Long-Distance Person Travel: A Cluster-Based Approach

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Transport Findings

Many long-distance person trips (LDPT) modelling efforts fail to accurately represent trips using traditional segmentation approaches. Thus, a clustering approach was used herein to segment an intra-provincial trips data set. The trips’ segments found were short economical getaways (36%), same-day shopping (16%), personal business (14%), visiting friends/relatives (10%), business/casino trips (10%), young adults playing team sports (6%), same-day trips of snow/festival loving young families with kids (3%), costly cottage/camping trips (3%), seniors with medical appointments (2%), and multiple city visitors (1%). The existence of clusters and associated activities shows what segmentation approaches modern models should follow.

The analysis of travel demand often includes the partitioning of the demand into “market segments” seeking to separate these influences into groups. As demonstrated in (Larse 2010; Travel Demand Modelling 2016; Lintanakool, Dijst, and Schwanen 2006; Bhat 1997b; Koppelman and Sethi 2000; Mandel, Gaudry, and Rothengatter 1997; Ben-Akiva and Lerman 1987; Wardman, Toner, and Whelan 1997; LaMondia, Bhat, and Hensher 2008; Carlsson 1999; Hensher 1991; Morrison and Winston 1985; Hassanvand 2020), the development of such models includes substantial effort that encompasses enormous revalidation work, which has been reduced with the aid of advanced computer technology. However, there still exists a gap in model design that arise from failure to segment markets.

This paper defines travel alternatives made by market segments with the aim of optimizing the selection of descriptive variables and strengthening the explanatory power of the model. Nearly all long-distance person trips (LDPT) models (Federal Highway Administration 2015; Golob 2001; Kizielewicz et al. 2017; Bhat 1997a; Golob and Hensher 1998; Badoe and Miller 1998; Lieberman et al. 2001) developed in various countries are based not on empirical procedures but rather by educated guesses to describe the travel market variables. This research transforms the approach to traditional segmentations using computer science approaches for network-based data that stem from fuzzy logic (Zadeh 1965). Such approaches are based on grouping of data points by examining their proximity (e.g. Euclidean distance) to one another. This is essential as LDPT is not merely the longer version of short-distance daily trips. While fuzzy-neuro models have been used in transit and some short-distance models (Kumar, Sarkar, and Madhu 2013; Sarkar 2012; Tharwat 2014; Roxas 2016; Yaldi et al, n.d.; Gite 2013), they have not been used in LDPT – excluding goods movement, trucking, or air travel.
Methods and Data

Clustering is a statistical tool used in pattern recognition and machine learning to find similar groups in seemingly dissimilar network-based datasets (e.g., transport data). Objects in a cluster/class share many characteristics but are very dissimilar to objects not belonging to that particular cluster (Punj and Stewart 1983). In most of the classification works (Milligan 1996; Posse 1998; Everitt, Landau, and Leese 2001), considerable number of algorithms belong to two major types of clustering used here namely Hierarchical and Partitional. The former is based on finding clusters hierarchy using a criterion and producing a dendrogram. The latter is partitioning the data based on minimization of an objective function such as the squared error function (Kaufman and Rousseeuw 1990; Bezdek 1974):

\[ J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| \mathbf{x}_{i}^{(j)} - \mathbf{c}_{j} \right\|^2 \]  

(1)

Where \( \left\| \mathbf{x}_{i}^{(j)} - \mathbf{c}_{j} \right\|^2 \) is the distance between a data item \( \mathbf{x}_{i}^{(j)} \) and a centre point \( \mathbf{c}_{j} \).

One type of partitional clustering, with steps shown in Table 1, is called the k-means approach as a specific form of the more general fuzzy c-means clustering that minimizes a similar objective function [34]:

The uniqueness of this work lies partly in the essential three-step cluster validity checks which are often ignored in many clustering themed studies (Dunn 1974; Zaki and Meira, Jr 2014):

1. Cluster tendency checks: which is a measure of clusterability of a data set considering that algorithms such as k-mean unquestioningly find some clusters in a data set regardless. Thus, to ensure the data is actually clusterable, one must examine it for its clustering tendency using indices such as the Hopkins statistics prior to any clustering practices.
2. Cluster stability checks: is the practice of clustering randomly generated data sets out of the original data and data belonging to other years/locations in order to examine if the resulting clusters are persistent and show up each time. Also, clustering the data set using fuzzy c-means provides an additional check on the existence/lack of potential outliers and acts as a precautionary measure against model-dependency of results.

