited access to it due to a number of reasons.

Similar studies about internet use amongst the mid-life citizens and the elderly were done which had a lot of statistical analysis and has some major findings which goes very well with the research purpose of this paper. (Keenan, 2009). The author talks about the reasons for using the internet, and also the frequency of using the internet by these mid aged people. A study was done among 1013 respondents who were chosen if they were older than 50 years. Most of the respondents used it for communication purposes 51% like send or receive mails, a few used them for online purchasing44% and some used to make travel plans41%. All the rest used it for online research purposes 57%. Most of these elderly class didn't use online platforms for travel because they were not interested, and did not have the time and technical aptitude for this.
(UK, n.d.)Similar discussions were done as review based paper and explains the same thing as the previous studies that the major reason for the elderly people to use internet was commination and social aspects like keeping in touch with their distant relatives and friends. Technical aspects prove to be a concern in being a barrier between the adoptions of this technology for them in the day to day lives. Mostly these people acquire information based on TV, Radio and newspapers as they are easy to operate (Passey, n.d.).The author suggests that using more user friendly technologies would help better decision making and also help in making business more inclusive.

The other aspects of the literature review discuss about various form of employment and the impacts of ICT on the travel behaviour. A study was done in Sweden on the work based trips and the use of ICT (Bertil Vilhelmson, 2001). The author states that with the increase in ICT the people have the choice to decide when, where and how to travel to their work. This study was taken from the Swedish surveys to investigate the choice of the commuters for several groups of workers like homes based and not and see if their locations change with the information available. It describes about the jobs and new services in ICT like video conferencing, telecommuting, tele communication etc and explains that the concept of expected versus the real outcome depend on the way the travellers perceive the information of the travel. Substitution of trips or almost similar trips can take place depending on the similarity of the activities or the ICT search. Only if the search or the characteristics are extremely similar in terms of similar functions and equal value, only then substitution takes place. The use of ICT is becoming more and more time consuming and is a part of daily life, both for home based and work lives. Therefore, the travel functions are diminishing with time and the substitution of these trips are taking place. Therefore, the author proves that with the introduction of the ICT, the number of trips to work based on various location and geographic characteristics are diminishing with the new technologies in ICT and services and facilities like work from home.

Similar studies were done in Eindhoven where mixed logit model is used to analyse the impacts of ICT on social interaction behaviour. The key results from this study was that the number of work hours showed a negative relation with the social networking. Also, the average number of social interaction hours were found to be less for people who had a lower social circle. Also, the negative results for social interactions in the weekend could be seen. For a mixed logit model, the author focused on gender as well, and found that females have larger likelihood to interact more than males in forms of IM and mobile phones. Results also showed that younger and more educated people had more social interactions. Personal characteristics added a significant effect on the mode choice as the younger people are better in adapting to new technologies and are better in making decisions based on ICT (Pauline Van den Berg, 2012).

A major socio demographic factor that determines travel behaviour and ICT use is gender, and several studies around the globe are done based on this.

Studies were done to model the relationship between ICT use, and how differently they are being used by each gender. Columbus metropolitan area, US in the year 2003-2004 collected data for this study from two-day activity-internet diary. Different models were used for this. One was SEM, structural equation modelling, and it was used because it

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has the capacity to estimate the casual relationship among the chosen variables multivariate normality and goodness of fit models.

The results indicate that the impacts of Internet activities on people's activity– travel patterns are significantly different across gender. In general, Internet use for maintenance purposes has a greater impact on women's activity–travel in the physical world, while Internet use for leisure purposes affects men's physical activities and travel to a greater extent. First, the same type of Internet activities (e.g., maintenance) unequally influences activity–travel patterns across gender. Similarly, Internet use for leisure purposes reduces men's travel demand for leisure activities while increasing their travel demand for maintenance activities. Third, the same patterns across gender seem to have been generated by different processes (Fang Ren a, 2009) there we many other such studies which were done based on age, gender and tracking down social and behavioural travel patterns and with similar models as above, most of them had the same results such as social trips can be related to the network theory and others stated that the social trips are complicated in nature and can be understood by choice based preferences (Pauline E.W. van den Berg, 2008). It varied from age, gender and between various income groups. (MILLER2, 2003)All have different impacts on tri patterns, if they are social, leisure based trips or are more work related trips. It also talks about substitutions and alternatives that ICT can provide and states that it widely depends on the nature of individual's choices and preferences. A wide range of studies showed impacts on consumer's behaviour related to tourism and other aspects (Raubal Martin, 2012).

Research Gap and Need for the Study

It could be seen that several studies were done to understand the impact of ICT on travel behaviour, and emphasized on social groups as well. However, not many studies were to be seen where the impact of every medium of ICT like TV, radio or GPS had an impact on a specific travel behaviour like choosing a public transport based on that information. Also, a clear break up on particular travel behaviours based on socio demographic factors could not be seen, like if gender, employment or age plays an important role in taking a public transport. Thus, this paper focuses on fulfilling the research gap and answering the research questions with suitable models which would be explained in detail in the chapter for methodology. As mentioned in the research gap, not many studies were focused on answering the impacts of individual forms of technology on specific travel behaviour.

Ever since the introduction of new technologies in the world of transportation has taken place, several studies have been undertaken to understand ICT and its' impact on transportation with quite a few definitions being put forth by various authors and researchers. There have also been studies that show the relationship between users of ICT (primarily internet and smartphone users) and their travel. Studies have also looked at gender and age based patterns in terms of such correlations.

Although numerous papers were written on the impacts of ICT in travel behaviour, not many papers were written down on the impacts of individual mediums of information acquiring methods on travel behaviour. For example, when the components are broken down into major sub groups such as impact of acquiring travel information from social media on choosing a public transport or impact of acquiring travel information on choosing a different route than previously planned could not be seen.

Also, there were not many studies that showed the impact of these ICT in trip choice based on travel timings. In this paper, ICT is considered not only as internet and smart phones, but it takes into account many other mediums by which information can be acquired for travel updates, for example, TV, Radio, Alerts, Websites and Applications on smartphones etc. It focuses on understanding who are these people that use this information for travel . What are the impacts on the travellers on their trips based on the journey time, route choice, if they used public transport, or they chose a completely different mode?

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Another aspect that the paper aims on focusing is the quantitative analysis of these impacts by various statistical methods. Significant amount of data was taken and regression analysis for the dependent and independent variables was done to have a better understanding of the impacts in a number based method. The regression models used for this paper, based on the variables would be explained in the next chapters of the paper which will in depth explain the data and methods used to analyse the research questions which mainly focuses on answering the following:

1. What are the characteristics of the people that use ICT to acquire travel information?
2. What are the different methods of acquiring travel information?
3. What are the differences in the ways to acquire travel information between various demographic groups?
4. What is the impact of these travel information on their Travel Behaviours?

Methodology

Data Used:

The data set that has been used for the purpose of research for this paper is PSRC (Puget Sound Regional Council Data) Data. This is an organisation which provides with data to various decision makers, planners etc to understand the cities better and has a wide range of data. It is an open source data that could be easily downloaded from their website. PSRC has various data sets available year wise, which are like census data, population and employment, forecasts and growth projections, GIS maps and a plethora of transportation data (PSRC, 2017).

For this paper a data set from the year 2014 is used called “persons” data set, which has information about the people and their travel behaviour. The most important reason this data set was chosen for this study was because it has a variety of information about the usage and application of ICT and hence analysis for the paper was appropriate. The data set that was used for the purpose of this paper was of 2014, as the latest data set did not cover the aspects about ICT

This data set is for Seattle; it is a seaport city on the west coast of the United states. The total population according to 2016 census was 704,352. In 2016, Seattle was the fastest growing city of the United States with the annual growth rate of 3.1%.

