Identification of Factors Contributing to Geographic Scale and Mode Choice of Long-Distance Travel

by

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A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
August 02, 2014

Keywords: Long-Distance, Travel, Geographic
Scale, Multinomial Logit

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ABSTRACT

As long-distance travel increases it is emerging as an increasingly important consideration in transportation planning. Not only is this in response to an increase in magnitude but also in recognition that such trips possess a greater per person effect on the systems they utilize. However, as planning organizations begin to respond accordingly for such travel they have been confronted with the prospect of accounting for such travel with methodologies and data developed for daily travel. Unfortunately the behavior of long-distance travel differs drastically from that of daily travel and available data and procedures are often unable to provide the necessary means to develop meaningful models. Therefore, this paper develops a technique for long-distance travel analysis by developing a geographic scale and mode choice multinomial logit model. Use of this model, through the context of geographic scale, will provide a better understanding of the factors that influence long-distance trip making. Specifically, this study uses detailed long-distance trip diaries from the 2008 New Zealand Domestic Travel Survey to look at how household, travel party, trip characteristics, and scale affect where and how individuals make long-distance trips. Utilizing this approach, the transportation planning community will be able to better forecast travel trends and the demands placed on systems due to long-distance travel.

ACKNOWLEDGEMENTS

It is with the utmost appreciation that I would like to thank the following individuals, it is only through their support that this endeavor reached fruition. First and foremost, my loving wife April, her unwavering commitment provided me with the foundation upon which to achieve my dreams. It is through her that I found the strength and inspiration required. I would also like to thank the members of my committee, Dr. Rod Turochy and Dr. Dheeraj Raju for their dedication to the development of this project. Lastly I would like to thank my professor, Dr. Jeffrey LaMondia. His tireless guidance, patience, energy, and determination, provided an atmosphere built for success. It is to him that I owe the deepest of gratitude, fully acknowledging that without his trust I never would have had this opportunity.

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LIST OF ABBREVIATIONS

ATS	American Travel Survey
CAM	Commercial Accommodation Monitor
CATI	Computerized Assistance
CFD	Cumulative Frequency Diagram
CO_2	Carbon Dioxide
DCM	Discrete Choice Model
DOT	Department of Transportation
DTS	Domestic Travel Survey
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
HOV	High Occupancy Vehicle
IID	Independent and Identically Distributed
Km	Kilometer

LD	Long-Distance
MNL	Multinomial Logistic
MPO	Metropolitan Planning Organization
NHTS	National Household Travel Survey
NPTS	Nationwide Personal Transportation Survey
NTS	National Travel Survey
NZ	New Zealand
POV	Personally Owned Vehicle
RTO	Regional Tourism Organization
RTI	Regional Tourism Indicators
TA	Territorial Authority
TAZ	Traffic Analysis Zone
TMIP	Travel Model Improvement Program
UK	United Kingdom
US	United States

1. INTRODUCTION

Increasing economic prosperity, expanding infrastructure development, and integrated policy planning, have allowed populations of developed nations to enjoy growing mobility over the past few decades. The effect of such behavior has been tremendous. Set in a quid pro quo relationship with mobility, economic health is one area that has benefited directly, and many communities born due to proximity to a transportation network are testament to this fact. Yet such mobility comes at a cost; due to the vast scale of such travel, the supporting infrastructure requires continuous repair and construction, and environmental concerns have resulted in extensive financial investment to implement mitigation strategies. While transportation engineers have been able to account and prepare for most of the US' growing travel needs, much work has been focused on daily travel alone. Long-distance travel has also experienced tremendous growth in duration, extent, and frequency, but our understanding of this travel is still lacking to adequately inform our planning decisions and forecasts (Frändberg and Vilhemson 2003).

The impact of long-distance travel is becoming ever more pronounced. In fact, tourism, an industry heavily represented by long-distance travel, now represents the largest industry in the world (Lise and Tol 2002) and accounts for over 11% of the GDP in the European Union alone (LaMondia et al 2010). As a result, non-daily travel behavior is no longer able to be discounted as insignificant. Failure to account for it, especially in consideration that such growth is expected to continue, will result in inadequate, and gross mismanagement of, resources.

Response to shifting behaviors, from that of almost exclusive daily travel to substantial representation by long-distance travel, has been slow. Within transportation planning, daily travel has received extensive attention, as has the long-distance transportation of freight. Yet the endeavor to fully understand long-distance personal travel remains relatively young, only recently beginning to receive the attention it truly deserves. Without effective knowledge of such behavior, and an understanding of how to manage and implement this knowledge, the largest transportation network may also be the least effective. Investment of resources into the understanding of long-distance travel has become warranted for a number of reasons, all mentioned above. Yet, until such effects become fully recognized a true assessment for the impacts of such travel will remain underestimated.

Hindering development of a thorough understanding of long-distance travel behavior is the lack of a unified approach to defining long-distance. Often, definitions are simply based upon past practice instead of an investigation of the specific context in question. Both the subjectivity used in deciding how to define and reliance upon past definitions are cause for concern, allowing for the introduction of less than appropriate thresholds. Current definitions differ in numerous ways, including distance variations approaching hundreds of miles, inclusion of mode components, and incorporation of temporal factors. Table 1 briefly outlines the current breadth of definitions used to characterize long-distance travel.

Table 1- Long-Distance Definition (Zurich and Frei 2008)

DATA SOURCE	LONG-DISTANCE DEFINITION
Census Switzerland	3 or more hours
Italian National Travel Survey	20 km (12.4 miles) or more
U.K./ U.S. National Travel Survey	50 miles or more
French Nation Travel Survey	80 km or more (as the crow flies)
Dateline (Europe)	100 km or more (as the crow flies)
European Tourism Demand Survey	One overnight stay

The majority of thresholds used a distance in the 50 to 100 mile range. The U.K. National Travel Survey definition of long-distance travel as 75 km (46 miles) or greater (Dargay 2010) was similar to American distance-based definitions, consistently hovering between 50 and 100 miles. Earlier American surveys, such as the NPTS and ATS, used a 100 mile threshold while more recent surveys used a shorter distance of 50 miles. One such example of this is the NHTS (DOT 2011). Yet as exhibited by Table 2, these distance-based definitions did not directly match to any long-distance personal travel patterns.

Table 2: Average Person Trip Length (Bricka 2001)

Geographic Level	ATS (miles)	NPTS (miles)
NATIONAL	515	510
MASSACHUSETTS	610	525
NEW YORK	705	1,099
OKLAHOMA	392	220

Table 2 illustrates the variation present across regions in many of the surveys. These numbers represents data obtained in the both the NPTS and ATS, conducted in 1990 and 1995 respectively, in which long-distance travel was defined as 100 miles or above. It demonstrates that although trips considered were all above 100 miles, the average person trip length for long-distance travel in America was above 500 miles. Additionally, depending on the survey, vast differences were observed between trips originating at the national and state levels. For example, of all long-distance trips considered nationally the average length was 510 miles. However, for the same pool, trips originating from the state of New York more than doubled that average. This demonstrates not just the significant differences long-distance trips may contain in regards to distance thresholds, but especially as they relate to a threshold from an aggregated geographic level.

Despite such variations in long-distance thresholds, all are geared towards capturing a single component, a measure of scale. Whether it is through distance, temporal, or mode, all approaches attempt to measure some degree of proximity that differentiates between local travel behavior and long-distance travel behavior. Yet data collection efforts utilizing the above mentioned approaches, in addition to creating transferability barriers, fail to adequately account for the vast variations in impedance within, and between, regions. Alternatively, by using geographic regions as a measure of scale, researchers are able to avoid transferability based upon definition of scale and simultaneously capture impedance within a regional context.

Furthermore, the contexts of geographic scale and mobility shift dramatically within the long-distance literature depending on the specific location and trip purpose being considered (Schwanen et al 2001). As such, a single definition of scale is not appropriate for all endeavors. For example, using a threshold applicable to a MPO for a major metropolitan area, interested in impact to local infrastructure regardless of purpose, may not necessarily be adequate for use by the tourism industry interested in the factors that will draw business based upon leisure. In other words, each trip is not created equal and impedance is different according to the context of the trip. Areas in which travel is conducted have different forms and degrees of travel barriers. Some are physical such as a lack of infrastructure or lodging. Some are specific to the trip-taker such not having access to a specific mode (Limtanakool 2006).

For the consideration of travel behavior to be complete, geographic scale according to regional boundaries must be combined with mode and destination components. This is required, but often overlooked, in order to fully understand infrastructure and policy behavior response. According to the Bureau of Transportation Statistics, nine out of ten long-distance trips are conducted using a personal vehicle and almost all others are accomplished using air travel

(USDOT 2014). However, the behavior represented within each of these modes is drastically different. Without a proper understanding of these modes as they relate to the traveler and their region, any insight gained may be misleading. Similarly, results obtained without proper consideration of destination would also fail to properly convey travel behavior. Incorporation of destination considerations is critical as they allow a complete picture of what is drawing a visitor to an area. Without this, researchers may be able to ascertain a purpose, but such a determination is useless without understanding why that purpose motivated travel to that region. For example, planners attempting to account for tourism travel to a region are ill-equipped to act if the only knowledge they possess is that the trip was drawn to the region for the purpose of holiday travel. By expanding considerations to include measures of demographic characteristics, economic health, recreation resources, and accessibility, proper steps may be taken to plan policy according to the specific motivators influencing such behavior.

Also important for proper consideration of scale, yet often overlooked, is the definition of destination. Different objectives dictate different requirements for geographic scale. For example, an understanding of behavior according to high speed rail policy and infrastructure may require a different definition of destination than an investigation into tourism behavior. Many approaches currently aim to accomplish this; however, from a practical planning perspective, it is more important to understand long distance trips according to scale, (i.e. within an area, in an adjacent area, or farther out). Whether it is in the interest of developing a larger long distance modeling framework or in support of specific urban area, understanding geographic scale is critical. Additionally, a proper understanding of how this scale interacts with trips and travelers according to different modes is also required for transportation planners to effectively develop policy and infrastructure.

Therefore, this thesis develops a unique region- and ringed-based discrete choice model to predict households' preferred joint geographic scale and mode choice for different types of long-distance travel. It examines the ability of geographic scale combined with mode considerations, rather than a linear distance-based definition, to more accurately incorporate long-distance travel into regional transportation planning and forecasting analyses. This work considers the impact of household and travel party characteristics, along with readily available census data for origin-destination pairs, to predict magnitude of long-distance trips at a household level. Models in which destination/mode choice pairs have been analyzed as a product of trip, household, travel-party, and geographical based characteristics, or a combination thereof are not new (Yang et al 2010). However, when these models have been developed, they have lacked proper consideration of destination attraction considerations (Bhat et al 1998). In consideration of this, the following work develops a joint long-distance geographic scale and mode choice multinomial logit (MNL) model to understand the factors that not only influence long-distance trip making, but also the travel that falls within different geographic limits.

The following thesis begins with a discussion of past work through a literature review. In this section, past work concerning transportation planning is explored with a specific focus on long-distance travel, geographic scale, mode choice, and destination definitions. Following the literature review the methodology utilized for this project is introduced. In this section, the reader is provided information on the model type and structure utilized and the reasons supporting such a decision. The methodology section transitions into model estimation in which model results are presented. In this section, independent variables are discussed as they relate to the dependent variable, that is, the scale/ mode choice represented, and the meaning of such results. In closing, the research is summarized and resulting conclusions presented. It is in this section that the specific findings are presented and discussed in detail.

2. LITERATURE REVIEW

2.1. Characterizing long-distance Travel

Long-distance travel is still underrepresented as a comprehensive consideration in transportation modeling within the United States, especially long-distance modeling that incorporates geographic scale and mode based considerations. However, a developing recognition of the importance of such behavior has been spurring the emergence of related research. Due to the infancy of such endeavors, when it has been attempted, the effort to model such travel has been met with substantial obstacles. Primarily amongst these are the limited data sources available to account for long-distance travel. Additionally, when they are available they often characterize long-distance travel according to a distance based threshold. Occasionally purpose (such as excluding commute-trips) (United States 2013), temporal (Andreas 2008), or mode-based definitions (such as automatic long-distance categorization for air travel) (Dargay 2010), are utilized in conjunction with distance for defining long-distance travel. Yet, almost non-existent are thresholds according to geographic scale. The dominance of such distance based data is understandable, it is relatively easy to acquire, explain, and in many instances provides adequate information for simple analysis. However, Yang et al (2010) points out that developing long-distance models structured according to distance alone does not address topics such as inter and intra-regional trips, both significant and unique in their characteristics, especially as they relate to rapidly changing regions. Some agencies have responded to such concerns and defined trips according to the crossing of boundaries (Mokhtarian 2001) but these have been relatively limited.

Not surprisingly, many of the mathematical models used to study personal daily travel can be applied to understanding long-distance travel behavior. However, models of geographic scale are not as common in the transportation literature, more often found in migration and animal-behavior studies. Utilizing methodologies developed for individuals of a species, such models have also proven accurate in predicting the scale of travel for human travel. In such models the probability of length frequency for geographic scale to a certain point is able to be predicted. However, these models generally are better suited for shorter distances and obviously lack many of the considerations applicable to human behavior such as increased ability to travel further and more often due to freedoms allowed through technology and infrastructure (Brockmann et al 2006). Additionally limiting was that implementation of this model was accomplished using tracking of individual currency bills. A unique, and subsequently proven, approach but one that lacks the ability to directly account for trip, household, and person based characteristics. Such an approach also fails to consider the transaction of bills between individuals between location identification periods. The work was able to provide valuable information on general flows of bills, but failed to directly connect the dispersion to individual trip-takers and trips. However, the study did account for limited regional characteristics in which the bill first appeared in the tracking system allowing for consideration of some region specific traits. From this research two thresholds were observed, 10km (6.2 mi) and 800 km (497.1 mi). These thresholds corresponded to a positive linear relationship between the probability and distances prior to 10 km and a negative linear relationship between probability and distance above 10 km.