3. Cluster validity: consists of three tests namely External (one-way ANOVA, Post-hoc Bonferroni, and Logistic Regression), Internal (Beta-CV index), and Relative (Elbow method). Other tests include variables’ correlation checks, F-tests, Grubb’s test of outliers, Ward’s (AHC) dendrogram analyses and stopping rules comparison of a large Duda-Hart Je(2)/Je(1) index with a small Pseudo T-tests and a large Calinski-Harabasz Pseudo-F indices for detection of number of clusters (Everitt, Landau, and Leese 2001).

The publicly available standardized and weighted 2017 Travel Survey of Residents of Canada (TSRC) data set – including 14064 Province of Alberta (AB) residents, 4167 AB to AB trips, and 6128 nights travelled – is examined and compared with 2016 and 2015 data. TSRC is a supplement of the Canadian Labour Force Survey (LFS) (Statistics Canada 2017b, 2017a) after which TSRC questions are asked of a random 18+ household (HH) member regarding any one-way 40+ km trips from home finished in the previous month (same-day/overnight) plus any overnight trips ended two months before regardless of distance. Figure 1 shows trip counts by distance/purpose followed by variables’ list in Table 2. Analysis is based on 100 variables with minimal correlations from socio-demographic factors to places visited and 37 different activities divided into same-day/overnight.

FINDINGS

Table 3 describes 10 clusters found in the 2017 data set followed by Figure 2 which is a 3D representation of clusters’ center points across some of the most important dimensions (for brevity). Figure 3 represents a dendrogram of classes hierarchy found through (AHC) clustering.

Examinations revealed the data possess a natural structure with 10 clusters at 68% confidence level. Such results are consistent with other literature findings for LD trips (Future Foundation 2015; Birley and Westhead 1990; Mooi and Sarstedt 2011). For example, trips done for pleasure have consistently been found to belong to mostly the top two categories of LDPT. The second largest cluster is representative of individual adults from the same HH who travel in smaller groups with no kids. Their purpose is mainly same-day trips of shopping with moderate levels of spending with activities such as walking. This finding is novel and could be a characteristic of the Province of Alberta, in that malls and shopping centres such as Banff, Lake Louise, West Edmonton...
mall, or other shopping avenues are also long-distance traveller attractors. The existence of such clusters demonstrates how traditional LDPT trips segmentation through “guessing variables and rechecking” are obsolete and would need to be enhanced using comprehensive clustering approaches targeted for network-based data to better represent the overall LDPT market while relying less on conjecture and assumptions.