This data set was an open source data and was easily available to all for research purpose. This data set had 172 different variables with a surveyed size of total 12198. However, for this paper 14 variables were used and the total sample size was 4143. The demographic breakdown of the of the valid data are given below-

Table 1 Breakdown of Age from Total Sample Size

Age			
Code	**Age group**	**Count**	**Percentage**
5	18-24	271	6.54
6	25-34	1287	31.06
7	35-44	972	23.46
8	45-54	688	16.61
9	55-64	609	14.70

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10	65-74	268	6.47
11	75-84	43	1.04
12	85 or older	5	0.12
	Total	4143	100

Table 2 Breakdown of Employment from Total Sample Size

Employment			
code	**Interpretation**	**Count**	**Percentage**
1	Paid	3337	80.54
2	Unpaid	806	19.45
	Total	4143	100

Table 3 Breakdown of Gender from Total Sample Size

Gender			
Code	**Interpretation**	**Count**	**Percentage**
1	Male	1997	48.20
2	Female	2146	51.79
	Total	4143	100

Statistical Modelling Approach Used- Multinomial Logistic Regression Model

Multinomial logistic regression is used to predict categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables. The independent variables can be either dichotomous (i.e., binary) or continuous (i.e., interval or ratio in scale). Multinomial logistic regression is a simple extension of binary logistic regression that allows for more than two categories of the dependent or outcome variable. Like binary logistic regression, multinomial logistic regression uses maximum likelihood estimation to evaluate the probability of categorical membership.

Multinomial logistic regression is used more frequently than discriminant function analysis because the analysis does not have many assumptions. Multinomial logistic regression does have assumptions, such as the assumption of independence among the dependent variable choices. This assumption states that the choice of or membership in one category is not related or does not have a strong co relation to the choice or membership of another category (Ying So, 2010).

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Limitations of Multinomial Logistic Regression Model

- **Independent Observations Required**

  Logistic regression requires that each data point be independent of all other data points. If observations are related to one another, then the model will tend to overweight the significance of those observations. This is a major disadvantage, because a lot of scientific and social-scientific research relies on research techniques involving multiple observations of the same individuals.

- **Identifying Independent Variables**

  Logistic regression attempts to predict outcomes based on a set of independent variables, but if researchers include the wrong independent variables, the model will have little to no predictive value.

- **Limited Outcome Variables**

  Logistic regression works well for predicting categorical outcomes like admission or rejection at a college. It can also predict multinomial outcomes, like admission, rejection or wait list. However, logistic regression cannot predict continuous outcomes (Robinson, 2017).

Models Used

All the variables that are used for the analysis of this paper are based on the research questions that were chosen in the beginning of the paper. All the four research questions have been stated down below again, with the variables used to understand the dependent and the independent variables better, and if the variables are appropriate for the research questions.

In this case, a multinomial logit model is used, and the variables used in it are:

Table 4 Description of Variables used in the model with Variable names from the "persons" data set PSRC 2014

Variable Name	Variable Description
Apps_Use	How often travel information is acquired from: applications in Smartphones
Alerts_Use	How often travel information is acquired from: Text or email alerts sent to you
Gps_Use	How often travel information is acquired from: In-Vehicle navigation/GPS device
Tv_Use	How often travel information is acquired from: Television
Socialmedia_Use	How often travel information is acquired from: Social media (e.g. Twitter, Facebook, etc.)
Radio_Use	How often travel information is acquired from: Radio
Impact_earlier	I start my trip earlier than previously Planned
Impact_later	I start my trip later than previously Planned
Impact_diffmode	I choose a different mode, e.g.. I take the bus instead of driving

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Impact_diffroute	I choose a completely different route than originally planned
Transit_Freq	how often in past 30 days have I ridden a bus/ferry, or any public transport etc
Age	Age of the respondents
Employment	If a person is Paid or Unpaid worker
Gender	Gender of the respondents

To answer the research questions, these variables were used respectively.

Dependent Variables:

1. What is the impact of travel information from different mediums of ICT on travel behaviours?

The impacts of ICT on travel behaviour:

1. Impact_earlier
2. Impact_later
3. Impact_diffroute
4. Impact_diffmode
5. Impact_transitfreq

The dependent variables were renamed as the following:
impact_diffroute “i”
impact_diffmode , “j”
impact_earlier , “e”
impact_later, “l”
transit_freq, “t”

Independent Variables:

1. What are the differences in the ways to acquire travel information between various age groups? (Age Vs Methods of acquiring information)

The use of ICT in mediums:

1. Apps_use
2. Alerts_use
3. Gps_use
4. Radio_use
5. Tv_use
6. Socialmedia_use

2. Who are these people that use ICT to acquire travel information?

Socio demographic factors:

1. Age
2. Gender

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3. Employment

Data Modification and Interpretation Codes

All the variables, have different types of data. Therefore, they are categorised or modified into subgroups for easy interpretation.

Starting with the Dependent variables,

1. Impact_earlier
2. Impact_later
3. Impact_diffroute
4. Impact_diffmode
5. Impact_transitfreq

Table 5 Initial Group Classification Interpretation for Dependent Variables

impact_diffroute	
1	Always
2	Sometimes
3	Rarely
4	Never
5	Not Applicable

Therefore, it was regrouped into 4 categories:
Group1- 1- always
Group2- 2-sometimes,3-rarely
Group3- 4-never
Goup4-NA

This was done for all the 5 dependent variables separately in R.

Table 6 Codes for initial group Classification for Transit_freq

Transit_freq	
1	6-7 days/week
2	5 days/week
3	2-4 days/week
4	1 day/week
5	1-3 times in the past 30 days
6	I do this, but not in the past 30 days
7	I never do this

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Group1-1-6-7days/week,2-5days/week = Always
Group2- 3- 2-4 days/week, 4-1day/week = Sometimes
Group3- 5 1-3 times a month, 6-not in past 30 days = Rarely
Goup4- 7 – I never do this= Never

The same methods were applied to independent variables as well. For the mediums of ICT used, the data is below:

1. Apps_use
2. Alerts_use
3. Gps_use
4. Radio_use
5. Tv_use
6. Socialmedia_use

Table 7 Initial Group Classification for Independent Variables

apps_use	
1	6-7 days/week
2	5 days/week
3	2-4 days/week
4	1 day/week
5	A few times/month
6	Less than once/month
7	Never

Similarly, it was applied for employment:

Table 8 Initial Grouping of Employment (Independent Variables)

Employment	
1	Employed full-time (paid)
2	Employed part-time (paid)
3	Self-employed
4	Unpaid volunteer or intern
5	Homemaker
6	Retired
7	Not currently employed

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Employment was split into two categories as 1 and 2
Group 1 consists of 1,2,3 subgroups = Paid
Group 2 consists of 4,5,6,7 subgroups = Unpaid
However, for the age, the data was kept as it is.

Table 9 Group codes for Age (Independent Variable)

age	
1	Under 5 years old
2	05-11
3	12-15
4	16-17
5	18-24
6	25-34
7	35-44
8	45-54
9	55-64
10	65-74
11	75-84
12	85 or older

New classes were created according to the defined subgroups, for which the codes are depicted above. This was the final subset used for the purpose of the paper, 'persons_valid' and it had a sample size of 4143.
The interpretations of new groups after the process of regrouping, are given below:

Independent Variables: (Apps_use, Alerts_Use, Socialmedia_Use, Radio_Use, TV_Use, Gps_Use)

Table 10 New Code Interpretation of Independent Variables after Regrouping

code	**Interpretation**
1	Never
2	Rarely
3	Sometimes
4	Always

The interpretations of new groups after the process of regrouping, are given below:
Dependent Variables:
(impact_diffroute, impact_diffmode, impact_earlier, impact_later)

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Table 11 New Code Interpretation of Dependent Variables after Regrouping

code	Interpretation
1	Never
2	Sometimes
3	Always

But for 'transit_frequency' the grouping is different; therefore the interpretation is as follows:

Table 12 New Code Interpretation of Dependent Variables after Regrouping(Transit_freq)

code	Interpretation
1	Never
2	Rarely
3	Sometimes
4	Always

For this paper, we are using the following equation to understand the relationship between travel information from various means of ICT and travel behaviour of a commuter:

Equation 1 Multinomial Logit Model Equation for this paper

$$\mathbf{Pr}(\boldsymbol{y_i} = \boldsymbol{m}|\boldsymbol{x_i}) = \frac{\mathbf{exp}(\boldsymbol{x_i}\boldsymbol{\beta_m})}{\mathbf{1} + \sum_j^J} = \mathbf{exp}(\boldsymbol{x_i}\boldsymbol{\beta_j})$$

For m>1

Where *Y* =Dependent Variables which are as follows:

Impact_earlier ,Impact_later,Impact_diffroute ,Impact_diffmode ,Impact_transitfreq

$\boldsymbol{x_i}$= Independent Variables are as follows:

Apps_use ,Alerts_use,Gps_use,Radio_use,Tv_use,Socialmedia_use,Age ,Gender,Employment,

$\boldsymbol{\beta_j}$= the vector of coefficients

Note: J=m

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Models in detail

There were five different models used in this paper to understand the impact of ICT on each dependent variable, which have been described above. These models will give the significant analysis of the extent of relationship between variables, and it understand if they are significant enough to have an impact. Based on this model using the software "R", analysis will be done using statistical regression knowledge.