2.2. Definition of Scale

Much of the research examined in which travel was defined according to geographic scale of trips was often limited to constrained areas, resulting in more localized considerations and the exclusions of many travelers and trips into or out of a region. For example, in an effort to model traffic demands within a city, distance-based definitions often are structured relative to the extent of a city boundary. Consequently, in regards to use of boundaries, there is debate on how a geographic scale should be defined. Currently, arguments exist for defining long-distance travel according to both political boundaries, such as state, and behavioral boundaries, such as tourism regions. This is especially true in consideration of travel impedance. The concept, as it relates to long-distance travel, does not apply equally to all individuals or trips. Characteristics such as gender, age, and income, all change the manner in which a long-distance trip is defined. Men tend to travel farther than women; age negative corresponds to travel time; and a higher income corresponds to longer trips (Yang 2010). However, it is also observed that despite extensive insight into many of the relationships between individual socio-demographics and complete destination choice behavior, many remain relatively unstudied. Of these, a lack of knowledge exists on the effect of trip-taker occupation on destination choice, rather than simply work destination choice.

The majority of research that was found to include geographic scale as a dependent variable was done so at the most basic of levels: domestic and international trips. As observed in Table 3, categorization of geographic scale in identified research was able to be accomplished according to three labels: “By Border”, “By Type”, and “By Structure”. Well over half of these fell within the “By Border” classification with all but two research endeavors defining scale according to a national boundary. Lang et al (1997) examined destination choices of travelers according to country and an “Asia-Pacific”. The research did prove productive in realizing the effect of a number of trip and traveler factors yet did so at an aggregated level without consideration of destination characteristics. Bieger et al (2002) sought to differentiate domestic pleasure travelers from international according to tourism sector utilized. Lise et al (2002) sought to utilize linear regression to predict the number of foreign travelers to a country based upon the size of the country and climatic data. Nicolau et al (2005) developed a nested model in which geographic scale was the second nest below the most basic of decisions, to take a vacation. In this approach, if the trip taker did decide to take a vacation then the model would determine if the vacation was foreign or domestic in nature. Within the scale component node frequency was predicted. In his work *The Role of Routines In The Vacation Decision-Making Process of Dutch Vacationers,* Bargeman et al (2005) examines the effect normalization of vacation travel has on the domestic/ international travel engaged in. For example, if travelers have developed a pattern of routine travel are they more inclined to engage in domestic travel or international travel? Beerli et al (2007) utilized a more empirical approach attempting to predict domestic versus international travel according to differences between a destination’s image and the travelers own perception of the destination. Deviations from the dominance of national boundaries to define geographical scale according to boundaries are McFadden (1978) and Boarnett (2005). McFadden’s research (1978) attempts to predict housing location according to self-defined residential zones, however, the zones were determined to be too specific for effective calculations with available resources. Boarnet et al (1995) attempted to test the relationship between local (county level) infrastructure development and economic health according to county and state based thresholds. Four projects were identified in which scale was predicted according to type. Handy et al (2002) sought to predict travel behavior according to three unique scales based upon mode: human scale, automobile scale, and airplane scale. The remaining research within this classification, Yang et al (2010), Bhat et al (2008), and Jie et al (2014) all deviated from the multi-scale approach by utilizing a single scale the varied according to characteristics as the dependent variable. For example Yang et al attempted to predict destination according to traffic analysis zones but did so according to the type of zoning code such as residential or commercial. This allowed for extensive level of detail but limited consideration of scale. Bhat et al and Jie et al also utilized small scale zones according to type but, again, in doing so eliminated proper consideration of scale. Lastly, Lew (2002) attempted to predict geographic scale according to the type of destination, according to whether it was singular or a gateway in nature. Using these thresholds allowed for compilation of minute regions according to singular, or extensive chained regions if multiple gateways were determined. Such an approach, while unique, due to the vast array of possible outcomes did not provide adequate structure to fully incorporate destination based characteristics.

Inter-regional and intra-regional travels tend to demonstrate different behaviors as a result of the constraints and freedoms particular to each (LaMondia and Bhat, 2008, Jansen-Verbeke 1995). Inter-regional travel, for example, is primarily motivated by activities unique enough to warrant the additional cost and time required to travel further. In other words, activities such as holiday travel allows for greater inter-regional travel for the purpose of visiting attractions (Pearce et al 1993). Alternatively, intra-regional travel tends to include activities that fit within the time and spatial constraints of a typical day. Despite the unique travel behaviors associated with each scale, efforts to identify models in which interregional or intraregional personal trips are estimated yielded minimal or outdated results (Dredge 1999). McFadden was on the forefront of this effort, when in 1978 he applied economic theory of choice behavior into analysis of residential zones and while more current work does exist, it often does so in the shadow of other endeavors.

Many current efforts to model this behavior rely on procedures developed for daily travel and, as discussed above, often using distance or some combination with mode or time thereof as the definition of a long-distance trip. At first glance this appears to be an obvious decision, however long-distance trips inherently have unique demands on the trip-maker and a distance threshold definition may not translate to the same amount of resource required by each user, be they financial, temporal, or accessibility. This makes it difficult to properly consider factors unique to long-distance travel (Van Nostrand et al 2013, Rohr et al 2013, Yang et al 2013) using mainstream practices. By ignoring geographical scale based considerations, defining travel by zonal considerations, models severely limit their consideration of location-based characteristics and region-based applications. In support of this, the 1995 TMIP, under the guidance of the FHWA, FTA, EPA, recommended that long-distance travel be studied relative to discrete geographic scales rather than a continuous measure of distance (Waddell 2002). Since then, much work in the field of freight forecasting has focused on geographic-scale based forecasts of demand (Hesse et al 2004, Boarnet 1995), but the research pertaining to long-distance geographic scales in personal travel is rather limited (Dellaert et al 1998; Handy et al 2002). Zhang et al (2013) furthered the argument, demonstrating utilizing a geographic scale based definition, structured according to individual behaviors, would enable a reduction in false reads within discrete choice models. This would be enabled through an added degree of selectiveness through individual patterns interacting with boundaries. Furthermore, as the use of geographic scale increases, so too does the potential for improved planning beyond the context of selfselected boundaries. Transportation organizations responsible for planning may gain a better understanding of behavior within their jurisdiction as considerations are expanded to include not only geographical areas within the area of responsibility but other geographical areas that may influence the area under consideration.

The Michigan Department of Transportation 2009 Household Travel Program provides an example of alternative distance-based long-distance definition with a geographic scale component. This survey defines long-distance trips as approximately 100 miles or greater. Additionally, within the long-distance category trips were classified according to a basic geographic scale: “Within Michigan”, “Neighboring States”, and “Other States or International” (Michigan 2009). Utilizing these classifications during consecutive surveys allowed researchers to identify an increase in “Within Michigan” trips at the expense of “Other States or International” trips and created an opportunity to develop a model that accounted for an increase in inter region travel. This trend was a continuation on the part of the State to include geographic scale in model development stemming from previous success in such endeavors. As early as the 1970 Michigan’s Statewide Travel Demand Model incorporated 2,307 in state zones and 85 outstate zones (Nellett 1996) to improved long-distance components of forecasting models.

The use of boundaries as scale components in models, incorporated with measures of the characteristics contained within such boundaries would capture physical constraints and other influences affecting mode choices specific to a location. For example, Moeckel et al (2013) distinguished between areas by incorporating zone identities in model considerations. In considering zonal effects, models were able to successfully account for unspecified attributes in mode selection, such as a regional presence of HOV lanes. This approach is feasible in the United States and other developed countries. Yang demonstrated in consideration of TAZs that those with TAZ purpose with highest employment per are unit also had the highest draw from surrounding areas (2010). The U.S. Census (U.S. Department of Commerce 2010) for example provides extensive characteristics of specific areas according to Region, Division, or Tract. However, limited surveys directly account for such areas. Of the geographic boundaries that are accounted for in data collection and research efforts, as observed in Table 3, much diversity is present. All definitions do adhere to Yang's observation that scale based definitions are developed using five factors: size, location, structure, physical barriers (such as coastline), and distance in relation to origin (2010). Interestingly, size assignments in select cases were determined based on trip purpose. For example, for trips conducted for the purpose of employment, zonal employment was used to denote size; shopping trips determine zone sized based upon retail employment. Additionally, zonal structure was often defined by concentric, regions. Impedance due to factors specific to the trip taker must also be accounted for when considering scale. Yang reinforced the belief that gender, age, and income correlated to impedance, age negatively and income positively.

Table 3: Definition of Destination

ENTITY	DEFINITION OF DESTINATION CHOICE
BY BORDER	
Lang et al (1997) Biegeer et. Al (2002) Lise et al. (2002) Nicolau et al (2005) Bargeman et al. (2006) Beerli et al. (2007)	Country
McFadden (1978)	Residential Zone
Boarnet (1995)	State County
BY TYPE	
Handy et al. (2002)	Human Scale Automobile Scale Airplane Scale
Yang et al. (2010)	TAZ by purpose Education TAZ Administration TAZ Commercial TAZ Recreation TAZ Sport TAZ Medical TAZ Industry TAZ Park TAZ
Bhat et al. (2008)	Zones built upon spatial clusters
Jie et al. (2014)	Neighborhood Type Urban Elite Non-Hispanic Urban Black Low-Income City Minority Suburban Young Suburban Retired Middle-Income Suburban Working Class Suburban Wealthy Non-Black Hispanic Rural Natural Scenic
BY STRUCTURE	
Lew (2002)	Single Destination Gateway Destination Egress Destination Touring Destination Hub Destination

Geographic scale of trip, for the purpose of this study, is defined as trip extent, ranging from trip entirety remaining in local area to extending beyond, or remaining within, multi-level regions defined upon New Zealand tourism and political boundaries. This definition is more in line with those found in studies conducted by Pearce (1995) during analyses of tourism boundaries to investigate travel behavior. Despite these diverse approaches, a deficit continues to exist in incorporating scale-based measures into planning considerations (Hesse et al 2004). Furthermore, the use of boundaries as scale components in models, in a tiered structure such as division, state, and county, would capture not only the effect of scale on travel but also physical constraints and other influences affecting mode choice. For example, Moeckel et al (2013) distinguished between areas by incorporating zone identities in model considerations. In considering zonal effects, models were able to successfully account for unspecified attributes in mode selection, such as a regional presence of HOV lanes.

2.3. Destination and Mode Choice Factors

By incorporating mode choice into destination choice considerations, accessibility and impedance are able to be considered. This is important, as studies have demonstrated (e.g. Yang 2010), this allows for a more behaviorally-accurate representation of the true decision of destination choice and ease of mobility. Additional support for the inclusion of mode choice consideration in conjunction with scale improving resulting models is Ben-Akiva's et al 1985 book titled *Discrete Choice Analysis: theory and application to travel demand*. In this work with Lerman, Ben-Akiv develops a joint mode destination model in accordance with sample of alternatives theory.

Past research has demonstrated that decision makers utilizing flexible modes of travel (i.e. motorcycle and car) are more sensitive to impedance than those using inflexible modes such as train and air (Yan 2010). Such observations equate to flexible modes correlating to shorter travel distances over the entire spectra of purpose, and trip-taker characteristics. In such research it has been found that mode choices are highly correlated with travel distances (Hagen-Zanker 2013). Additionally, de Lapparent et al (2013) argue that for linked long-distance trips, relative to short-distance trips, traveler's mode choice decisions are more sensitive to travel times to main-modes of travel than on the main modes themselves. This specific example indicates a greater willingness to pay more for specific mode choices during long-distance travel as opposed to short-distance travel. Explicit attempts to model mode choice commonly employ logit discrete choice models (Hagen-Zanker 2013, Whalen 2013), multinomial probit discrete choice models (Can 2012), or linear regression models (Friedrichmeier 2013). In all observed mode choice models distance was a variable considered during model development. In addition to distance, Lehto et al (2004) demonstrate mode choices are significantly influenced by prior experience. Additionally, travel decisions are largely "reasoned decisions", affected by planning and policy decisions (Bamber et al 2003). This attribute of travel behavior indicates that, when considered in planning, future geographical scale and mode choices of personal travel may be better guided by planners aware of individual motivators much as they are by past habits. As such, it is important to consider these decisions in tandem.

Among trip characteristics identified in existing research, trip purpose was presented most often. Yang et al (2010) examined it according to shopping, recreation, and business. Notably absent from this list but included in almost all others was travel for the purpose of visiting, friends and relatives. Although not specified it is possible this may have been included under the classification of recreation. However, other research examined noted the differences between visiting friends and relatives and other recreation travel. Also commonly considered as was destination type, Whitten et al (2011) explored this concept thoroughly in her examination of destination and travel modes. However, unlike many other endeavors, in her research Dr. Whitten also incorporated the day of the week travel occurred in determination of scale and mode. While such a consideration was uncommon, it did prove significant in her research by capturing cyclical travel behaviors occurring on a weekly basis. In other words, in the context of her work, examined behavior adhered to trends established by weekly schedules.

Party characteristic exhibited much less variation between examined research than that of trip characteristics. These characteristics tending to capture four basic measures: travel party size, age distribution, gender distribution, and relationship. While all contribute to the scale of travel to some extent, party size corresponds to scale in the most direct manner, decreasing the likelihood for increased scale as party size increases (Yang 2013). Age, while not shown to directly correspond to scale, was shown to possess affinity to specific regions (Lin2008) (Bhat 1998). Sex, remarkably, did demonstrate significance on travel scale in multiple instances. In studies in which gender was considered it was shown males tended to travel more often and farther than their female counterparts (Bhat 1998) (Whitten 2011) Relationships of travel parties were also shown to effect scale. LaMondia et al (2010) demonstrated that trips taken alone or accompanied by young children were more likely to remain in close proximity to the trip origin (LaMondia 2010)

Household characteristics included income (Yang 2013) (LaMondia 2010), size, vehicle count, and tenure (Lin 2008). In his research on traveler behavior in the context of vacation travel Dr. LaMondia (2010) demonstrated income directly correlates to mode choice. Lower incomes, those in the bottom quartile, were more likely to conduct travel using surface transportation. In contrast those in the top quartile of household incomes were more likely to utilize air travel. Past research has also demonstrated that the more vehicles a household owned the greater the frequency and extent of travel that will be undertaken.