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| # | Name                  | Label                                      | Type       | Question                                                                 |
|---|-----------------------|--------------------------------------------|------------|--------------------------------------------------------------------------|
| 1 | TR_G08                | Household members 18 or older who went on the trip - Capped | continuous | Number of household members 18 years of age and over on trip - Capped.    |
| 2 | TR_D11                | Number of different trips - capped         | continuous | How many? (Identical trips).                                              |
| 3 | TS_TOTAE              | Total amount spent on all spending         | continuous | Total amount spent on all spending, including amount extracted from travel package. |
| 4 | DIST2                 | Distance of trip - farthest location       | continuous | One way distance in km travelled to the farthest destination location.   |
| 5 | TRP_CNT               | Total number of trip records               | continuous | Total number of trip records.                                            |
| 6 | TP_D01                | Total number of people in travel party - Grouped | continuous | Total number of people in travel party - Grouped.                        |
| 7 | T_G0802               | Household members who went on trip - Capped | continuous | Household members who went on trip - Capped.                            |
| 8 | TP_G02                | Household members under 18 who went on the trip - Capped | continuous | Number of household members under 18 years of age on trip - Capped.      |
| 9 | AGE_G03               | Age group of the respondent - Grouped      | discrete   | Age of the 18+ random respondent to TSRC.                                |
| 10 | SEX                   | Sex of respondent                          | discrete   | Sex of the 18+ random respondent to TSRC.                                |
| 11 | EDlevel                | Education level of respondent - Grouped    | discrete   | Education level of the 18+ random respondent to TSRC.                    |
| 12 | LSATATG               | Labour force status - Grouped              | discrete   | Employed or unemployed status of the 18+ random respondent to TSRC.     |
| 13 | DMDPLF                | Province of trip Destination               | discrete   | Province of the 18+ random respondent to TSRC.                          |
| 14 | INCOME               | Household income - 4 groups                | discrete   | Household income - 4 groups.                                            |
| 15 | CANNITE               | Total number of nights in Canada during the trip | discrete   | Total number of nights on the trip spent in Canada.                     |
| 16 | REFYEAR               | Reference year                             | discrete   | Reference year.                                                          |
| 17 | REFMONTH              | Reference month                            | discrete   | Reference month.                                                         |
| 18 | TRIPTYPE              | Type of trip                               | discrete   | Type of trip.                                                            |
| 19 | MORTIP3               | Main reason for the trip - 7 categories   | discrete   | Main reason for the trip - 7 categories.                                 |
| 20 | ORCPROV               | Province of trip origin                     | discrete   | Province of trip origin.                                                 |
| 21 | TRIPTYPEP3            | Mode of transportation used on the trip    | discrete   | Mode of transportation used on the trip.                                 |
| 22 | AT_G00X               | Activity - Attend an aboriginal event      | discrete   | On this trip did you attend an aboriginal event (pow wow, performance, other)? |
| 23 | AT_G00H               | Activity - Go to a beach                   | discrete   | On this trip did you go to a beach?                                     |
| 24 | AT_G00J               | Activity - Go boating                      | discrete   | On this trip did you go boating?                                        |
| 25 | AT_G00G               | Activity - Go wildlife viewing or bird watching | discrete   | On this trip did you go wildlife viewing or bird watching?               |
| 26 | AT_G00I               | Activity - Go camping                       | discrete   | On this trip did you go camping?                                         |
| 27 | AT_G00O               | Activity - Go canoeing or kayaking          | discrete   | On this trip did you go canoeing or kayaking?                            |
| 28 | AT_G00P               | Activity - Go to a casino                  | discrete   | On this trip did you go to a casino?                                    |
| 29 | AT_G00N               | Activity - Go cycling                       | discrete   | On this trip did you go cycling?                                         |
| 30 | AT_G00Q               | Activity - Attend a festival or fair        | discrete   | On this trip did you go to a fair or attend a festival?                  |
| 31 | AT_G00K               | Activity - Go fishing                       | discrete   | On this trip did you go fishing?                                         |
| 32 | AT_G00M               | Activity - Go golfing                      | discrete   | On this trip did you go golfing?                                         |
| 33 | AT_G00F               | Activity - Go hiking or backpacking         | discrete   | On this trip did you go backpacking or hiking?                           |
| 34 | AT_G00B               | Activity - Visit a historic site           | discrete   | On this trip did you visit a historic site?                              |
| 35 | AT_G00L               | Activity - Go hunting                       | discrete   | On this trip did you go hunting?                                         |
| 36 | AT_G00C               | Activity - Visit a museum or art gallery    | discrete   | On this trip did you go to an art gallery or visit a museum?             |
| 37 | AT_G00A               | Activity - Visit a national/provincial or nature park | discrete   | On this trip did you visit a national/provincial or nature park?          |
| 38 | AT_G00D               | Activity - Attend a performance            | discrete   | On this trip did you attend a performance such as a play or concert?     |
| 39 | AT_G00V               | Activity - Go cross country skiing or snowshoeing | discrete   | On this trip did you go cross country skiing or snowshoeing?             |
| 40 | AT_G00W               | Activity - Go snowmobiling                 | discrete   | On this trip did you go snowmobiling?                                   |
| 41 | AT_G01E               | Activity - Attend a sports event as a spectator | discrete   | On this trip did you attend a sports event as a spectator?              |
| 42 | AT_G01T               | Activity - Play individual or team sports   | discrete   | On this trip did you play individual or team sports?                    |
| 43 | AT_G01R               | Activity - Visit a theme or amusement park | discrete   | On this trip did you visit a theme or amusement park?                    |
| 44 | AT_G01S               | Activity - Visit a zoo or aquarium         | discrete   | On this trip did you visit a zoo or aquarium?                            |
| 45 | AT_G01Z               | Activity - Shop (includes all markets)      | discrete   | On this trip did you shopping (includes all markets)?                    |
| 46 | AT_G01U               | Activity - Go downhill skiing or snowboarding | discrete   | On this trip did you go downhill skiing or snowboarding?                |
| 47 | AT_G01A               | Activity - Attend a business/other meeting | discrete   | On this trip did you attend a business/other meeting/conference/seminar? |
| 48 | AT_G01AB              | Activity - Go to a medical/dental appointment | discrete   | On this trip did you medical/dental appointments?                       |
| 49 | AT_G01AC              | Activity - Sightseeing                     | discrete   | On this trip did you go for sightseeing?                                 |
| 50 | AT_G01AD              | Activity - Go to the movies                | discrete   | On this trip did you go to the movies?                                  |
| 51 | AT_G01AE              | Activity - Dine out/go to restaurant/bar/club | discrete   | On this trip did you restaurant/bar/club?                              |
| 52 | AT_G01AF              | Activity - ATV (quad, 4X4)                 | discrete   | ATV (quad, 4X4)?                                                        |
| 53 | AT_G01AG              | Activity - Did not do any activities        | discrete   | No activities?                                                          |
| 54 | AT_G01AH              | Activity - Other activity                  | discrete   | Other activities?                                                       |
| 55 | AT_G02                | Activity - Most important - Same day trip  | discrete   | Most important activity for same day trips?                             |