Each model is explained in detail below, and after the analysis of each, the paper aims to identify a relationship or significant outcome from these results on the research questions.

Model 1

M1-impact different route:

In this model, the impacts of various mediums of ICT and the methods of acquiring them, along with the socio demographic factors can be seen on choosing a different route than planned earlier. Which type of demographic class use the travel information acquired by various mediums such as radio, newspaper, television, social media. All these independent variable's impacts are seen on the travel behaviour for route selection of the individual. What is being trying to mean here is, if a person wanted to go from origin to destination from a particular route, how does this previously made decision about taking this path would impact on the change about taking a different route than chosen earlier. This might happen due to the traffic information, weather update, car share, parking availability information via various mobile applications, television, social media like Facebook or twitter, etc.

Model 2

M2- impact different mode:

This is another multinomial logit model to understand the impact of the travel behaviour on making a decision of taking a different mode of transport than previously decided. This impact might have taken place due to the various independent variables such as the methods that are being used to attain these kind of information, and what are the information types they acquire. What is being tried to understand and analyse in this model was if a person wanted to go from his origin to destination, with a previously planned mode, does this information change the person's prior decision about taking a certain mode?

Model 3

M3-impact_earlier

The next model is to understand the impact of the time that changes with the gaining of information related to transportation from various mediums. If a person chooses to travel from his respective origin to the destination at a particular time of the day, this model tries to identify the impact of this information in the change in time that was previously decided. For example, a person might acquire traffic data, availability of parking data, weather data etc from various methods and decide to go a little earlier than the previously decided time. This is also to see how the socio demographic factors can affect such decisions such as age, gender or employability.

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Model 4
M4- impact_later

Model 4 is somewhat similar to model 3, and this model understands the shift in timing, if a person decides to go a little later than the previously decided time. This might happen due to various reasons such as, clear weather, absence of traffic, clear path for the shortest routes, information about delay of transit arrival time etc.

Model-5
M5- transit_freq

This model tries to understand a very interesting impact of this information on the users. Users with different age groups, gender and different employability options attain various kinds of travel information through different mediums like social media, television, radio or various applications on their smart phones etc. This information helps them decide what kind of mode they would want to travel based on this information which has been attempted to understand in model 2, as discussed above. This model sees, if a person has used any kind of public transport within the last 30 days based on the information. Hence, it answers if the information communication technology encourages to take more of public transport, or they choose private cars instead.

Testing Assumptions

The multinomial logit model is widely used because of the limited test assumptions needed to prove while performing the regression. However, one of the important assumptions to be taken care of is that all the independent variables should be mutually exclusive to each other. The meaning of this is that all the independent variables should have an extremely weak relationship or no relationship between each other. If their associations are found to be extremely poor, then the model has a good fit.

Therefore, to take care of that, we perform correlation test between all the variables used in the model for the purpose of this paper. It was seen from the results that there was not any significant correlation between any of the independent variables and hence no strong association was being identified.

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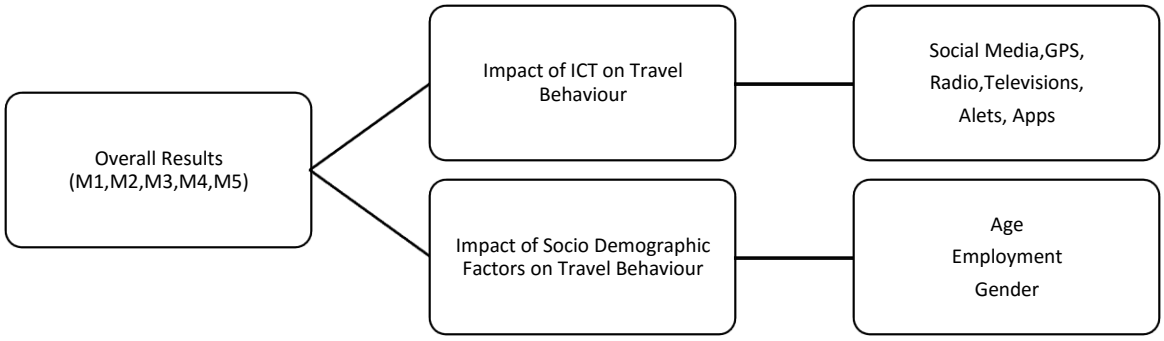
Results and Analysis.

Figure 1 Description of the flow of Analysis



The models that have been run for the paper was an attempt to answer the research questions stated above at the beginning of the paper. The impact of ICT on travel behaviour based on various socio demographic factors were been tried to assess.

The observations for the number of people who use ICT of different forms to acquire travel information has been recorded. This was done to understand the magnitude of the people's frequency of usage of various mediums to acquire travel information. The results are given below.

Table 13 Frequency/percentage of people who had an impact on choosing a different route than previously planned

Dependent Variables	codes	interpretation	Frequency	Percentage
Impact Different Route	1	Never	2025	48.87
	2	Sometimes	2015	48.63
	3	Always	103	2.48
		Total Sample	4143	

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Table 14 Frequency/percentage of people who had an impact on choosing a different mode than previously planned

Dependent Variables	codes	interpretation	Frequency	Percentage
Impact Different Mode	1	Never	2025	48.87
	2	Sometimes	2015	48.63
	3	Always	103	2.48
		Total Sample	4143	

Table 15 Frequency/percentage people who had an impact on choosing a to travel earlier than previously planned

Dependent Variables	codes	interpretation	Frequency	Percentage
Impact Earlier	1	Never	374	9.02
	2	Sometimes	3139	75.76
	3	Always	630	15.20
		Total Sample	4143	

Table 16 Frequency/percentage people who had an impact on choosing a to travel later than previously planned

Dependent Variables	codes	interpretation	Frequency	Percentage
Impact Later	1	Never	964	23.26
	2	Sometimes	3053	73.69
	3	Always	126	3.04
		Total Sample	4143	

Table 17 Frequency/percentage people who had an impact on choosing a to Public Transport

Dependent Variables	codes	interpretation	Frequency	Percentage
Impact Transit Frequency	1	Never	1191	28.74
	2	Rarely	1631	39.36
	3	Sometimes	675	16.29
	4	Always	646	15.59
		Total Sample	4143	

The above tables are the counts of the people who never, rarely, sometimes or always had an impact on their travel behaviour after the use of various mediums to acquire travel information. Now it is interesting to see, what percentage of people most frequently use travel information and what is the most convenient platform preferred to gain travel information that might or might not impact the decision of a traveller's choice. It is important to note that the answers of the people that use the mediums for travel information are not mutually exclusive of each other. That means, if a person uses social media to acquire travel information, he might also use GPS to acquire another kind of travel