Of characteristics utilized to capture regional measures, Yang et al (2013) demonstrated significance in employment according to occupation, population density, and land use. All three were shown to significantly impacted destination choice of travel. Additionally, in research conducted by Lin (2008), population density, housing density, road density, transit, intersection density also proved effective in prediction of travel to geographic areas. In regards to employment characteristics, Bhat et al (1998) demonstrated regional employment positively correlate to travel to a region.

The following research develops a unique region- and ringed-based discrete choice model to predict households' preferred joint geographic scale and mode choice for different types of long-distance travel. The geographic scales considered in this study are smaller than all past research: travel within an origin, to an adjacent region, and to a non-adjacent region. This allows for two outcomes: first, regions are structured according to geographic "rings" allowing for direct incorporation of scale, second, destination characteristics may be developed. Second, these choices are predicted according to characteristics based upon household, travel party, trip, and regional characteristics. The specified methodology improves upon past research in four areas. First, structuring geographic zones according to concentric regions is unique and allows for direct consideration of both scale and zonal characteristics. Second, the scale of travel behavior presented in this research is smaller than that provided in other endeavors. This allows for greater level of detail and a more complete understanding of travel behavior. Third, an extensive use of policy variables, enable through zonal structure, allows for a better understanding of the factors that motivate visits. Lastly, the research effectively and thoroughly considers trip, traveler, household, origin, and destination characteristics simultaneously in the determination of scale and mode choices.

3. DATA SOURCES

This thesis utilizes a unique location-based long-distance household travel dataset from New Zealand (along with supporting policy-oriented regional characteristics) to analyze long-distance trip geographic scale and mode choices. While some long-distance travel datasets exist within the United States and Europe, they are limited for such an analysis for a number of reasons, including the lack of detailed geographic origin and destination identification, either small or too large geographic extent of trips cataloged, and relative age of the datasets. This section describes the data collection process and summarizes the travel data used in the geographic and mode choice modeling analysis.

3.1. Defining Geographic Scale and Mode Choices

Geographic scale, as mentioned in the literature review, can be defined in various ways. Table 4 presents the geographic scales available for analysis within New Zealand's travel surveys. For information of the characteristics contained within specific datasets please refer to Appendix A.

Table 4- New Zealand Geographies

COMPONENT	GEOGRAPHIC IDENTIFIER
Domestic Travel Survey	Place (Point) Territorial Authority Regional Tourism Organization Regional Council
Census	Place Meshblock Area Unit Territorial Authority Regional Council
Other Statistical Data	Place Tourism Flows Area Territorial Authority Regional Tourism Organization Regional Council

For this thesis, geographic scale is defined by travel within and between New Zealand's tourism regions, characterized by regional tourism organizations (RTOs). This was selected for the geographic scale because they represent one of the smallest planning decision-making scales, both in New Zealand and in the US, that have variable land uses and policies. In New Zealand, transportation planning for the country is primarily done with respect to the RTOs, which are similar in size and governance to the US' metropolitan planning organization regions.

The country, as observed in Figure 1, is separated into 29 RTOs, each roughly the size and operation of a large US MPO. RTOs comprise a self-funded organization dedicated to the market of their respective regions to both domestic and international visitors. Other than acting as a link between the tourism community and local governments, RTOs vary greatly in structure, funding, size, and focus. For example, Auckland RTO, the largest RTO, is established as a charitable trust; Gisborne RTO is a non-profit incorporated society; while Hawke's Bay RTO is a integrated RTO funded by administered fees. However, regardless of the structure, some degree of funding is often provided by local government or through membership fees administered to constituents within an RTO.

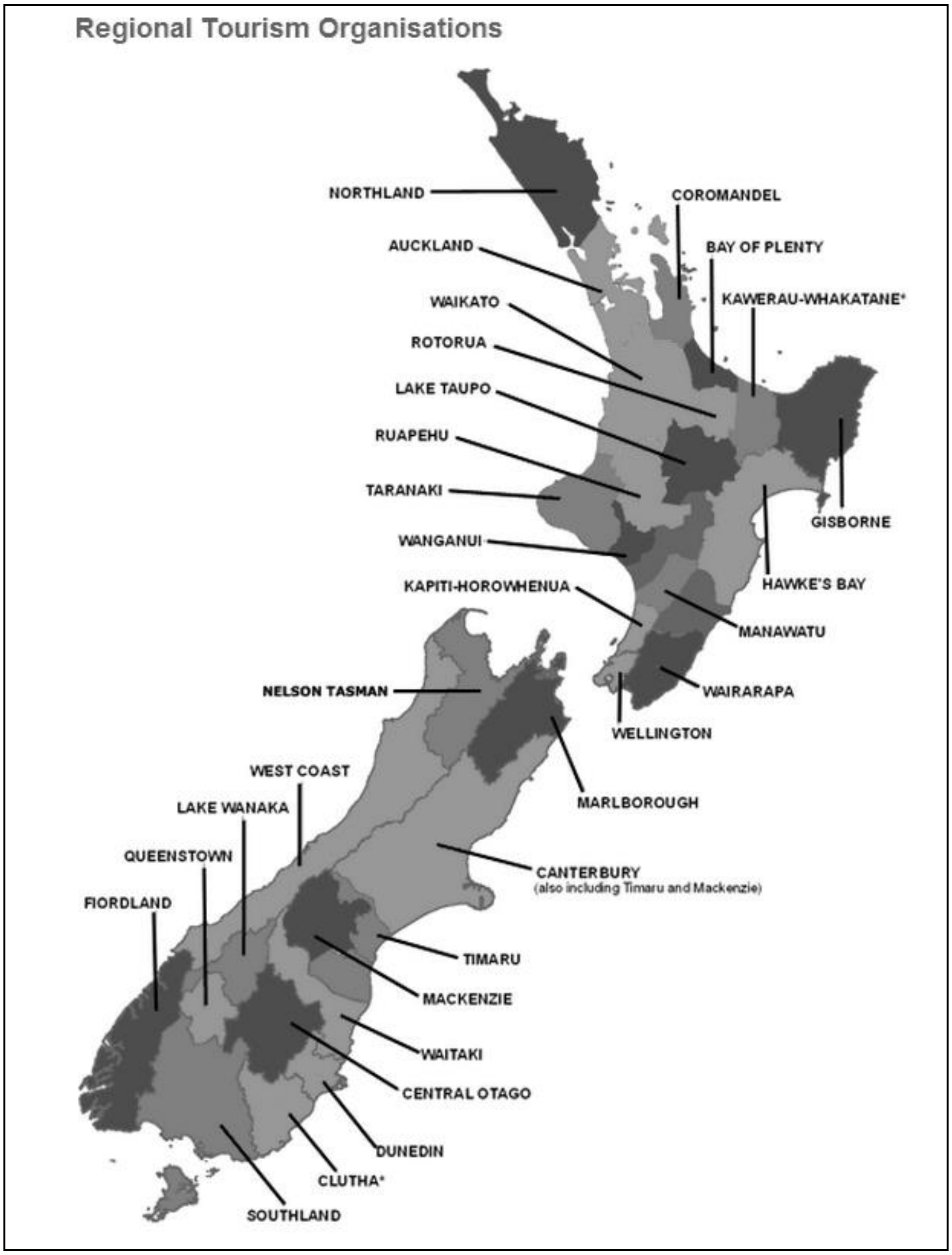

Figure 1: Regional Tourism Organizations

Mode choices are limited to driving, rail and air travel based upon analysis presented in Figure 2. In this cumulative frequency diagram (CFD) personal vehicles and air travel are shown to account for the vast majority of travel in the Domestic Travel Survey (DTS).

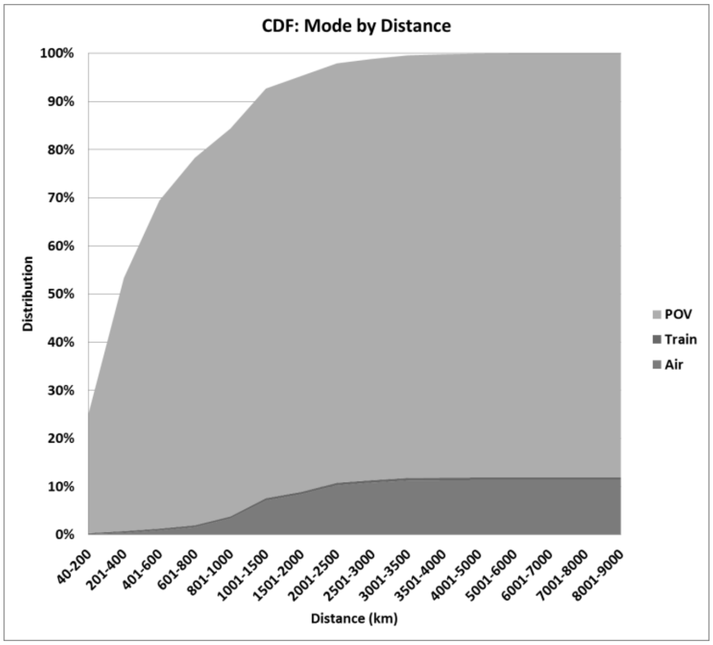

Figure 2: Mode by Distance

3.2. The 2008 New Zealand Domestic Travel Survey

The New Zealand Domestic Travel Survey is an annual survey conducted since 1981 with the exception of the 1991 to 1998 time period. Prior to 1991 the survey only accounted for overnight trips, however in 1999 the Foundation for Research and Science Technology (FRST) funded additional development of the survey resulting in expansion to include day trips of 40 km or more away from the home. The ongoing survey receives funding from the Government of New Zealand. Currently managed by the NZ Ministry of Tourism (previously the Office of Tourism and Sport), with data collection portions outsourced, the survey captures both leisure and work-oriented long-distance trips with domestic trip origins. The survey is conducted as part of the core dataset the Ministry of Tourism maintains in order to forecast travel demands. The dataset, as shown in Figure 2, also includes regional, international and commercial surveys.

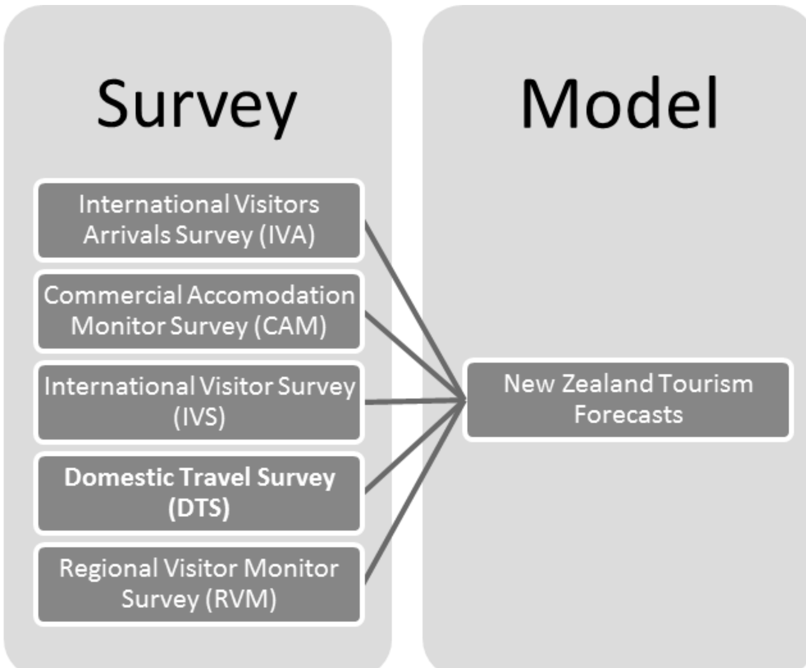

Figure 3: Ministry of Tourism Data

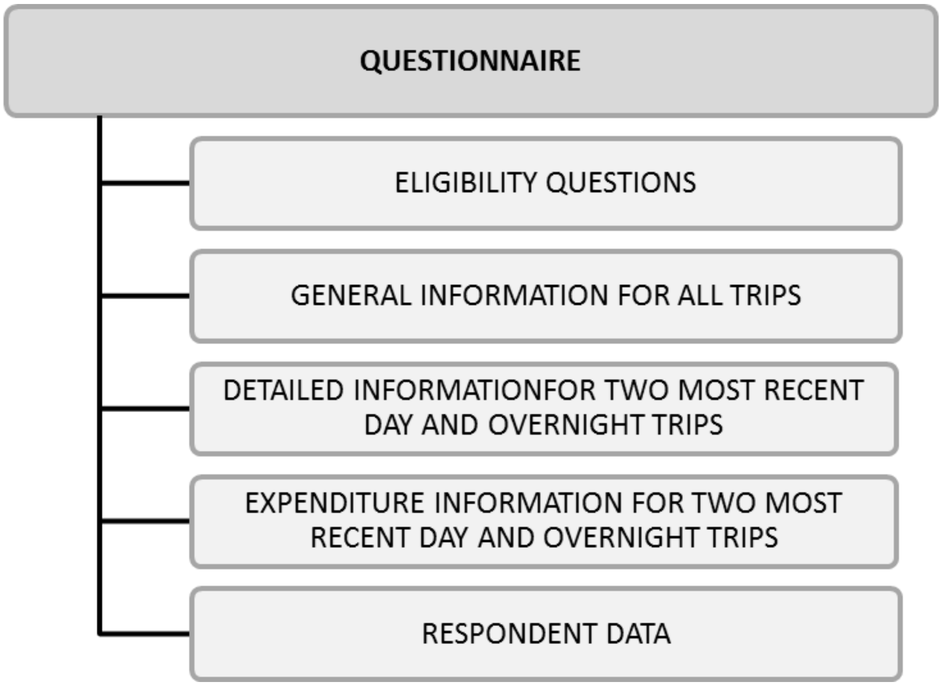

Figure 4: Questionnaire Major Components

The DTS reports quarterly on the characteristics, types, behavior, and expenditure of domestic travel. In addition to the behavior of domestic travelers, including expenditure, activity participation, demographics, and resources utilized. Quarterly domestic tourist expenditure reports and domestic trip reports are generated from this data. Responses regarding those trips completed over the past month (i.e. 4 weeks) are collected using telephone surveys with computer aided telephone interviews (CATI).