Table 2: List of Variables
| Cluster/Class Title                  | Description                                                                                                                                                                                                 | Percentage of Total |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| **Short Economical Getaways**       | Represents trips (with frequency of two) made by most likely University educated adults in smaller groups (mostly one traveller or potentially only one other partner) not from the same HH going on short (same-day) getaways of about 100 km in private cars for pleasure purposes and having low spending amounts (less than $100) with potential overnight activities such as skiing and same-day activities such as cycling, hiking, and visiting parks. | 36                  |
| **Same-day Shopping**               | Trips (with frequency of two) consisting of smaller groups (two travellers) of adults from the same HH travelling with no kids on short trips (same-day) with moderate levels of spending (about $150) and travelling shorter distances (about 100 km) in mostly private cars. | 17                  |
| **Personal Business Trips**         | Represents trips (with frequency of two) characterized by individual older adults travelling mostly alone or with only one other traveller for longer distances (about 300 km) by air and taxi for long number of nights (about one week) with no kids and moderate spending (about $250) and having “other” types of activities. | 14                  |
| **VFR Trips**                       | Trips (with frequency of one) consisting of larger groups (about 4) mostly from the same HH with older kids travelling shorter distances (about 100 km) on trips of about three nights in private cars with moderate spending (about $150) for the purpose of visiting friends and relatives and having not many activities. | 11                  |
| **Business/casino Trips**           | Represents trips (with frequency of one) consisting of younger adults (with mostly low incomes in groups of about two) travelling by air, bus, and/or rental cars for longer distances (over 250 km) and about two nights away and spending around $200 visiting casinos while on the trip, playing sports, skiing, or being a sports spectator most likely alongside business partners. The fact that such trips are mostly taken by young adults confirms the findings of [38] stating that 45% of most business trips are taken by Millennials and younger adults. | 10                  |
| **Young Families with Children going to Seasonal Events** | Trips (with frequency of two) consisting of younger parents with lower levels of income from the same HH (with groups of three travellers) going on shorter (about 100 km) low budget trips in private cars (under $100) for about two nights with kids and participating in snow related activities in the winter time and visiting zoo, parks, and festivals in the warmer months. These results confirm the findings of [39] that states events have now become one of the main attractors of travellers as many seek a more planned trip as well as a cultural experience in the process. | 3                   |
| **Team Sport Players**              | Represents trips (with frequency of one) consisting of non-adult members (in groups of three or more) from the same household with high school education and low incomes going on overnight trips (about a week) in buses and most likely participating in team sports and spending about $200 having travelled longer distances of about 300 kms. | 3                   |
| **Costly Cottage/Camping trips**    | Represents trips (with frequency of two) consisting of mixed generation of adults in groups of two from different HHs with high levels of spending (over $400) and lower kilometers travelled (about 150 km) on cottage, camping, or boating trips of about two nights in private cars. | 3                   |
| **Seniors with Medical Appointments** | Trips (with frequency of one) consisting of low income low educated seniors travelling in groups of about three or in pairs on same-day or overnight shorter trips (about 100 km) with private cars or buses with light levels of spending (about $80) and having no or little activities such as shopping and going to medical appointments. | 3                   |
| **High Educated Multiple City Visitors** | This grouprep represents high educated outdoorly visitors (in groups of three or more) on higher budget trips (about $500) involving visiting more than two locations along the way having travelled about 200 km and spent two nights using travel modes such as RVs and private cars. | 2                   |

Table 3: Clusters Found in the 2017 (TSRC) (AB) to (AB) Trips at 68% Confidence Level
Figure 2: 3D Representation of 10 Clusters Across a few Key Dimensions: Household (HH) Members on the Trip, Travelling Group Size, Total Nights Away from home while on Trip, One-way Distance from Home in km, Trips Frequency, Total Amount of Spending while on Trip in 2017 $CAD

| Class | Label                                      |
|-------|--------------------------------------------|
| 1     | Short Economical Getaways                  |
| 2     | Same Day Shopping                          |
| 3     | Personal Business                          |
| 4     | Visiting Friends and Relatives (VFR) Trips |
| 5     | Business/casino Trips                      |
| 6     | Team Sport Players                         |
| 7     | Snow/Festival Loving Young Families        |
| 8     | Costly Cottage or Camping Trips            |
| 9     | Seniors with Medical Appointments          |
| 10    | High Educated Multiple City Visitors       |

Figure 3: 2017 (TSRC) (AB) to (AB) Trips (AHC) Ward’s Dendrogram

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