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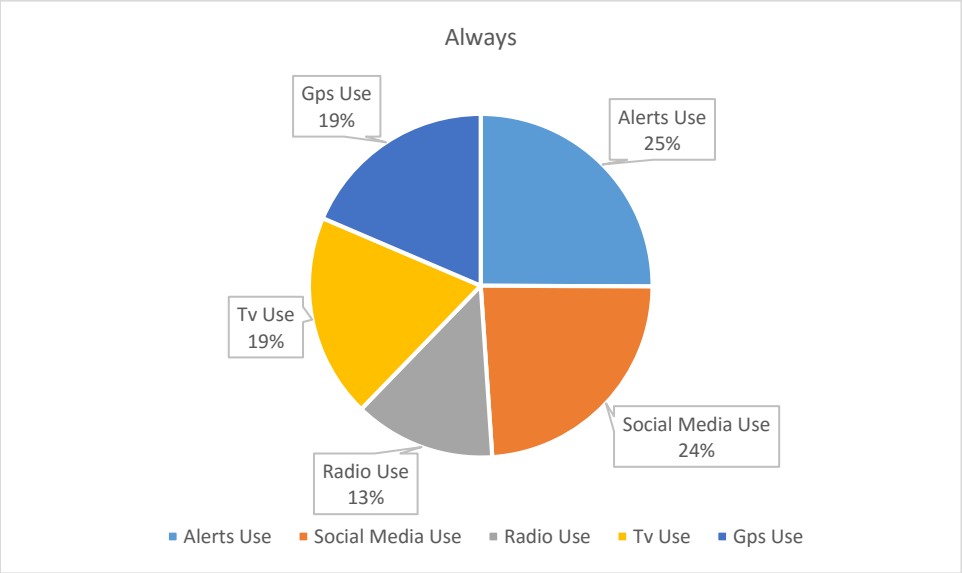
information. This is why, only the significant results from the models which affects the travel behaviour due to various mediums are taken into consideration to explain these charts better.

Figure 2 Percentage distribution of People who always use various mediums of ICT to Acquire Travel Information



The above chart explains that 25% of the total sample size always acquire travel information via various kind of alerts use. These alerts may be in the form of text messages, or emails, or other such informative mediums. This is followed by 24% of the sample size always acquire travel information from social media like Twitter, Facebook, Instagram, Snapchat, Whatsapp etc. These kind of information is easy to attain and also has more visual impacts and many other people are talking about the same thing at a single platform.

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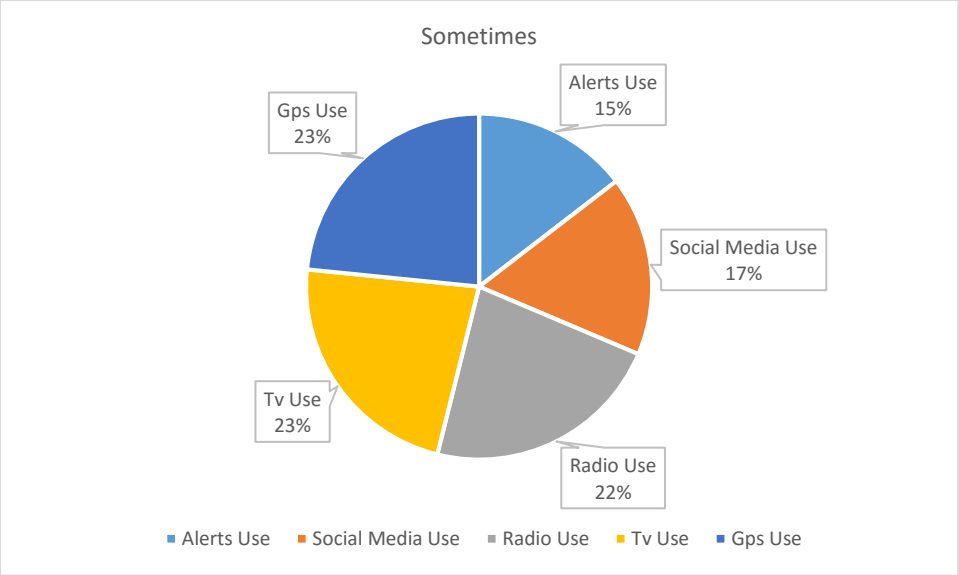
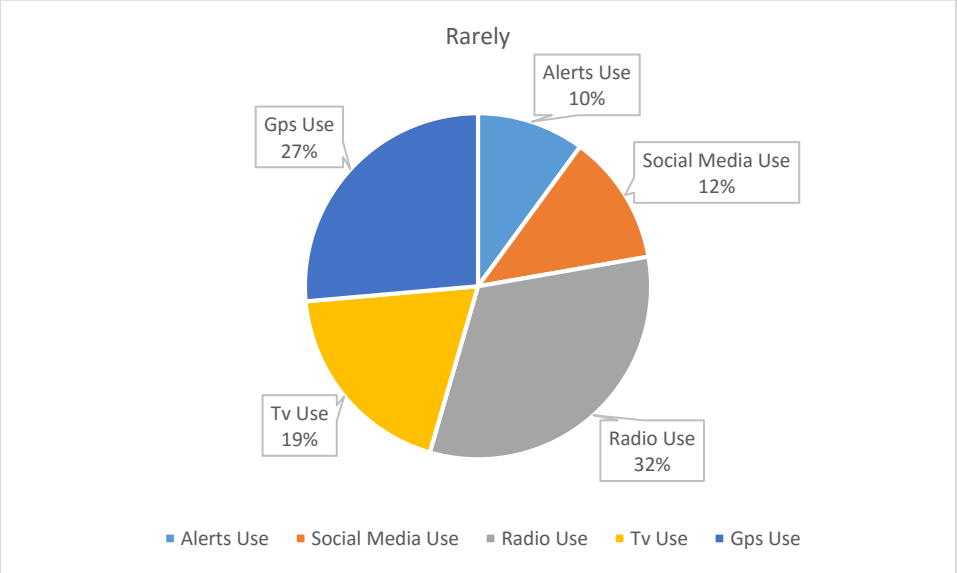
Figure 3 Percentage distribution of People Who Sometimes use various mediums of ICT to Acquire Travel Information



The above chart is more evenly distributed because it depends on what kind of information for travel they are looking for and through what medium. Therefore, the frequency of this is not as strong as never or always. However, it can be seen that people sometimes use travel information via GPS, Television or radio to make some decisions about their trips,

Figure 4 Percentage distribution of People who rarely use various mediums of ICT to Acquire Travel Information



This chart explains the percentage of people who rarely use the kind of medium to acquire any kind of travel information. The percentage for this is the radio being 32% of the total sample size, followed by GPS use and tv. This

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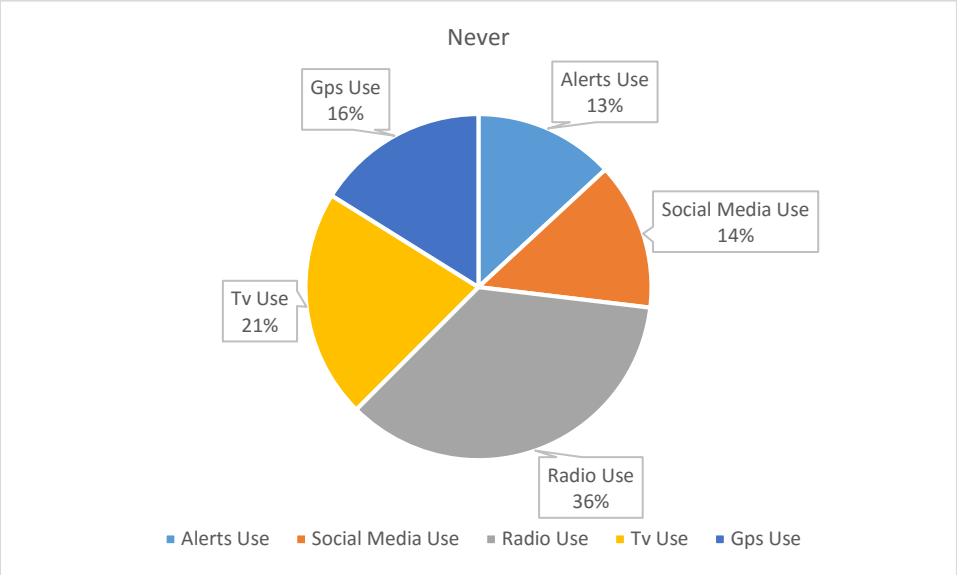
means that they rarely acquire any kind of information like care share, parking, congestion etc related to travel from these mentioned mediums.