The DTS was selected for this study because it was a recent comprehensive and detailed long-distance survey that covered a large geography with many similarities with other countries, especially those in the developed world. Of paramount importance to this research was the determination of geographic scale, and specifically the fact that this dataset included very detailed identification of origins and destinations of the non-daily trips. Ultimately, upon crosstab examination of characteristics according to the scale, cumulative distribution figures (as observed in Figures 4 and 5), consideration of the scope and intent of the research, and the use of scale by the Ministry of Tourism for describing different planning jurisdictions and modeling travel patterns, the Regional Tourism Organization (RTO) was selected for definition of scale.

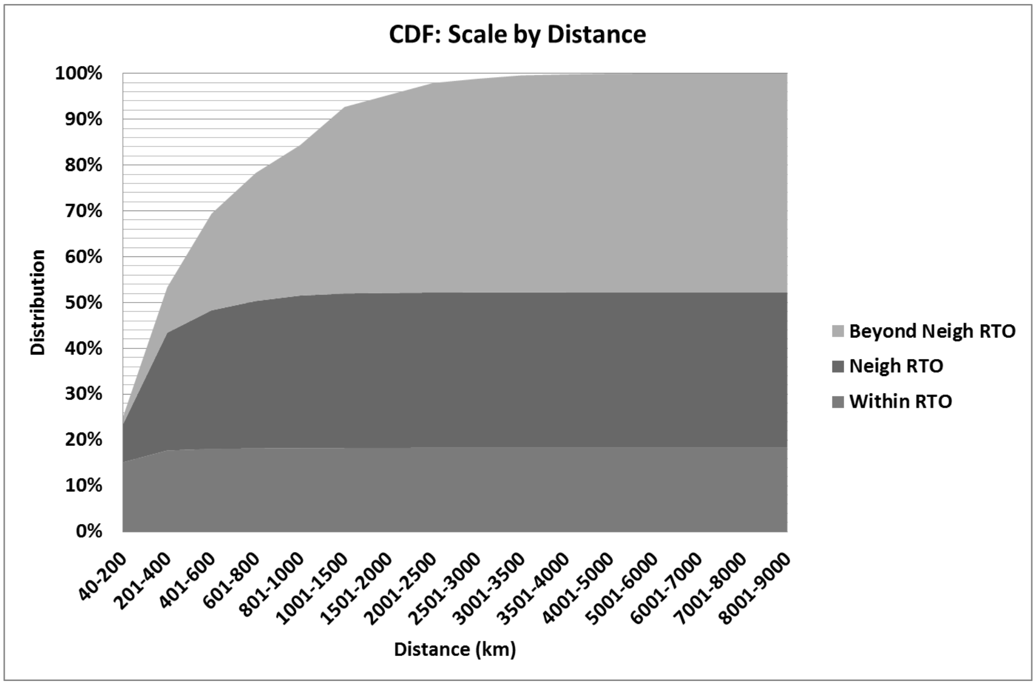

Figure 5: Scale by Distance

3.3. Supplemental Regional Characteristics

3.3.1. Statistics New Zealand: 2006 Census

The New Zealand Census is administered once every five years in order to acquire accurate data for government, non-government, and community groups to effectively plan and develop policy. Statistics New Zealand, a government department, is responsible for the collection, processing, and distribution of official statistics. New Zealand Census practices provide a paper form to every dwelling. However, the 2006 Census was the first census in which an online option was available to complete the census. As a result seven percent of the 3,160,371 responses were completed online. Although more recent census data was available, 2006 data was utilized as it was closer to the time frame captured in the 2008 New Zealand Domestic Travel Survey. This provided more accurate representation of characteristics during the behavior captured in the travel survey. The census provided gender, income, age, and education characteristics according to regions and territorial authorities. This data was readily available on Statistics New Zealand’s online database. Other than restructuring according to desired geographic scale (RTO then consolidated adjacent and non-adjacent zones for each trip destination) data processing was minimal. Data was able to be assigned to RTOs as these areas, for the most part, followed territorial authority (TA) boundaries. In cases in which this was not the case it was due to RTOs containing multiple TAs. In these cases the TA that comprised the majority of the RTO was selected as the controlling area. Following TA assignment to RTO classifications zones were developed.

3.3.2. Statistics New Zealand: Survey of Family, Income and Employment

The Family, Income, and Employment Survey, also collected by Statistics New Zealand contained information on employment, household, and income characteristics. Although updated annually as a longitudinal survey, the 2004 update was utilized for this research as surveys conducted closer to the 2008 time period covered in the Domestic Travel Survey were not complete. That is, they were missing significant characteristics that were available in the 2004 data. Although representing a smaller sample size than the census (hundreds of thousands rather than millions) it did provide a greater level of detail on the change experienced over time within characteristics. As with the 2006 Census data all datasets were available to the public on the

Statistics New Zealand online database. All zone and zone characteristics development was accomplished in the same manner as that used for census data.

3.3.3. Ministry of Business, Innovation and Employment: CAM

The Commercial Accommodation Monitor contained measures of accommodation usage according to Regional Tourism Organizations or Territorial Authorities. As this research developed scale based upon RTO definitions, TA data was not considered in analysis. The CAM dataset provided monthly measures of capacity, occupancy, and nights stayed according to lodging type (i.e. motel, hotel, or hostel). Datasets reflecting accommodation for 6,375 lodging establishments were surveyed across the entire country. All data was publicly available on the Statistics Ministry of Business, Innovation and Employment online database. Zone development did not require RTO assignment as these assignments were already in the data, however, zone characteristics did require development and was accomplished in the same manner as that used for census and Survey of Family, Income and Employment data.

3.3.4. Ministry of Business, Innovation and Employment: RTI

The Regional Tourism Indicator database provided expenditure amounts according to region for both domestic and international travel. As the scope of this study only included domestic travel, only the domestic data was downloaded from the publicly accessible Ministry of Business, Innovation and Employment website. Although not ideal due to the data reflecting a time not included in the travel survey, only 2012 data was available, dictating its use. Additionally, this survey is updated monthly and reflects the past four years. Therefore the 2012 database actual reflected a time period immediately following the behaviors collected in the travel survey and reflects trends that were already in place during the survey. As with the

Commercial Accommodation Monitor, RTOs were used for regional definitions, eliminating any need to assign such labels. These indicators simply reflected economic growth according to region but provided tremendous insight into the health and performance of an area. No modification was required for this data other than consolidating it with the other regional characteristics for addition to a master file.

In addition to trip, party, and household characteristics for each trip provided by the 2008 New Zealand DTS, Regional Tourism Organization characteristics were attained from multiple government agencies. This was conducted in order to enable identification and examination of RTO based characteristics influencing travel within Origin RTO, to neighboring RTO, and to a RTO beyond a neighboring RTO. Located through a collective database managed by the Department of Internal Affairs (New Zealand 2013), many of the characteristics located and utilized, highlighted in Table 5 were already aggregated to the RTO level.

Table 5: RTO Characteristics

AGENCY	SOURCE	CHARACTERISTIC
POPULATION AND SOCIETY		
Statistics New Zealand	2006 Census	• Age • Education • Household Composition[a] • Household Structure[b] • Employment by Industry • Employment by Type[c]
	Survey of Family, Income, and Employment	• Income (HH)
TOURISM		
Ministry of Business, Innovation, and Employment	Commercial Accommodation Monitor	• Nights stayed by lodging type
	Domestic Travel Survey	• Number of trips by purpose • Number of trips by length[d] • Financial transactions by type[e]
	Regional Tourism Indicators	• Expenditure[f]

[a] number of individuals in a household by role
[b] relationships present in the household respectively
[c] employment status (i.e. full-time, part-time, seasonal, or unemployed)
[d] categorized as either day trip or overnight trip
[e] categorized for retail, accommodation, food, tourism, and other transportation
[f] traveler change in expenditure between 2013 and 2008

For resources utilized that did not directly provide RTO level data, characteristics were calculated from component territorial authorities. In these cases the calculations were determined using mean values. Following determination of RTO characteristics, additional processing was conducted in order to allow for such measures to correspond to identified destination choices. This was accomplished by determining the neighboring RTOs, and the RTOs beyond the neighboring RTOs for every Regional Tourism Organization in New Zealand. In addition to this allowing for each trip to be classified according to scale, by comparing the origin RTO with destination RTO, it also allowed for a series of neighboring and beyond neighboring zones to be established relative to every origin RTO. Characteristics for each of these zones were determined using the median value for characteristics of contained RTOs. Categories utilized were selected based upon measures proven to be significant in past work or otherwise shown as lacking in previous endeavors on individual decision maker choices. However, other considerations were also included such as the manner in which the characteristic related to mobility.

The regional data, maintained by the Government of New Zealand, spanned a number of years ranging from 1996 to 2013. Additionally, as may be observed in Table 5, the collection and maintenance of the data pertinent to this study spanned two broad government agencies. Statistics New Zealand, New Zealand's official statistics office, consists of approximately 1000 employees effectively executing continuous operations for over 120 years. Its primary goal to "collect, compile, analyze, and communicate" numerous measures spanning the economy, environment, people and communities, and government activity (Statistics New Zealand 2014). The 2006 Census is part of a five-year census program conducted by Statistics New Zealand.

The Ministry of Business, Innovation, and Employment operates in order to assist economic development in New Zealand. It pursues this endeavor through assisting domestic business's grow productivity and become more competitive against foreign counterparts. Originally four separate agencies; the Department of Building and Housing, the Ministry of Economic Development, the Department of Labour (sic), and the Ministry of Science and Innovation; the Ministry collects, maintains, and analyses data in support of developing economic competitiveness (Ministry of Business 2014).

3.4. Compiling the Geographic Scale and Mode Choice Dataset

Final dataset development was accomplished by combining all datasets into a single master dataset. This original dataset included long-distance trips organized across three files describing households, trips, and visits (i.e. intermediate stops and side trips). As highlighted by Table 6, the final dataset was heavily representative of trips extending beyond RTOs boundaries and those utilizing personal vehicles as the primary mode. Despite the appearance of data skewed according to boundary, it is important to note these classifications are established by the New Zealand Government to manage tourism specific to those regions and instead reflects a perspective as it relates to influential factors within those boundaries. For example, the lopsided representation may be indicative more of attraction to new experiences rather than boundary definitions as they relate to scale.

Alternative-specific variables were calculated separately and merged into the trip dataset. Each trip's origin and destination RTOs were recorded in the survey, and the decision of travel "within origin region", "to adjacent region", or "to a beyond region" was identified from a master list of every possible combination of adjacent RTOs. Additionally, 29 sets of alternative-specific variables were generated for each of the origin RTOs. Once the adjacent and non-adjacent RTOs were identified for each origin RTO, the median characteristics of land use, economic, and demographic characteristics were taken to describe each set. Ultimately, each trip was identified according to scale (within origin, adjacent, or non-adjacent) and had geographic characteristics assigned that reflected the characteristics of the RTO of origin and destination according to the median values of the RTOs comprising that destination.

Table 6: Mode by Scale Cross Tabulation

Main Mode by Geographic Scale Cross Tabulation			
	Geographic Scale		
	Within RTO	Neighboring RTO	Beyond Neighboring RTO
Mode	Mode Choice Distribution	Mode Choice Distribution	Mode Choice Distribution
Personal Vehicle	5248	9658	10609
Air or Train	58	166	3217

The final dataset was developed with each case representing a single household trip (of which a single household may have completed multiple trips). Starting with 58,172 cases, 17,199 were removed from consideration as they did not meet the Survey's classification of 40 km for non-daily long-distance travel. An additional 12,017 cases were removed in order remove cases in which data was incomplete resulting in a final dataset contained valid responses for all contained variables. Of these 12,017 data was not ascertained for one of the following measures:

- Number of person trips conducted during period
- Housing Density
- Percent Renter Occupied
- Population Density
- Respondent Age
- Respondent Employment Status
- Worker Density
- Number of Adults in Household

The final dataset used in the analysis was comprised of 28,956 completed long-distance trips, with characteristics describing each household, home RTO, neighboring RTO and all other RTOs.

3.5. Characteristics of the Final Dataset

Figure 6 displays the national educational distribution of New Zealand according to the 2006 Census. “None”, representing those that did not finish high school or a trade school seems exceptionally high. However, it must be noted, that culturally the importance of a high school diploma does not contain the same stigma, or loss of employment opportunities, as other areas of the world. NZ has a robust apprenticeship program. In this program, in lieu of their final two years of high school, students may transfer to an apprenticeship program and begin training for a career in a trade industry. Also notable is 40% of the population reporting at least some education past a high school level. This is well under the 58% reported for the same statistics for Americans by the United States Census Bureau (2013). This too may be a result of the apprenticeship program, largely vacant from the American workforce.

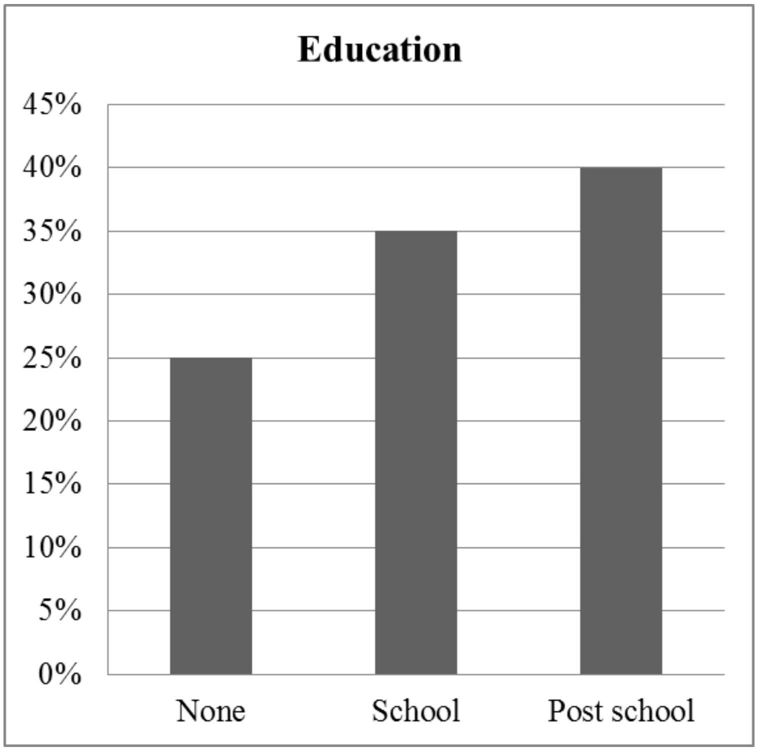

Figure 6: National Education Levels (New Zealand 2006)

Figure 7 represents the distribution of the New Zealand workforce according to industry. This figure demonstrates the heavy representation of administrative personnel in the workforce. Managers, clerical, and administrative employment represents approximately 30% of the entire workforce. Additionally, professionals represent 20%, which, in addition to technical employment, may represent some other administrative employment.