Figure 5 Percentage distribution of People who never use various mediums of ICT to Acquire Travel Information



The above chart explains the percentage of people who never acquire travel information from various mediums of ICT. This is highest for the case of radio being 31% followed by TV which is 21%.

Now, after understanding how many people acquire travel information from different mediums and their frequency, multinomial logit models were performed for each dependent variable to understand the impact of every variable on person's travel behaviour. There are a total of 5 different models which attempts to understand the impact of each independent variable on them. Each model explains in detail the magnitude or extent of significance of each variable on the possible impacts on them. This is explained along with the coefficients of each significant variable of how prone they are in terms of making that choice of taking a different route, different mode, or a change in travel time on the basis of how significant they are. The overall summaries of all the 5 models are given below which includes all the variables which has a significant impact on the travel behaviour, however, it is broken down into two different segments to analyse the impacts on various elements on each significant travel behaviours. The first part explains the impact of ICT on travel behaviour, which includes the use of GPS, Tv, Radio, social media, alerts and apps for travel information. In the later part of the paper, the impact of socio demographic factors such as age, gender and employment on each travel behaviour are explained in detail.

For the multinomial logit regression, the following indicators were used to interpret the R output in an efficient way.

P value-

A p value helps in determining the significance of the results. It is usually used to weigh the strength of the evidence and is a number between 0 and 1. If the p value is small, that is less than 0.05, then it has a strong evidence against the null hypothesis, and hence we reject the hypothesis. In this paper, if the p value is less than 0.05, then the independent variables have a strong impact on the dependent variables. Similarly, if the p value is higher than 0.05,

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then the null hypothesis is failed to be rejected and has a very weak evidence on the result. However, if the p value is very close to 0.05, then it has a marginal impact and the result can be interpreted in both ways (Rumsey, 2017).

Coefficient value-

Multinomial logit coefficients can be interpreted in terms of relative probabilities and it can be categorised as discrete data or continuous data. This paper has used discrete values as it has categories like male/female, paid/unpaid etc. even for age, it was converted to categorical data, and hence the discrete ways of testing the coefficient will be useful for interpretation. Thus, here a positive coefficient means the probability of choosing to make a decision is higher compared to the baseline that is set for each variable. If the coefficient value is negative, the probability of deciding is less likely to make when compared to the baseline (Rodríguez, 2017).

Table 18 Summary table for all the variables that had an impact on Model 1

Model 1: impact different route			
Independent Variables	**Category**	**p value**	**coefficients**
Alerts-Always	Sometimes	0	-0.3
	Always	0	-0.9
Social Media- Always	Sometimes	0.02	-0.3
	Always	0.04	-0.7
Gender-Females	Always	0.05	0.41
Radio-Always	Sometimes	0	0.42
Tv-Rarely	Always	0.09	-0.4
TV-Sometimes	Sometimes	0.04	-0.05
Tv-Always	Sometimes	0.04	0.14
Age (55-64)	Sometimes	0.03	-0.56

Table 19 Summary table for all the variables that had an impact on Model 2

Model 2: impact different Mode			
Independent Variables	**Category**	**p value**	**coefficients**
Apps-Rarely	Sometimes	0.04	0.09
Apps-Sometimes	Always	0	-0.49
Alerts-Always	Sometimes	0	-0.35
	Always	0	-0.96
Social Media-Always	Sometimes	0.02	-0.3
	Always	0.04	-0.7
Radio-Always	Sometimes	0	0.36
Tv-Rarely	Always	0	-0.49
TV-Sometimes	Sometimes	0.04	0.09
Tv-Always	Sometimes	0.04	0.14
Age (55-64)	Sometimes	O	-0.56

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	Always	0.02	-1.08
Age(65-74)	Sometimes	0.03	-0.38

Table 20 Summary table for all the variables that had an impact on Model 3

Model 3: impact Earlier			
Independent Variables	**Category**	**p value**	**coefficients**
Apps-Always	Always	0.34	0.37
Gender-Female	Always	0.03	0.28
Alerts-Always	Sometimes	0.01	0.76
Social Media-Always	Sometimes	0.04	-0.54
GPS -Sometimes	Always	0	-0.14
GPS-Always	Always	0	-0.91
Tv-Always	Sometimes	0	0.39
Age (84 and above)	Sometimes	0	0.47
	Always	0	0.47

Table 21 Summary table for all the variables that had an impact on Model 4

Model 4: impact Later			
Independent Variables	**Category**	**p value**	**coefficients**
Employ-Unpaid	Sometimes	0.02	0.25
	Always	0	0.65
Apps-Always	Sometimes	0.01	0.19
Alerts-Always	Always	0	-0.99
Social Media-Rarely	Sometimes	0.04	0.43
Radio-Rarely	Sometimes	0	0.32
	Always	0	1.05
Radio-Always	Sometimes	0	0.34
	Always	0	0.91
GPS-Always	Sometimes	0.01	-0.3
	Always	0	-0.99
TV-Rarely	Sometimes	0	0.19
TV-Always	Sometimes	0	0.23
	Always	0	-0.5
Age (75-84)	Always	0	-12.33

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Table 22 Summary table for all the variables that had an impact on Model 5

Model 5: transit frequency			
Independent Variables	**Category**	**p value**	**coefficients**
Apps-Rarely	Sometimes	0.01	0.13
Radio-Always	Always	0	1.51
GPS-Rarely	Sometimes	0.04	0.4
	Always	0.03	0.52
TV-Sometimes	Sometimes	0.01	-0.02
TV-Always	Sometimes	0.03	0.07
Gender	Sometimes	0.07	0.04

Conclusion

The paper was an attempt to explain the impact of ICT on travel behavior within all classes of the society. For the purpose of the paper, five dependent variables were chosen to understand the impacts of the independent variables on them. The dependent variables were:

Impact_diffroute, Impact_diffmode, Impact_later, Impact_earlier, Transit_frequency.

The various independent variables were

Age, Gender, employment, Tv_use, Radio_use, GPS_use, Socialmedia_use, Apps_use, Alerts_use.

The total sample size on which 5 different models to understand the research questions was 4143.

Every research question is being explained in detail according to the results that could be seen after performing a Multiple Logit Model in the software R, and they are explained below:

1. **What are the characteristics of the people that use ICT to acquire travel information?**

It could be seen from the models that; gender was a major factor to determine the impact on travel behaviour. Women always seem to change their behaviour in terms of deciding the travel timeand always seemed to leave their origins of the journey earlier than they had previously planned.

This might be due to the information they have acquired from various means of ICT which might lead to making such a choice. It was also observed that there are changes in behavioural patterns in terms of choosing a different route or a different mode than previously planned. However, it does not have any significant impact on choosing to travel later than decided or any decision related to choosing a public transport for their travel.

To understand the age band, the baseline chosen for this study was group 5 which was people between the age group of 18-24. It could be seen that older people do not get greatly affected for the travel impacts, but in rare cases sometimes a difference in their choice of traveling in a different mode, taking a different route or leaving the origin a

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bit earlier than decided could be noticed. However, their inclination towards doing such things are really low and hence it can be said that it does not have a very strong impact compared to the younger groups of the society.

It is discussed in many papers that employment determines the travel behaviour of a person, or the trip length or the choice of travel according to the work place. However, in the models of this paper, no such significant impact could be seen. There was only one significant result where it was seen that people who are currently unpaid (unpaid volunteer/intern, home makers, Retired, or not employed) tend to choose their trips a little later than the ones which was formerly decided. Another aspect through which it could be seen was the concept of millennials, that a lot of people now work for start-ups and hence work from home, hence the requirement to travel anywhere has been reduced than the earlier times where people had to travel for their work places.

2. What are the different methods of acquiring travel information?

There we independent variables chosen to answer this particular research question. These were: Tv_use, Radio_use, GPS_use, Socialmedia_use, Apps_use, Alerts_use.

From the models, it was observed that people prefer to use more of modern technologies compared to the traditional ones like television or radio. The most commonly used method to acquire any kind of travel information like traffic update, car share availability or clearer routes, public transport information was alerts. That means people found the methods of information via mails or messages more convenient compared to the rest. The second was information from social media like Twitter or Facebook and applications in the smartphones or tablets. This had a great effect on the decision to take a different route, or mode than the one previously decided, however they are less prone to make such a decision. Whereas, those people who always used these methods to acquire travel information had a great impact on choosing to travel a bit later or earlier than previously decided and also in terms of taking a public transport.