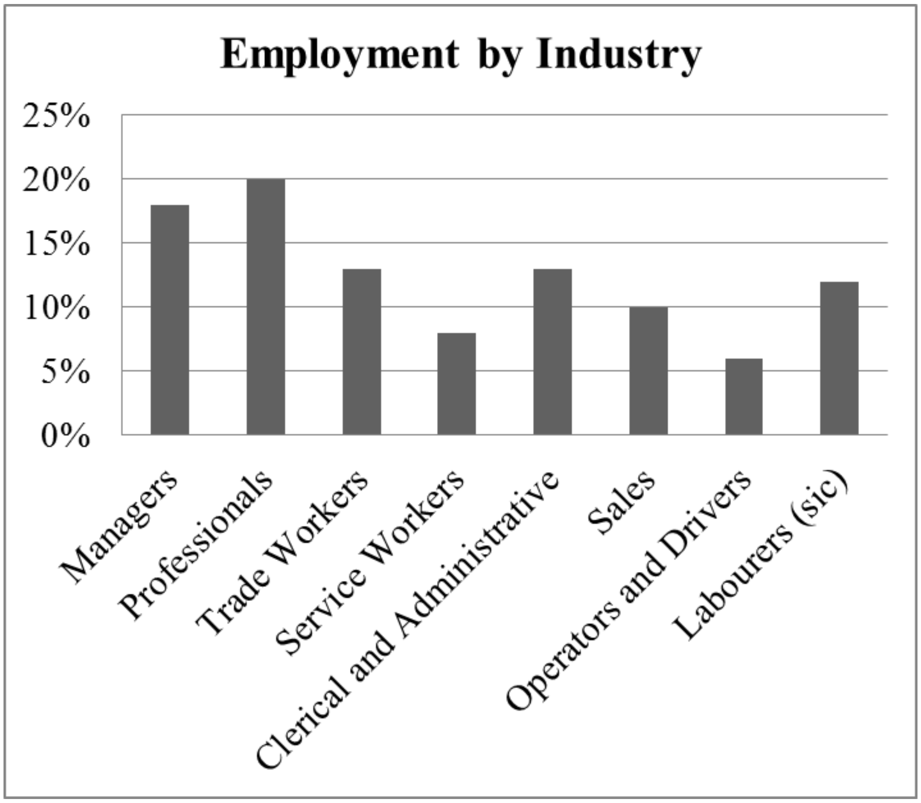

Figure 7: National Employment by Industry (New Zealand 2006)

Figure 8 represents the structure of all New Zealand families. It indicates that, of all the families, the vast majority (82%) are couples. Similarly, the majority (60%) have children. This leaves a sizeable 18% of all families conforming to a one parent with child(ren) structure. This is meaningful in the context of this paper in terms of the additional constraints this adds to long-distance travel. Couples without children are, independent of all other considerations, by far the best able to engage in long-distance trips.

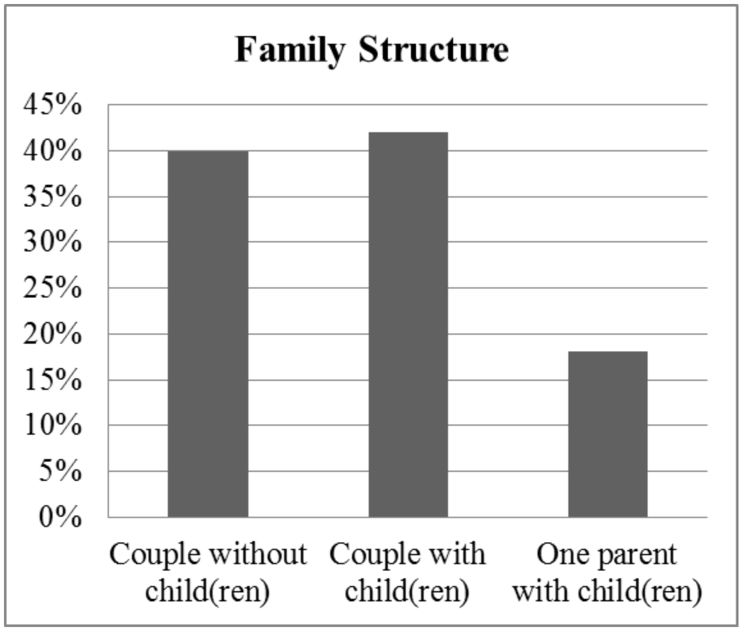

Figure 8: Family Structure (New Zealand 2006)

Figure 9 displays the income distribution for all New Zealand households. The distribution indicated demonstrates that, while a considerable group of households earn minimal incomes, the majority of NZ households earn a significant amount. In fact, two peaks may be observed in the distribution, one at $10,001 to $15,000 and the other at $50,001 to $70,000. Although it would be expected that higher incomes would lead to greater long-distance trip activity, this has not always been the case. Evidence seems to indicate this is due to higher incomes corresponding also corresponding with higher ages that are less likely to engage in long-distance travel.

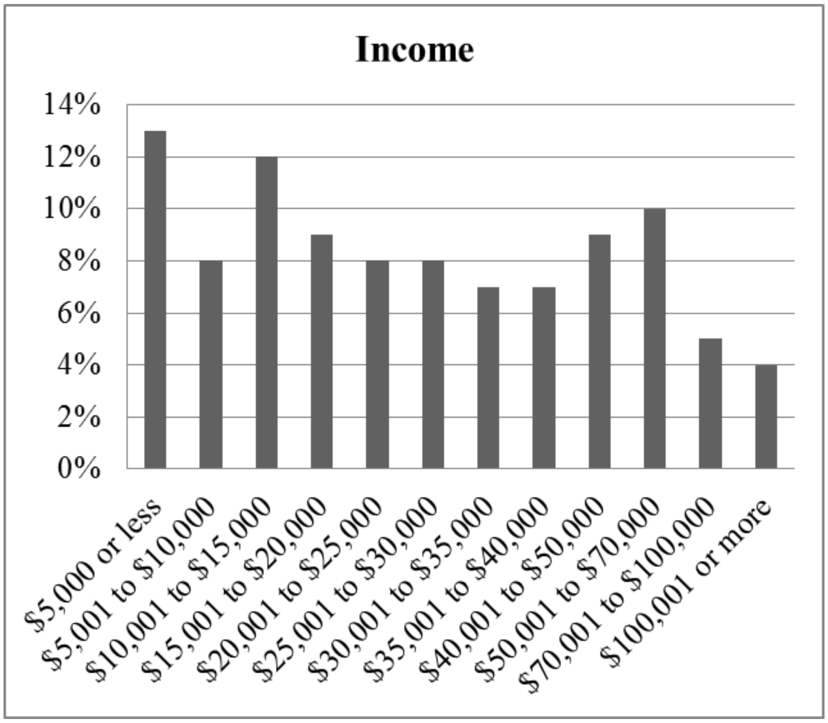

Figure 9: National Income Distribution (New Zealand 2006)

3.6. Transferability of New Zealand Data to the United States

Although New Zealand, a relatively isolated island nation in the southwest of the Pacific Ocean, differs from many other nations in regards to proximity to other countries (the closest neighbor to New Zealand is Australia, 900 miles to the northwest), it is similar to many developed nations with respect to personal mobility. Infrastructure, wealth, education, and culture, are all comparable to many western nations. Another benefit of examining the factors contributing to scale in the context of New Zealand is that, although consisting of numerous islands, the main land mass of New Zealand is primarily comprised of only two large islands, the North Island and the South Island. This allows research to inherently incorporate impedance due to the nature of such aquatic boundaries while not limiting the scope of work due to them. Also beneficial to the scope of this research is the population density of New Zealand. The nation's population is approximately 4.5 million and, as observed in Figure 10, contains a full spectrum of population densities within its borders, ranging from dense urban communities to sparse rural areas. The majority of the population resides within, or in close proximity to, one of the 16 main urban areas. Over half reside in the cities of Auckland, Christchurch, Wellington, and Hamilton (Statistics New Zealand 2013). Combined with a land mass of 271,000 km^2 (104,000 mi.^{2}) the population density is 16 persons/km^2 (41 persons/mi.^{2}) (Statistics New Zealand 2009).

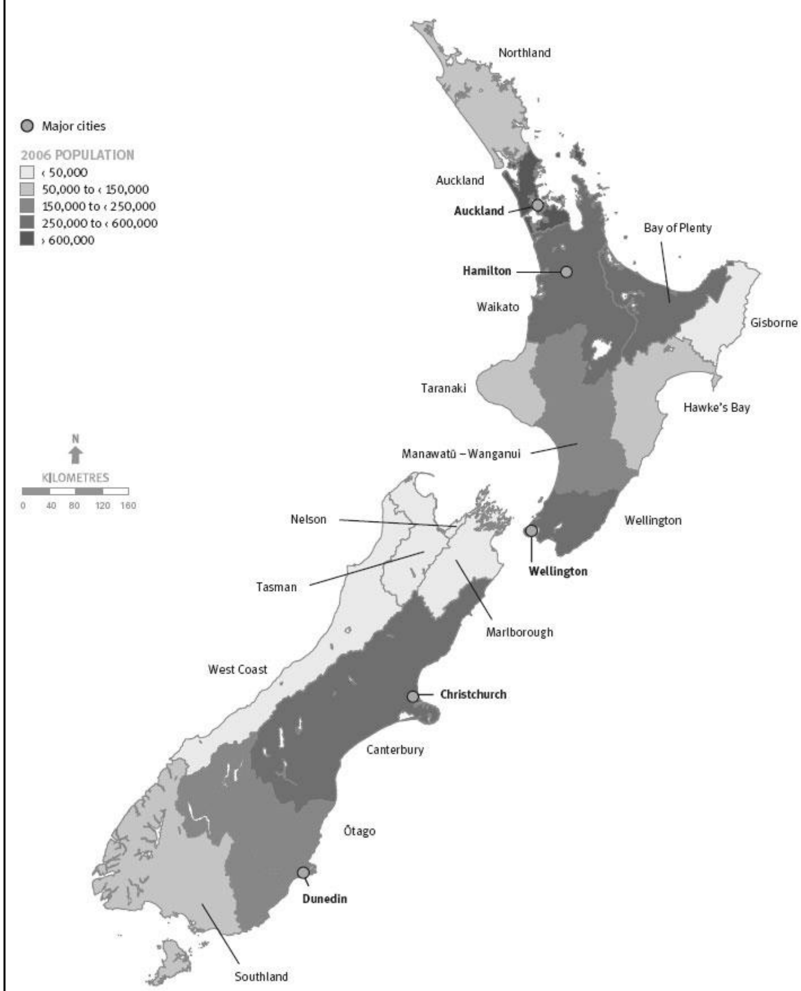

Figure 10: NZ Population Distribution (New Zealand 2006)

Despite only six metropolitan centers contributing to over half of the nation's population, Figure 11 demonstrates infrastructure provides access to all regions and rail networks extend the entire length of the nation.

Figure 11: NZ Infrastructure (National Infrastructure Unit 2014)

As observed in Figure 12, domestic air service provides air access to 26 domestic locations within the nation (Air New Zealand 2014). This level of service provides direct air access to all but the most minute of geographic scales.

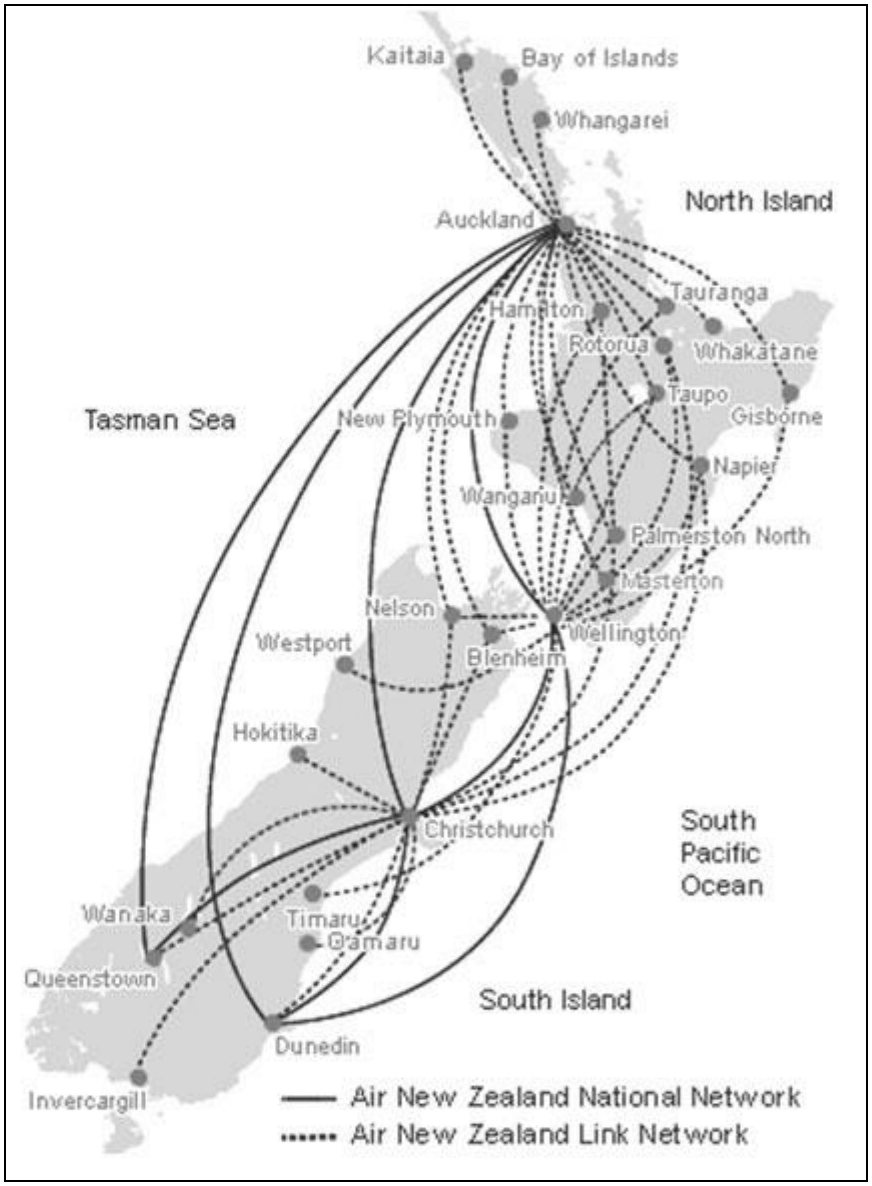

Figure 12: NZ Domestic Air Routes (Airline Network News and Analysis 2014)

Both the nation’s geography and wildlife are varied, and combined with a mild and temperate climate, contribute to a robust tourism industry that draws both domestic and foreign visitors.With a gross domestic product of $166 Billion (NZD) the country invests over $36 Billion (NZD) on roads and public transit (NZ Ministry of Transport 2014. Adding to the breadth of knowledge available in understanding NZ travel is the nation’s geography and wildlife. Both are varied and, combined with a mild and temperate climate, contribute to a robust tourism industry that draws both domestic and foreign visitors.

4. METHODOLOGY

4.1 The Multinomial Logistic Regression Model

Destination and mode choice models are frequently estimated jointly using discrete choice multinomial logistic (MNL) regression models, as opposed to gravity models (LaMondia et al 2010). This is done for a number of reasons, including the ability to evaluate the impact of many factors on these decisions beyond the few used in a gravity model (e.g. distance or time), the ability to consider multiple unique alternatives (as well as evaluate factors differently for each alternative), and the relationship between mode and destination decisions. Specifically, this thesis utilizes a MNL regression to examine the factors influencing the joint dependent decision-variable geographic scale and mode choice, of which there were four possible outcomes (Figure 13). This simplified set of alternatives was selected due to the fact that the majority of within zone and to adjacent zone trips were done with personal autos, as seen in Table 6.

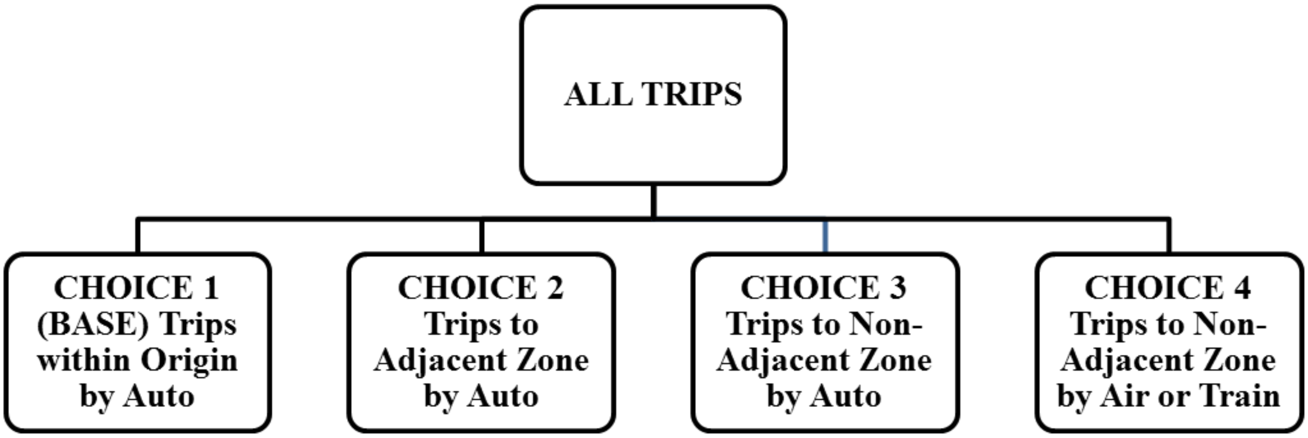

Figure 13: Model Structure

This model was selected as it supported the nominal nature of the dependent variables under examination while, allowing for the relaxation of the independent and independent and identically distributed (IID) assumption between some sets of alternatives (in this case between modes within a single geographic scale). The relaxation of these was determined to be desirable as random variables for the data set could not be determined to have equal probability distributions. In fact, it was suspected, that due to traveler preference, probability distributions were not equal. The dependent variables supported by this model are nominal, that is, not linear or ordinal but conforming to categorical data with no relative value between categories.

The multinomial logit model output is structured by utility and probability. Each possible choice within the dependent variable is assigned a utility function, shown in Equation 1. Subsequently, with the utility for each choice in a particular alternative (trip), the probability function, shown in Equation 3, is used to determine the relative probability of each choice for that alternative. The utility function for each alternative choice *i* and decision maker *j* is defined as:

$$U_{ij} = \beta' x_{ij} + \varepsilon_{ij} \quad (1)$$

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (2)$$

Where U_j is the utility of alternative j, x_j is a singular matrix of alternative specific characteristics, and ε_j is an error term following a generalized extreme value distribution, independent and identically distributed with a variance of $\frac{\pi^2}{6}$, that incorporates unobserved utility. By setting the variance to this value the model can be normalized to the scale of the utility. The incorporation of the unobserved utility is accomplished in this type of model through approximation of an integral through the determination of the probability of some unobserved value (ε). The error term allows the model to specify the difference between predicted outcomes and actual outcomes. In other words, if Ɛ, and subsequently all model considerations, could be observed, then the utility equation could be perfectly predicted. However, this is obviously not the case; all influencing factors are never able to achieve full consideration in a specified model. The multinomial logit model is able to account for this through consideration of the probability of ε given the observed portion X, where $X = \beta' x_j$, of Equation 1. This is accomplished through the use of simulation or the calculation of an average over some density. Simulation may be accomplished using a number of different techniques, however, for multinomial logit the most common is an inverse cumulative technique. In this method any density $f(\varepsilon)$ is transformed to an associated cumulative density $F(\varepsilon)$ through the use of random variable selection and transformations according to a determined distribution. In this technique any value ε for the associated mean output provided by the model may have the probability of that value or less occurring. Simulation with the use of an indicator function can be developed as shown in Equation 3.

$$I(X_{ij} + \varepsilon_{ij} = U_j) = \begin{matrix} 1\ if\ true \\ 0\ if\ false \end{matrix} \qquad (3)$$

In turn, Equation 3 allows the probability of ε such that$U_j = X_j + \varepsilon_j$.

$$P(U|X) = \int I(X_{ij} + \varepsilon_{ij} < U_{ij}) f(X) d\varepsilon \qquad (4)$$

Equation 4 is then used to calculate a complete closed form, shown in Equation 5, for the logistic ε in which action is taken only if $U > 0$.

$$F(\varepsilon) = \frac{1}{1+e^{-\varepsilon}} \qquad (5)$$

Consequently leading to the choice probability model shown in Equation 6.

$$P_{ij} = \int I(\beta' x_{ij} + \varepsilon_{ij} > 1) f(\varepsilon) d\varepsilon$$

$$P_{ij} = \int I(\varepsilon_{ij} > -\beta' x_{ij}) f(\varepsilon) d\varepsilon$$

$$P_{ij} = 1 - F(-\beta' x_{ij})$$

$$P_{ij} = 1 - \frac{1}{\sum_j e^{V_{ij}}}$$

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_j e^{V_{ij}}} \tag{6}$$

Utilizing this model provides a number of appealing aspects. First, each choice is assigned a probability between 0 and 1. In this scenario all choice probabilities will add to one. It must be noted that in this model structure one of the choice alternatives must be utilized as a base for the other alternatives to be compare to. Additionally, as with most discrete choice models, the probability representation of a choices utility is sigmoid, as shown in Figure 14.

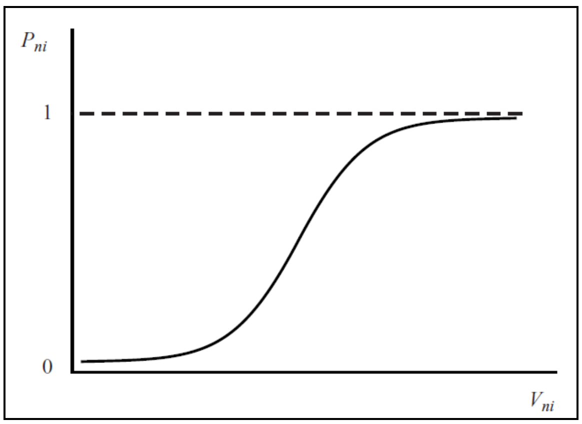

Figure 14: Sigmoid (Train 2009)

This is appealing as it directly reflects the utility of a choice against other choices. For example, in the context of this report, if the trips utility for a specific choice increases, the magnitude of change for the probability of the same choice will also be dependent on the magnitude of the choices utility in relation to the other choice utility. In other words, if a choices utility is small compared to the alternative utilities a significant increase in the utility may not results in a similar increase in the probability. As such the greatest changes in choice probability are observed when the probability is close to 50%.

5. MODEL ESTIMATION

The model estimation results can be found in Table 7. The multinomial logit structure proved to be a preferred model for estimating these choices. The likelihood ratio test value of 37,961 was significantly greater than the critical chi-squared test at any confidence level, indicating that this model is statistically more effective at forecasting joint destination and mode choices than a constants-only model.

Table 7: Model Estimation Parameters

	TRIP SCALE					
	Adjacent Zone with Auto		Non-Adjacent Zone with Auto		Non-Adjacent Zone with Plane or Train	
VARIABLE	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
TRIP CHARACTERISTICS						
PRIMARY TRIP PURPOSE IS…						
…Business					1.134	13.34
…Holiday					-0.852	-9.43
…Visit Friends and Relatives	0.248	4.57	0.320	5.52		
PRIMARY TRIP ACTIVITY IS…						
…Sports	-0.167	-4.42	-0.344	-8.79	-0.507	-8.96
…Cultural Attraction			-0.073	-1.77	0.480	7.56
…Dining					0.256	5.51
…Shopping					0.253	4.14
TRIP STRUCTURE IS…						
…Day trip	0.320	8.72			-0.483	-5.22
…Overnight trip with only one destination but multiple excursions					0.381	3.30
TRIP LENGTH						
Number of stops exceeding one hour			0.342	11.89	-0.728	-10.58
Number of legs in trip	-0.278	-8.81	-0.582	-17.56	-1.283	-30.70
Round trip distance (KM)	0.014	110.50	0.018	157.54	0.021	169.48
PARTY CHARACTERISTICS						
Number of Children on the Trip					-0.472	-15.67
HOUSEHOLD CHARACTERISTICS						
HH INCOME IS…						
…$19,999 or less					-0.247	-2.36
…$20,000 to $39,999					-0.306	-3.62
…$40,000 to $69,999					-0.223	-2.86
AGE OF RESPONDENT IS…						
…Age of Respondent 25 to 34			-0.200	-5.48		
COMPOSITION						
Number of Adults					-0.168	-5.39
ORIGIN CHARACTERISTICS						
Percent of population with higher than a Bachelors Degree			0.043	12.63	-0.007	-13.89
HOUSEHOLDS						
Percent of households earning $10,000 to $19,999					-0.003	-20.09
Percent of household earning $9,999 or less	0.004	24.34	0.002	12.45		
Number of single parent households	0.007	22.08				

MODEL ESTIMATION PARAMETERS CONTINUED						
EMPLOYMENT						
Percent of population employed as clerks			-0.061	-13.39	0.163	19.54
Percent of population with full time employment	-0.028	-21.00				
LODGING						
Number of guest nights reported from hostels	-0.007	-29.43	-0.003	-37.13		
Number of guest nights reported from hotels or motels	0.001	28.22				
TRIP TYPES						
Number of overnight trips for business	-0.008	-20.47	-0.004	-26.81		
Number of day trips for holiday	0.003	-15.94				
Number of overnight trips for holiday	0.003	22.87				
Percent population 65 years or older					-0.004	-8.97
NEIGHBORING RTO CHARACTERISTICS						
HOUSEHOLDS						
Percent of households that are multi-person					-0.110	-12.54
Household income $9,999 or less	0.009	10.65				
EMPLOYMENT						
Percent employed as equipment operators					0.200	14.17
FINANCIAL						
Count of financial transactions for accommodation	-0.213	-11.88				
Count of financial transactions for food	0.121	25.61			0.084	13.68
Count of financial transactions for fuel	-0.123	-14.20	0.040	11.06		
Count of financial transactions not related to tourism	-0.306	-27.14				
Count of financial transactions for retail	0.101	22.15	-0.029	-10.85	-0.094	-18.42
Count of financial transactions not related to retail			0.001	15.31		
LODGING						
Number of guest nights at hostel	-0.002	-5.22	0.003	26.62	0.001	8.47
Number of guest nights at motel or hotel			0.008	26.66	-0.001	-17.66
TRIP TYPES						
Number of overnight business trips	-0.015	-18.21	0.002	11.63	0.006	10.38
Number of overnight holiday trips	-0.002	-29.85	-0.003	-32.85		
Count of day trips for visiting	-0.004	-25.22	-0.001	-12.30	-0.002	-9.81
Number of overnight trips for visiting					0.005	6.92
BEYOND NEIGHBORING RTO CHARACTERISTICS						
HOUSEHOLDS						
Percent of household that are one parent					-0.002	-5.60
LODGING						
Guest nights at hostel					-0.009	-13.58
Guest nights at motel or hotel			0.004	16.24	0.007	11.99
TRIP TYPES						
Day business trips	-0.002	-10.53	0.006	8.99		
Number of overnight trips for holidays			-0.001	-2.30		
Number of day trips for visiting			-0.008	-18.12		

5.1. Trip Characteristics

The first category of variables included characteristics specific to the recorded trip. Trips conducted for the purpose of business, relative to traveling within the origin, to an adjacent zone, or to a non-adjacent zone using an automobile, had an increased utility of 1.134 to travel to a non-adjacent zone plane or a train. This increased utility was also relative to all other trip purposes and is likely reflective of the fact that business trips are often funded by entities other than the traveler and, as compared to personal trips, demonstrate a higher value of time than on financial cost. In contrast to this, trips conducted for the holiday travel, compared to all other purposes and relative to the same zones as business travel, had a decreased utility of 0.852 to travel to a non-adjacent zone by plane or a train. Similar to the reasons supporting business travel to this scale and mode, this was likely due to the fact that personal trips are often more sensitive to cost and less sensitive to time. This supports the negative coefficients reflecting a negative utility for a longer travel distance and a more expensive mode. Relative to the travel within the origin zone and non-adjacent zone using air or rail, trips conducted for the purpose of visiting friends and relatives had an increased utility of 0.2248 for travel to adjacent zones and 0.320 for travel to non-adjacent zones by automobile. This is most likely due to visiting of acquaintances within the origin zone reflecting more daily travel considerations than other long-distance travel. Furthermore when long-distance travel is conducted in order to visit friends and family it is often done so with in an environment in which an automobile is more convenient, such as travel with children. Additionally this type of travel adheres to personal travel characteristics in which the traveler is more sensitive to financial cost than time.