The use of GPS information was useful in determining the decision to take a public transport rather than a private vehicle. This could be because the information about how much travel time, origin or destination points and the availability of the quickest transport is available in this method.

Traditional methods like television and radio are used lesser to gain travel information compared to the modern methods of technology like laptops, and cellphones. People who always used television or radio for that matter, only sometimes had an impact on their travel behaviour's decision making abilities, like whether to choose a different route or a different mode or choose a public transport for the purpose of their travel.

3. What are the differences in the ways to acquire travel information between various age groups?

Compared to the younger age, the elder groups of the society, whose age was above 55, preferred to acquire travel information via traditional methods like television and the radio. This was discussed in the literature review in the previous section, that older people do not find technology to be very handy as the methods are not very easy. Also, some of them also couldn't be bothered to learn this method again as it was complicated for their use. They were more comfortable with the traditional technologies. Most of the elder people do have mobile phones, but majority of them were not smart phones. Also, another assumption was, those people who had smart phones, did not have internet connection in them as it was assumed that it was expensive. Most people of this age group only used forms of ICT to socialise or to communicate with their distant relatives or friends.

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4. What is the impact of different mediums to acquire travel information on people's Travel Behaviours?

To understand the impact of travel information on travel behavior, 5 different dependent variables were chosen, namely:

Impact_diffroute, Impact_diffmode, Impact_later, Impact_earlier, Transit_frequency.

It was observed that most of the variables had an impact on these travel behaviors. The major impacts of all the forms of ICT could be seen mostly on choosing a different route, a different mode and choosing to travel a little later than the previously planned time based on the travel information they have acquired from most of these mediums.

The maximum impact could be seen on choosing to travel a little later than previously decided as from the interpretations of model 4, 7 independent variables had an impact on it, followed by impacts in choosing a different route and then on choosing a different mode for their travel as 5 independent variables had significant impacts on making such a decision.

It was interesting to see that despite of all the information in different mediums of ICT, there wasn't any major impact on choosing a public transport. Surprisingly radio and television use had an impact on it, whereas GPS and Alerts had hardly any impacts on this. Gender and employment or age didn't have any significant association with the decision making ability to take the public transport.

Therefore, it can be concluded that ICT has a major impact on travel behaviour in terms of choosing a different route, different mode of transport, choosing a public transport, or choosing to travel earlier or later than planned. Women tend to make more decisions regarding travel when compared to men. Also, the younger generations tend to use more modern technologies like social media, mails, or GPS when compared to the age group above 55 who prefer to use more of traditional methods like television and radio to acquire travel information.

Major Findings and Policy Implications

The paper considered several dependent and independent variables to understand the impact of each variable on travel behavior. The findings showed the results which was also discussed in the literature review that the older section of the society doesn't use many of the ICT mediums to depict their travel behavior. This might be due to various reasons like legibility, access to internet, comfort of using new tools etc as discussed earlier. Hence this could be improved to make the user class more inclusive.

Also, it could be seen that people were more comfortable in using the mail and SMS systems compared to the traditional mediums like TV and radio. Therefore, this could be used as a strength to spread awareness which would lead to influence the travel behavior. There wasn't any major significant change seen when it came to choosing a public transport as a result of the travel information they acquired from these mediums. Hence it could be encouraged in various ways to take the public transport more often based on information on social media, GPS etc.

These were some of the key findings and based on which policies can be derived or improved to make the travel experience more comfortable, convenient, faster, affordable and inclusive.

1. The user group ratio can be improved by making information through the smart mediums more legible, accessible and user friendly especially for the elderly so that it is more inclusive.
2. All these mediums are widely used to determine a person's travel behaviour. Therefore, it would be great if the older sections of the society used them as frequently as their younger counterparts.

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3. Older people could be tutored via public awareness channels on how to use these technologies to make them more aware of how it could be extensively used in terms of making decisions related to their travel.

4. More information based on public transportation could be spread out and also some alerts regarding the ill effects of using private vehicles could be sent as advertisements as it would somehow affect the decision of a person to use public transport more and more frequently.

5. Newer mediums of incorporating ICT into travel mediums can be explored and implemented, including the usage of electronic prompters and panels on bus stops, train stations etc. which can help provide commuters accurate information about their travel routes.

6. Public service messages can be relayed on electronic prompters within buses and trains that provide real time information about traffic conditions and ETA (Estimated time of arrival) at the next stop.

7. Mobile applications containing information about traffic, end-to-end connectivity, route options etc. can be introduced with a special emphasis on ease of use by the elderly.

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Appendix A.

Figure 6 R Output for Model 1 Summary- Impact_diffroute

```
> summary(m1)
Call:
multinom(formula = impact_diffroute ~ age + gender + apps_use +
    employment + alerts_use + socialmedia_use + radio_use + gps_use +
    tv_use, data = persons_valid)

Coefficients:
  (Intercept)        age6        age7       age8       age9      age10      age11     age12     gender2   apps_use2   apps_use3
2   0.1229402  0.03380419 -0.04916302 -0.2529788 -0.5639419 -0.3834592 -0.5268848  1.284143 -0.07686558  0.09031153 -0.05605756
3  -1.0866753 -0.17651263 -0.40283141 -0.6800713 -1.0853535 -1.2266676 -0.6947960 -8.472886  0.41384483 -0.18298136 -0.49227364
   apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 -0.0561316  0.07955486  0.02446117   0.1349629  -0.3572032       0.09721859       0.01523335       -0.3009372  0.1669816
3 -0.3460340  0.16003111  0.08385518  -0.3645781  -0.9653165      -0.04533166      -0.40809038       -0.7032969 -0.3258607
  radio_use3 radio_use4   gps_use2   gps_use3   gps_use4     tv_use2     tv_use3     tv_use4
2  0.4296405  0.3655091  0.1570949  0.2105923  0.1722722 -0.05605756  0.09031153  0.14481782
3 -0.2639158  0.1562471 -0.2357693 -0.6770057 -0.1125333 -0.49227364 -0.18298136 -0.06538632

Std. Errors:
  (Intercept)      age6      age7      age8      age9     age10     age11        age12    gender2  apps_use2  apps_use3  apps_use4
2   0.1506539 0.1397620 0.1443424 0.1520329 0.1564143 0.1866388 0.3486119 1.144218e+00 0.06506775 0.04606606 0.05086083 0.08226604
3   0.3599249 0.3627349 0.3872796 0.4315711 0.4767056 0.6856681 1.0902311 3.142298e-05 0.21349431 0.15040460 0.18957825 0.23381804
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2  0.08993482   0.1798183   0.1601412   0.1337861       0.1699687       0.1558018       0.1347753  0.1019136  0.1073308
3  0.27159051   0.4252285   0.4408189   0.3405509       0.4220760       0.4349983       0.3483843  0.3523229  0.3734482
  radio_use4  gps_use2  gps_use3  gps_use4    tv_use2    tv_use3    tv_use4
2 0.09417389 0.1298633 0.1275924 0.1128542 0.05086083 0.04606606 0.07245049
3 0.28200040 0.3649545 0.4064908 0.3087240 0.18957825 0.15040460 0.20578132

Residual Deviance: 6336.647
AIC: 6436.647
> z1<-summary(m1)$coefficients/summary(m1)$standard.errors
> p1<-(1-pnorm(abs(z1),0,1))*2
> p1
  (Intercept)      age6      age7       age8         age9      age10     age11     age12    gender2  apps_use2   apps_use3
2 0.414475168 0.8088811 0.7334046 0.09611762 0.0003116289 0.03992223 0.1306919 0.2617398 0.23747718 0.04993985 0.270385380
3 0.002534665 0.6265305 0.2982672 0.11507113 0.0227994079 0.07361307 0.5239344 0.0000000 0.05257018 0.22375865 0.009413016
  apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 0.4950379   0.3763813   0.8917954   0.3993545 0.007586106        0.5673359        0.9221118        0.0255568  0.1013253
3 0.1388923   0.5557025   0.8436708   0.4082103 0.004588698        0.9144703        0.3481712        0.0435144  0.3550219
    radio_use3  radio_use4  gps_use2   gps_use3  gps_use4     tv_use2     tv_use3     tv_use4
2 6.255549e-05 0.000103936 0.2263963 0.09883910 0.1268846 0.270385380 0.04993985 0.04562434
3 4.797530e-01 0.579532942 0.5182638 0.09581536 0.7154764 0.009413016 0.22375865 0.75067713
>
```

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Figure 7 R Output for Model 2 Summary- Impact_diffmode

```
> summary(m2)
Call:
multinom(formula = impact_diffmode ~ age + gender + apps_use +
    employment + alerts_use + socialmedia_use + radio_use + gps_use +
    tv_use, data = persons_valid)

Coefficients:
  (Intercept)        age6        age7       age8       age9      age10      age11     age12     gender2   apps_use2   apps_use3
2   0.1229402  0.03380419 -0.04916302 -0.2529788 -0.5639419 -0.3834592 -0.5268848  1.284143 -0.07686558  0.09031153 -0.05605756
3  -1.0866753 -0.17651263 -0.40283141 -0.6800713 -1.0853535 -1.2266676 -0.6947960 -8.472886  0.41384483 -0.18298136 -0.49227364
   apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 -0.0561316  0.07955486  0.02446117   0.1349629  -0.3572032       0.09721859       0.01523335       -0.3009372  0.1669816
3 -0.3460340  0.16003111  0.08385518  -0.3645781  -0.9653165      -0.04533166      -0.40809038       -0.7032969 -0.3258607
  radio_use3 radio_use4   gps_use2   gps_use3   gps_use4     tv_use2     tv_use3     tv_use4
2  0.4296405  0.3655091  0.1570949  0.2105923  0.1722722 -0.05605756  0.09031153  0.14481782
3 -0.2639158  0.1562471 -0.2357693 -0.6770057 -0.1125333 -0.49227364 -0.18298136 -0.06538632

Std. Errors:
  (Intercept)      age6      age7      age8      age9     age10     age11        age12    gender2  apps_use2  apps_use3  apps_use4
2   0.1506539 0.1397620 0.1443424 0.1520329 0.1564143 0.1866388 0.3486119 1.144218e+00 0.06506775 0.04606606 0.05086083 0.08226604
3   0.3599249 0.3627349 0.3872796 0.4315711 0.4767056 0.6856681 1.0902311 3.142298e-05 0.21349431 0.15040460 0.18957825 0.23381804
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2  0.08993482   0.1798183   0.1601412   0.1337861        0.1699687        0.1558018        0.1347753  0.1019136  0.1073308
3  0.27159051   0.4252285   0.4408189   0.3405509        0.4220760        0.4349983        0.3483843  0.3523229  0.3734482
  radio_use4  gps_use2  gps_use3  gps_use4    tv_use2    tv_use3    tv_use4
2 0.09417389 0.1298633 0.1275924 0.1128542 0.05086083 0.04606606 0.07245049
3 0.28200040 0.3649545 0.4064908 0.3087240 0.18957825 0.15040460 0.20578132

Residual Deviance: 6336.647
AIC: 6436.647
> z2<-summary(m2)$coefficients/summary(m2)$standard.errors
> p2<-(1-pnorm(abs(z2),0,1))*2
> p2
  (Intercept)      age6      age7       age8         age9      age10     age11     age12    gender2  apps_use2   apps_use3
2 0.414475168 0.8088811 0.7334046 0.09611762 0.0003116289 0.03992223 0.1306919 0.2617398 0.23747718 0.04993985 0.270385380
3 0.002534665 0.6265305 0.2982672 0.11507113 0.0227994079 0.07361307 0.5239344 0.0000000 0.05257018 0.22375865 0.009413016
  apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 0.4950379   0.3763813   0.8917954   0.3993545 0.007586106        0.5673359        0.9221118        0.0255568  0.1013253
3 0.1388923   0.5557025   0.8436708   0.4082103 0.004588698        0.9144703        0.3481712        0.0435144  0.3550219
    radio_use3  radio_use4  gps_use2   gps_use3  gps_use4     tv_use2     tv_use3     tv_use4
2 6.255549e-05 0.000103936 0.2263963 0.09883910 0.1268846 0.270385380 0.04993985 0.04562434
3 4.797530e-01 0.579532942 0.5182638 0.09581536 0.7154764 0.009413016 0.22375865 0.75067713
```

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Figure 8 R Output for Model 3 Summary- Impact_earlier

```
> summary(m3)
Call:
multinom(formula = impact_earlier ~ age + gender + apps_use +
    employment + alerts_use + socialmedia_use + radio_use + gps_use +
    tv_use, data = persons_valid)

Coefficients:
  (Intercept)      age6        age7        age8       age9      age10        age11     age12    gender2 apps_use2 apps_use3
2     1.89690 0.2043956 -0.07885478  0.05282701  0.1275441  0.0690864  0.004642525  9.473964 0.07989453 0.4128080 0.4356025
3     1.46279 0.0908792 -0.41964615 -0.26624574 -0.1717567 -0.1941028 -0.966046080 10.939981 0.28503115 0.2615048 0.3774669
  apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 0.6535292    0.1069420   0.2381476   0.7606588   0.2513025       0.03411225       0.02234423       -0.5468331  0.1598214
3 0.7794648    0.2359724  -0.1779834   0.4493674  -0.1137016      -0.01604786      -0.17556071       -0.5600726  0.3123012
   radio_use3 radio_use4     gps_use2    gps_use3    gps_use4    tv_use2    tv_use3     tv_use4
2  0.09798552 -0.1636660  0.004802214 -0.1396254 -0.4070188 0.4356025 0.4128080 0.39496014
3 -0.07784733 -0.2728528 -0.393102334 -0.7463476 -0.9143222 0.3774669 0.2615048 0.04435307

Std. Errors:
  (Intercept)      age6      age7      age8      age9     age10     age11     age12   gender2  apps_use2 apps_use3 apps_use4
2   0.2867999 0.2356985 0.2388337 0.2564896 0.2660376 0.3265130 0.5827835 0.4716571 0.1115443 0.09091857 0.1032287 0.1559213
3   0.3181603 0.2771646 0.2848551 0.3041470 0.3134981 0.3813653 0.7661190 0.4716575 0.1342172 0.10351913 0.1150462 0.1731430
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2   0.1601660   0.3193531   0.3097863   0.2282862        0.3552412        0.3240720        0.2678422  0.1880558  0.1961225
3   0.1864719   0.3705549   0.3497376   0.2626723        0.3944724        0.3642105        0.3001750  0.2166541  0.2323437
  radio_use4  gps_use2  gps_use3  gps_use4   tv_use2    tv_use3   tv_use4
2  0.1590914 0.2571291 0.2490791 0.2172492 0.1032287 0.09091857 0.1304584
3  0.1912109 0.2857173 0.2796554 0.2411136 0.1150462 0.10351913 0.1497936

Residual Deviance: 5750.184
AIC: 5850.184
> z3<-summary(m3)$coefficients/summary(m3)$standard.errors
> p3<-(1-pnorm(abs(z3),0,1))*2
> p3
   (Intercept)      age6      age7      age8      age9     age10     age11 age12    gender2    apps_use2    apps_use3    apps_use4
2 3.740253e-11 0.3858376 0.7412745 0.8368209 0.6316389 0.8324281 0.9936440     0 0.47383190 5.614367e-06 2.445403e-05 2.772322e-05
3 4.272838e-06 0.7429957 0.1406994 0.3813645 0.5837801 0.6107746 0.2073229     0 0.03369898 1.153203e-02 1.034386e-03 6.736289e-06
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2   0.5043284   0.4558374   0.0140716   0.2709740        0.9235003        0.9450307       0.04118883   0.395402  0.6173470
3   0.2057071   0.6310029   0.1988377   0.6651129        0.9675495        0.6297840       0.06206648   0.149451  0.7375855
  radio_use4  gps_use2    gps_use3    gps_use4      tv_use2      tv_use3     tv_use4
2  0.3035949 0.9850994 0.575093097 0.06099790 2.445403e-05 5.614367e-06 0.002466027
3  0.1535875 0.1688701 0.007612006 0.00014939 1.034386e-03 1.153203e-02 0.767157873
>
```