Trips conducted for sporting activities, compared to all other primary activities and relative to traveling within the origin, had a decreased utility of 0.167 to travel to an adjacent zone, a decreased utility of 0.344 to travel to a non-adjacent zone by auto, and a decreased utility of 0.507 to travel to a non-adjacent zone by air or train. This is likely due to sporting activities reflecting local competition, inherently not requiring long travel distances on the part of the participant. Trips conducted to experience a cultural attraction, also relative to all other activities and travel within the origin and to an adjacent zone, had a decreased utility of 0.073 to travel to a non-adjacent zone by automobile but an increased utility of 0.480 in travel to a non-adjacent zone using air or train. This is likely tied to travel behavior in which travelers desire unique experiences and are willing to travel further distances in order to accomplish as much. The increased utility of air and train most likely reflect the greater distances trip-takers travel in pursuit of such an endeavor. Relative to the travel within the origin, to an adjacent zone, and to a non-adjacent zone using an automobile, travel conducted for participation in a dining activity, also relative to all other activities, had an increased utility of 0.256 for travel to non-adjacent zones by air or train. This was most likely reflective of long-distance travel for dining representing a unique event in which travel mode also reflected the unique nature of the travel involved. Relative to the travel within the origin, to an adjacent zone, and to a non-adjacent zone using automobile, shopping activities had an increased utility of 0.253 for travel to non-adjacent zones by air or train. As with dining this was most likely due to long-distance travel for shopping representing a unique, and extravagant, event in which financial resources supported more expensive travel. Increased financial ability translated to more sensitivity to time rather than financial cost.

For trips in which stops exceeding one hour were present, relative to traveling within the origin and to adjacent zones, an increased utility of 0.342 was present for travel to a non-adjacent zone using an automobile and a decreased utility of 0.728 in travel to a non-adjacent zone by air or train. This was likely due to the fact that trains and airplane travel are not conducive to stops exceeding one hour. The more stops the traveler was likely to make the greater the ability of the automobile over a train or airplane to conform. For trips in which multiple legs were present, for every additional leg within a trip a decreased utility was observed. For travel to an adjacent zone a decreased utility of 0.278, a decreased utility of 0.582 in travel to a non-adjacent zone using a car, and a decreased utility of 1.283 in travel to a non-adjacent zone using air or rail. This was likely due to the fact that, as the number of legs in a trip increased, so too did the likelihood the trip conformed to a chained format. In this format more attention is focused on multiple activities, usually in closer proximity to an origin, than one destination farther away. If a trip was a day trip, relative to trips extending overnight and traveling within the origin or to a non-adjacent zone by automobile, both an increased utility of 0.320 for travel to an adjacent zone and a decreased utility of 0.483 in travel to a non-adjacent zone using air or rail were observed. This was likely due to the restriction of day trips to time constraints and conformance to those restraints by closer regions requiring less time for travel. Trips conducted that conformed to an overnight structure with only one destination but multiple excursions, relative to all other trip structures and travel within the origin, to an adjacent zone, or a non-adjacent zone using an automobile, had an increased utility of 0.381 to travel to a non-adjacent zone by plane or a train. This was likely due to the diminished freedom of movement provided by automobile at the destination outweighed by the convenience of air and train for a trip that contained no deviations. For trip distance, for every additional kilometer traveled round trip, an increased utility of 0.014

to travel to an adjacent zone, an increased utility of 0.018 in travel to a non-adjacent zone using a car, and an increased utility of 0.021 in travel to a non-adjacent zone using air or rail was observed. This agreed with the condition that travel to more distant regions naturally requires farther distances be traversed.

5.2. Party Characteristics

Travel parties with children present, relative to traveling within the origin, to an adjacent zone, or to a non-adjacent zone using an automobile, had a decreased utility of 0.472 to travel to a non-adjacent zone by plane or a train for every additional child in the party. This was likely due to the presence of children adding higher cost as modes charged by individual. This was in contrast to automobile in which additional children did not directly increase cost. Additionally, the presence of children also increased the amount of time and resources that would be required to be absorbed by those responsible for the children. By remaining in the origin, adjacent zone, or travel to a non-adjacent zone by automobile, many of these demands would be more easily met.

5.3. Household Characteristics

Household characteristics observed to have a significant impact on analyzed travel scale mode choice combinations were household income and household composition. Households earning $19,999 or less annually, relative all other income levels, travel within the origin, to an adjacent zone, or to a non-adjacent zone using an automobile, had a decreased utility of 0.247 to travel to a non-adjacent zone by plane or a train. This is likely due to travel to further destinations by these modes require more financial investment. Similarly, households earning between $20,000 and $39,999, relative to all other income levels, also had a decreased utility of to travel to a non-adjacent by plane or a train. This negative utility was of the magnitude 0.306. Again this was likely due to households with this level of annual income representing travelers that are more sensitive to mode cost than their counterparts. Additionally, households earning between $40,000 and $69,999, had a decreased utility of 0.223 to travel to a non-adjacent zone by plane or a train. This level of income may no longer be considered a direct factor in decreased utility tied to the higher cost of airplane and train. Instead these cases are most likely due to a higher age bracket in which travel by air or train is not desired due to time or convenience preferences.

5.4. Characteristics for Zone of Origin

Origin characteristics observed to have a significant impact on scale of travel and mode choice for trips generated were household characteristics, employment characteristics, lodging characteristics, and trip type. Additionally, for origin bound trips, education also demonstrated a significant impact on travel. For every additional percentage of the population with an education above a bachelor's degree, relative to traveling within the origin and to an adjacent zone, an increased utility of 0.043 was observed to travel to an adjacent zone by automobile and a decreased utility of 0.007 for travel to a non-adjacent zone by air or train. This was likely due to higher educational levels providing increased motivation and ability to travel. However, the preference to travel by air or train is not supported indicating higher education does not, by itself, provide sufficient financial or time advantages to develop these as preferred mode choices.

For every additional percentage of households earning between $10,000 and $19,999, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by automobile, a decreased utility of 0.003 to travel to a non-adjacent zone by air or train was observed. This was most likely reflective of this income level being more sensitive to mode cost than other income levels may be. This statement is supported by the findings for the representation of $9,999 and less households. For every additional percentage of households earning less than $9,999, relative to travel within the origin, and to travel to non-adjacent zones by air or train, both travel to an adjacent zone and travel to a non-adjacent zone by automobile observed an increased utility of 0.004. Again, as with the proceeding income variable, this was likely representative of households with this level of income indicating fewer resources to devote to travel. For every additional household with only one parent, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, an increased utility of 0.007 for travel to an adjacent zone was observed. This was likely a result of fewer resources available within a household to support long-distance travel.

In regards to the effect of zone of origin on long-distance trips two employment measures proved significant: percent of origin zone employed as a clerk, and percent of origin employed full time. For every additional percentage of workers employed as a clerk, relative to traveling within the origin and to an adjacent zone, a decreased utility of 0.061 to travel to a non-adjacent zone by automobile was observed. Also an increased utility of 0.163 for travel to a non-adjacent zone by air or train was observed. These utilities were likely due to the employment characteristics of the origin and the associated involvement of business activities for travel. For every additional percentage of workers employed full-time, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, a decreased utility of 0.028 to travel to an adjacent zone was observed. This was likely due to an increased employment within the origin generating an environment of greater financial freedom to engage in trips at the non-adjacent zone scale.

In regards to the effect of origin lodging characteristics on long-distance trips, two lodging measures proved significant: number of guest nights reported by hostels, and number of guest nights reported by either motels or hotels. For every additional guest night reported by hostels, relative to traveling within the origin and to a non-adjacent zone by air or train, a decreased utility of 0.007 for travel to an adjacent zone was observed. Additionally, a decreased utility of 0.003 for travel to a non-adjacent zone by automobile was observed. This was likely due to hostels supporting individuals without use of an automobile. For every additional guest night reported by hotels or motels, relative to traveling within the origin and to a non-adjacent zone by air or train, an increased utility of 0.001 for travel to an adjacent zone was observed. This was likely representative of hotel activity involving automobiles.

Factors within the origin demonstrated to have significance in determining scale and mode choice were found to be number overnight trips for business, number day trips for holiday travel, and number of overnight trips for holiday travel. For every additional overnight trip for business generated by the zone of origin, relative to traveling within the origin, and to a non-adjacent zone by air or train, a decreased utility of 0.008 for travel to an adjacent zone, and a decreased utility of 0.004 for travel to a non-adjacent zone by automobile were observed. This was likely due to business trips conducted by automobile being less likely to take longer than one day as opposed to business trips in which transportation by air or train was involved. For every additional day trip generated by the origin for holiday travel, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, an increased utility of 0.003 for travel to an adjacent zone was observed. This was likely representative of holiday travel reflecting repeating travel, or traditions. Additionally this was better enabled with the convenience of regions more easily accessible than those non-adjacent. Similarly, for every additional overnight trip for holiday travel generated by the origin, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, an increased utility of 0.003 for travel to an adjacent zone was observed. Again, as with day holiday travel, this was likely due to holiday travel reflecting repeating travel, or traditions, better enabled with the convenience of regions more easily accessible than those non-adjacent.

5.5. Characteristics for Adjacent Zones

Adjacent zone characteristics observed to have a significant impact on scale of travel and mode choice for trips generated were household characteristics, employment characteristics, financial characteristics, lodging characteristics, and trip type. Additionally, for adjacent zones, age demonstrated an impact on travel. For every additional percentage of the population above 65 years old demonstrated by the median value for adjacent zones, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by automobile, a decreased utility of 0.004 for travel to a non-adjacent zone by air or train was observed. This was likely due to higher age levels of the area reducing the involvement of air and train travel.

In regards to the effect of adjacent zone household characteristics on long-distance trips two household measures proved significant: median percent of households that are multi-person and median percent of households that have an income of $9,999 or less. For every median percent increase in households that are multi-person for the adjacent zones, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by automobile, a decreased utility of 0.110 for travel to a non-adjacent zone by air and train was observed. This was likely due multi-person households reflecting communities in which families with children are present and the associated logistical challenges that are inherent with air and rail travel. For every median percent increase in households that have an income of $9,999 or less for the adjacent zones, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, an increased utility of 0.009 for travel to an adjacent zone was observed. This was likely due to the cost of living in these regions providing financial incentive for them to become trip destinations.

For employment characteristics of adjacent zones, every median percent increase in workers employed as equipment operators, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by automobile, an increased utility of 0.200 for travel to a non-adjacent zone by air and train was observed. This was likely due these employment characteristics reflecting the industry (and conversely attractions) present in surrounding areas that would motivation travel to non-adjacent zones by air or train.

For financial characteristics of adjacent zones, every median increase in the count of financial transactions for accommodation, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, a decreased utility of 0.213 for travel to an adjacent zone was observed. This was likely due to travelers finding more utility in remaining at home rather than in an adjacent zone when high demand for lodging (and increased prices) are present. Every median increase in the count of financial transactions for food in the adjacent zones, relative to traveling within the origin, and to a non-adjacent zone by automobile, an increased utility of 0.121 for travel to adjacent zones, and an increased utility of 0.084 for travel to non-adjacent zones by air or train was observed. This may be due to conditions in which zone residents were compelled to travel to adjacent zones, most likely to engage in a more robust economy. The increase in utility for travel to an non-adjacent zone by air or train may be reflective of greater financial ability reflected by residents in regions with more purchasing activity. For every median increase in the count of financial transactions for fuel in the adjacent zones, relative to traveling within the origin, and to a non-adjacent zone by air or train, a decreased utility of 0.123 for travel to an adjacent zone, and an increased utility of 0.040 for travel to a non-adjacent zone by automobile were observed. This was probably due to increased fuel purchases reflecting an increased presence of daily life rather than experiences of novelty. This is supported by the increased utility of travel to a non-adjacent zone, reflecting travelers bypassing the higher fuel consumption areas to visit other areas. For every median increase in the count of financial transactions not related to tourism in adjacent zones, relative to traveling within the origin, to a non-adjacent zone by automobile, and to a non-adjacent zone by air or train, a decreased utility of 0.306 for travel to an adjacent zone was observed. This was likely due to tourism being a significant driver of travel to an adjacent zone. For every median increase in the count of financial transactions for retail in adjacent zones, relative to travel within the origin, an increased utility of 0.101 for travel to an adjacent zone, a decreased utility of 0.029 for travel to a non-adjacent zone by automobile, and a decreased utility of 0.094 for travel to a non-adjacent zone by air or train was observed. This was likely due to shopping activities in the adjacent zones inherently providing more convenience and cost-effectiveness than those in non-adjacent zones. For every median increase in the count of financial transactions for other than retail in adjacent zones, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by air or train, an increased utility of 0.001 for travel to a non-adjacent zone by automobile was observed. This was likely a result of increased business activities, associated with non-retail purchasing, increasing motivation to travel beyond the adjacent zone.