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Figure 9 R Output for Model 4 Summary- Impact_later

```
> summary(m4)
Call:
multinom(formula = impact_later ~ age + gender + apps_use + employment +
    alerts_use + socialmedia_use + radio_use + gps_use + tv_use,
    data = persons_valid)

Coefficients:
  (Intercept)       age6       age7       age8       age9      age10       age11       age12      gender2  apps_use2  apps_use3
2   0.8262986  0.1852791  0.23801879 0.03752709 -0.008170282  0.3801452  -0.1079743 -0.04078063 -0.002431542  0.2209873  0.1962439
3  -0.9812537 -0.1313338 -0.09971939 0.03536042 -0.082952509 -0.1086590 -12.3300511  1.48360022  0.287283760 -0.4402614 -0.2767908
  apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 0.1775507   0.2504387  -0.1190988   0.1101227 -0.08330066        0.4304483        0.3440592       -0.1150756  0.3288867
3 0.2419000   0.6548468  -0.6648202  -0.8720112 -0.99481491       -0.1257641       -0.2554982        0.1770607  1.0597272
  radio_use3 radio_use4    gps_use2   gps_use3   gps_use4    tv_use2    tv_use3    tv_use4
2  0.3430048 0.07773802 -0.01395871 -0.1783926 -0.3064599  0.1962439  0.2209873  0.2315168
3  0.9139211 0.52222509 -0.34437076 -0.7997334 -0.9901120 -0.2767908 -0.4402614 -0.5061015

Std. Errors:
  (Intercept)      age6      age7      age8      age9     age10        age11    age12    gender2  apps_use2  apps_use3  apps_use4
2   0.1768264 0.1595003 0.1655795 0.1730266 0.1767549 0.2271025 3.878582e-01 1.178574 0.07551581 0.05555006 0.06140268 0.09451076
3   0.3731107 0.3927322 0.4082520 0.4172387 0.4266143 0.5284712 5.279868e-06 1.469104 0.19762609 0.15524921 0.15227557 0.19609317
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2   0.1086588   0.2130505   0.1942555   0.1585735        0.2104978        0.1889466        0.1564696  0.1194109  0.1273069
3   0.2385781   0.4608402   0.4388030   0.3222564        0.5374357        0.5011423        0.3611102  0.3059855  0.3345395
  radio_use4  gps_use2  gps_use3  gps_use4    tv_use2    tv_use3   tv_use4
2  0.1052320 0.1607576 0.1550508 0.1367916 0.06140268 0.05555006 0.0839223
3  0.2973281 0.3329280 0.3408932 0.2891644 0.15227557 0.15524921 0.1948105

Residual Deviance: 5389.107
AIC: 5489.107
> z4<-summary(m4)$coefficients/summary(m4)$standard.errors
> p4<-(1-pnorm(abs(z4),0,1))*2
> p4
  (Intercept)      age6      age7      age8      age9     age10    age11     age12   gender2    apps_use2  apps_use3  apps_use4
2 2.969221e-06 0.2453889 0.1505790 0.8282970 0.9631319 0.09415169 0.780716 0.9723974 0.9743133 6.944937e-05 0.00139340 0.06029508
3 8.540326e-03 0.7380697 0.8070299 0.9324612 0.8458284 0.83709551 0.000000 0.3125588 0.1460369 4.570585e-03 0.06911046 0.21735306
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4  radio_use2  radio_use3
2 0.021176765   0.5761503  0.57078491 0.599365957       0.04086414        0.0686170        0.4620653 0.005882810 0.007053351
3 0.006054964   0.1491258  0.04689472 0.002021679       0.81497901        0.6101695        0.6239052 0.000533543 0.006297440
  radio_use4  gps_use2   gps_use3   gps_use4    tv_use2      tv_use3     tv_use4
2 0.46007100 0.9308060 0.24992031 0.025068814 0.00139340 6.944937e-05 0.005803106
3 0.07902124 0.3009631 0.01897642 0.000616963 0.06911046 4.570585e-03 0.009379118
>
```

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Figure 10 R Output for Model 5 Summary- Transit_freq

```
> summary(m5)
Call:
multinom(formula = transit_freq ~ age + gender + apps_use + employment +
    alerts_use + socialmedia_use + radio_use + gps_use + tv_use,
    data = persons_valid)

Coefficients:
  (Intercept)        age6       age7       age8        age9      age10      age11      age12     gender2    apps_use2  apps_use3
2  -0.1825749  0.17810596  0.1232792 -0.1039878 -0.07866599  0.2555543  0.2311348  -1.553543  0.04526641  0.132914776 -0.1097084
3  -1.1782765 -0.01614592 -0.3340359 -0.6528851 -0.85980294 -0.4252121 -0.5389807 -12.236090 -0.08662939 -0.021507642 -0.2853890
4  -0.7011292 -0.30867374 -0.8853444 -1.1568972 -1.33171505 -1.1856429 -2.2287590 -11.859394 -0.10323969 -0.001329894 -0.4772845
   apps_use4 employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2
2 -0.3865541 -0.11501308 -0.04130684   0.2294266  0.09563955        0.2213274        0.2357290       -0.06130074 0.12431425
3 -0.9467963 -0.04398691  0.03698476   0.3868510 -0.36712254        0.2049124        0.4051087       -0.04548193 0.61063988
4 -0.3117053 -1.05486761 -0.06813006  -0.1606403 -0.97243727        0.1413715        0.1990848       -0.08280167 0.01981678
  radio_use3  radio_use4  gps_use2  gps_use3  gps_use4    tv_use2      tv_use3    tv_use4
2  0.4146928 0.008400846 0.2285943 0.1411489 0.2587054 -0.1097084  0.132914776 0.18077280
3  1.2814501 1.203476464 0.4012817 0.2675221 0.6991289 -0.2853890 -0.021507642 0.07541633
4  0.9868704 1.519456852 0.5256275 1.2184177 1.2163912 -0.4772845 -0.001329894 0.08919049

Std. Errors:
  (Intercept)      age6      age7      age8      age9     age10     age11        age12    gender2  apps_use2  apps_use3 apps_use4
2   0.1833003 0.1896254 0.1920843 0.1980530 0.1997890 0.2316737 0.3900591 1.153012e+00 0.07827483 0.05472110 0.05725283 0.0937185
3   0.2425458 0.2112498 0.2192005 0.2337771 0.2440904 0.2862898 0.5412231 5.119288e-06 0.10150835 0.07457305 0.08158784 0.1480170
4   0.2416879 0.2058466 0.2170596 0.2331658 0.2474675 0.3421702 1.0727156 5.484879e-06 0.10563619 0.07907437 0.09847847 0.1336410
  employment2 alerts_use2 alerts_use3 alerts_use4 socialmedia_use2 socialmedia_use3 socialmedia_use4 radio_use2 radio_use3
2   0.1047713   0.2198436   0.1982382   0.1623601        0.2041381        0.1897365        0.1603662  0.1112191  0.1269116
3   0.1334931   0.2784370   0.2481063   0.2133250        0.2657077        0.2428772        0.2129259  0.1779729  0.1817664
4   0.1685126   0.2656053   0.2442787   0.2005256        0.2645391        0.2450609        0.2074067  0.2024112  0.1900044
  radio_use4  gps_use2  gps_use3  gps_use4    tv_use2    tv_use3    tv_use4
2  0.1096970 0.1465235 0.1440908 0.1261820 0.05725283 0.05472110 0.08612812
3  0.1629280 0.2033475 0.2077621 0.1793314 0.08158784 0.07457305 0.11630298
4  0.1617822 0.2442744 0.2332846 0.2149397 0.09847847 0.07907437 0.11774698

Residual Deviance: 10048.28
AIC: 10198.28
```

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