In regards to the effect of adjacent zone lodging characteristics on long-distance trips two lodging measures proved significant: number of guest nights reported by hostels, and number of guest nights reported by either motels or hotels. For every additional guest night reported by hostels, relative to traveling within the zone of origin, a decreased utility of 0.002 for travel to an adjacent zone, an increased utility of 0.003 for travel to a non-adjacent zone by automobile, and an increased utility of 0.001 for travel to a non-adjacent zone with air or train were observed. This was probably due to hostels supporting individuals desiring new experiences and that are willing to travel to gain those experiences. For every additional guest night reported by hotels or motels, relative to traveling within the origin, and to an adjacent zone, an increased utility of 0.008 for travel to a non-adjacent zone by automobile, and a decreased utility of 0.001 for travel to a non-adjacent zone by air or train was observed. This is likely due to travelers in a zone engaging in travel activity more often.

Trip types to adjacent zones demonstrated to have significance in determining scale and mode choice of trips were found to be number overnight trips for business, number of overnight trips for holiday travel, number of day trips for visiting friends and relatives , and number of overnight trips for visiting friends and relatives. For every additional overnight trip for business generated by an adjacent zone, relative to traveling within the origin, a decreased utility of 0.015 for travel to an adjacent zone, an increased utility of 0.002 for travel to a non-adjacent zone by automobile, and an increased utility of 0.006 for travel to a non-adjacent zone by air and train, were observed. This was likely due to the fact that business trips conducted in a region generate additional travel to non-adjacent zone. For every additional overnight trip for holiday travel generated by the adjacent zone, relative to traveling within the origin, and travel to a non-adjacent zone by air or train, a decreased utility of 0.002 for travel to an adjacent zone, and a decreased utility of 0.003 were observed. This was likely due to the fact that areas with higher holiday travel may experience less automobile trips to non-adjacent zones because they are better able to provide the financial resources for travel by plane. For every additional day trip for visiting generated by the adjacent zone, relative to traveling within the origin, a decreased utility of 0.004 for travel to an adjacent zone, a decreased utility of 0.001 for travel to a non-adjacent zone by automobile, and a decreased utility of 0.002 for travel to a non-adjacent zone by air and train, were observed. This is likely due to an increase in day trips for visiting in an adjacent zone reflects a regional characteristic meaning the travelers in the origin are also engaging in day travel, trips limited by time from extending to further destinations. For every additional overnight trip for visiting generated by the adjacent zone, relative to traveling within the origin, adjacent zone, and to a non-adjacent zone by automobile, an increased utility of 0.005 for travel to a non-adjacent zone by air and train were observed. This was likely due to an increased regional participation in overnight travel increasing the likelihood of travel by air or train.

5.6. Characteristics for Non-Adjacent Zones

Non-adjacent zone characteristics observed to have a significant impact on scale of travel and mode choice for trips generated were household characteristics, lodging characteristics, and trip type.

In regards to the effect of non-adjacent zone household characteristics on long-distance trips one household measures proved significant: median percent of households that are one parent. For every median percent increase in households that are one parent for the non-adjacent zones, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by automobile, a decreased utility of 0.002 for travel to a non-adjacent zone by air and train was observed. This is likely due one parent households reflecting less affluent communities that have less appeal to those that would travel by air or train.

In regards to the effect of non-adjacent zone lodging characteristics on long-distance trips two lodging measures proved significant: number of guest nights reported by hostels, and number of guest nights reported by either motels or hotels. For every additional guest night reported by hostels, relative to traveling within the origin, to an adjacent zone, and to a non-adjacent zone by auto, a decreased utility of 0.009 for travel to a non-adjacent zone with air or train was observed. This was likely due to travel to areas with many hostels would not often be conducted by those that spend the money to travel by air or train. For every additional guest night reported by hotels or motels, relative to traveling within the origin, and to an adjacent zone, an increased utility of 0.004 for travel to a non-adjacent zone by automobile, and an increased utility of 0.001 for travel to a non-adjacent zone by air or train were observed. This was likely due to travelers in being drawn to the activities in the areas that support the hotel and motels in the area.

Trip types to non-adjacent zone demonstrated to have significance in determining scale and mode choice of trips were found to be number of day business trips, number of overnight trips for holiday travel, and median number of day trips for visiting friends and relatives. For every additional day trip for business generated by the non-adjacent zone, relative to traveling within the origin, and travel to non-adjacent zone by air or train, a decreased utility of 0.002 for travel to an adjacent zone, and an increased utility of 0.006 for travel to a non-adjacent zone by automobile were observed. This likely represented the business trips in a zone drawing travel to the zone. For every additional median overnight trip for holiday travel generated by the non-adjacent zone, relative to traveling within the zone, travel to an adjacent zone, and travel to a non-adjacent zone by air or train, a decreased utility of 0.001 for travel to a non-adjacent zone by auto was observed. This was likely due to attractions that draw overnight holiday travel make travel to a non-adjacent zone by plane and train worth the added financial resources for travels. For every additional median day trip for visiting generated by non-adjacent zones, relative to traveling within the origin, travel to an adjacent zone, and travel to a non-adjacent zone by air or train, a decreased utility of 0.008 for travel to a non-adjacent zone by auto was observed. This was likely due to the fact that travel to visit friends and relatives warrants the cost in order to save time.

6. SUMMARY AND CONCLUSIONS

This study examined the influence of household, travel party, trip, and RTO (in conjunction with mode) characteristics on discrete geographic scale choices of long-distance personal travel. This process was performed through an examination of outcomes from a multinomial logit discrete choice model. However, unlike mainstream practices that rely heavily upon distance thresholds to define scale (or simply forego any consideration of scale once the determination of long-distance has been made), this study utilized discrete geographical boundaries to develop zones. This successfully allowed for the identification of numerous factors contributing to long-distance trip making and enabled a better understanding of how such trips are completed.

In this approach the selection of a MNL model for use, initially considered for its ability to efficiently compute utilities of multiple unordered discrete choices that lacked correlation, proved to be a viable option for consideration of geographic scale/ mode choice combinations. Initial concerns did arise about the models ability to process the large number of variables. However, running the model in separate iterations for each category of characteristics until a suitable number remained to enable all remaining to be considered in a single model proved to be an easy and effective means to overcome such a concern. Ultimately the model identified 51 variables that proved both significant and thorough in determining not only the scale of travel but also mode of travel for trips to non-adjacent zones.

Use of zones, structured as concentric regions based upon proximity of each trips origin, proved advantageous over definitions of scale based upon continuous measures of distance for a number of reasons. First, results indicate geographic zones are deeply ingrained in long-distance travel behavior. Results proved zones effectively capture the different factors that contribute to scale of long-distance trips. Each of the zones considered for this research were shown to be effected by highly unique sets of independent variables that were both significant and able to develop an effective consideration of household, travel party, trip, and regional demographic components examined. Second, such a structure allowed for researchers to overcome subjectivity associated with distance based approaches while allowing for geographic factors, both physical and perceptual, to be incorporated directly into the definitions of scale. Furthermore, it must be noted that relationships between these scales also became apparent through this research. For example, in cases in which the trip characteristics category coefficients were identified for variables in adjacent and non-adjacent zones, almost all of the variables that had a negative (or positive) coefficient for the utility of an adjacent zone with an automobile would also have a negative (or positive) coefficient for the utility of the non-adjacent zones. This indicated that when a variable had a specific effect on the utility of travel to an adjacent zone by car, relative to travel within the zone of origin, it would tend to have a negative effective on the utility of travel to non-adjacent zones also. However, within the category capturing demographic characteristics of RTOs neighboring the RTO of origin this trend was observed to be greatly reduced indicating that, within this category, variables did not tend to influence travel to non-adjacent zones in the same manner as travel to adjacent zones.

Model results indicated significant influence on selected scale and mode of travel by a diverse set of variables spanning household, travel party, trip, and regional demographic characteristics. Of these, variables within the trip characteristic category possessed coefficient with the greatest magnitude. Part of this may be attributed to the diminished scale of other variables such as the numerous variables in the zonal characteristics that reflect percentages rather than the predominately binary variables in trip characteristics. However, it must be noted that these variables are by no means the only binary variables represented and, of the variables representing values based upon percentages or other continuous values, minimal variability is often observed within them. This indicates that these values are comparable and magnitudes are meaningful comparisons. The fact that the trip characteristics selected for inclusion in the final model possess a larger magnitude is an indication that this category tends to have a greater impact on the scale and mode choice of observed trips. Also of note is every variable representing household characteristics had no effect on the utility of travel to an adjacent zone but a negative effect on travel to non-adjacent zones as compared to travel within the zone of origin.

Development of this methodology provides the greatest use to organizations committed to the development of policy regarding travel behavior, especially those supporting the interests of tourism and other sectors highly susceptible to long-distance travel. Such agencies will benefit through a better understanding of the factors that contribute to demands on infrastructure, both transportation related and that tied to support of tourism activities, and visitor motivation for travel. Such benefits will be realized through vastly improved efficiency in allocation of resources, both fiscal and otherwise. However, although counterintuitive, secondary benefits may also be provided to community planners as they may better understand the local resources that affect the travel within their region from an external perspective. Tourism organizations will be able to better analyze travel to areas as a consequence of attraction/ repulsion factors particular to an area and surrounding regions. Additionally, utilizing this approach, the transportation planning community will be able to better forecast travel trends and the demands placed on systems due to long-distance travel, independent of a subjective definition of scale. Benefits of this technique may also extend to broader areas influenced by transportation. For example, utilizing this approach to analyze travel behavior governmental agencies may better assess economic development and quality of life that has become so dependent on accessibility and equity of mobility.

Logically, this methodology would benefit from being further explored in other areas, with different geographies. Not only would this validate existing methodologies, it could also unveil variables significant to specific cultures, geographies, infrastructure, and a better understanding of the effect of policy. This may be accomplished through the consideration of other datasets that incorporate broader regions that are comprised of distinctly different populations. Through this approach, development of a larger dataset with a greater number of cases would be enabled that would also serve to increase statistical confidence. Accomplishing this would allow for a model better able to consider choices according to broader geographic contexts.

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8. APPENDIX A: RTO DEVELOPMENT

Table 8: Dataset Compilation

Component	**Title**	**Dataset**	**RTO Component**	**Comments**
Tourism	Tourism Forecasts 2012-2018	Sector Outlook	No	Focused on origin of international visitors, examines characteristics by country of origin no data on where visited within NZ
	Regional Tourism Indicators	International Data Tables	Yes	Focused on Destination RTOs. RTI is percentage of spending above 2008 (100 indicates equal spending)
		Domestic Data Tables	Yes	Focused on Destination RTOs. RTI is percentage of spending above 2008 (100 indicates equal spending)
		Detailed Data	Yes	Focused on Destination RTOs. RTI is percentage of spending above 2008 (100 indicates equal spending). Provides intra-RTO RTIs and RTO RTI by Industry.
	Tourism Satellite Account	Tourism Satellite Account	No	Reports expenditure amount.
	National Tourism Forecast Pivot Tables 2011 - 2016	Tourism Domain Plan	No	Plan to ensure data collected meets needs of the tourism industry
		International Travel	No	Interface reporting country of origin, age, gender, purpose, port of arrival, and length of stay of

				international visitors. Some measures may be filtered within each other.
		International Visitor Survey	No	Determines country of origin and purpose. Web states regional data available but unable to find any.
		Regional Tourism Indicators	Yes	Duplicated in Regional Tourism Indicator Section
		Regional Tourism Estimates	Yes	Reports expenditure amount by County of Origin, Industry, and RTO (and also TA and Regional Council)
		Domestic Travel survey	Yes	Reports domestic travel trips. Includes trip distributions by destination RTOs
		Commercial Accommodation Monitor	Yes	Includes PDF data by RTO by month on number of guest nights, accommodation type, occupancy rates, and guest origin (domestic or international)
		Tourism Satellite Account	No	Duplicated in Tourism Satellite Account Sector
		Tourism Forecasts	No	Reports trends and expenditures from a domestic and international perspective
		Other Research and Reports	Yes	(Tourism Flows Model) Graphically reports expenditure by RTO, nights by RTO, and air and road flows.
			Yes	(Regional Visitor Monitor) Extensive data but limited to 6 RTOs and only data available is summary of results in the form of a satisfaction index
Population and Society	Enrolment and Voting Statistics		No	Voting statistics organized by electoral region

from the General Election and Referendum on New Zealand's Voting System held on 26 November 2011			
National Family and Household Projections		No	Projected families by type
New Zealand General Social Survey		Yes	"Happiness" survey, only includes the 6 most populated RTOs
Subnational Population Projections		Yes	Projected population, age structure, and components of change
National Population Projections		No	By age structure and component of change
National Population Estimates		No	By age, gender, and year
National Ethnic Population Projections		No	By ethnicity
Family Income and Employment Survey		No	Family structure, earnings, and number in HH employed
Time Use Survey: 2009/10		No	Time use by demographics
Social Services Contracting Map		Yes	RTO apportioned amount
2010 Annual		Yes	Duplicated in Meshblock data

Areas File			
Recorded Crime Tables		No	Apprehensions and crimes listed by police districts
Household Economic Survey		Yes	Only HH data for four RTOs explicitly reported
Regional Family and Household Projections		Yes	Projected number of families and households by family type and household type
Marriage, Civil Union, and Divorce statistics		No	By year for all of New Zealand
Births and Deaths statistics		Yes	Births and Deaths by Year by Region
The Social Report and Regional Indicators 2009		Yes	Suicides, life expectancy, smokers, voter turnout, physical activities, road casualties by Region

Regional Tourism Organizations provided the best level of detail for the purpose of the research. However, only the Domestic Travel Survey and a number of other statistical survey's provided by the Ministry of Tourism actually included this geographic definition. In order to overcome this it was observed that RTOs were comprised of Territorial Authorities, and were able to have aggregated characteristics developed according to the TLAs they were comprised of. Through this approach Regional Councils could also be linked to the TLAs they were comprised of.

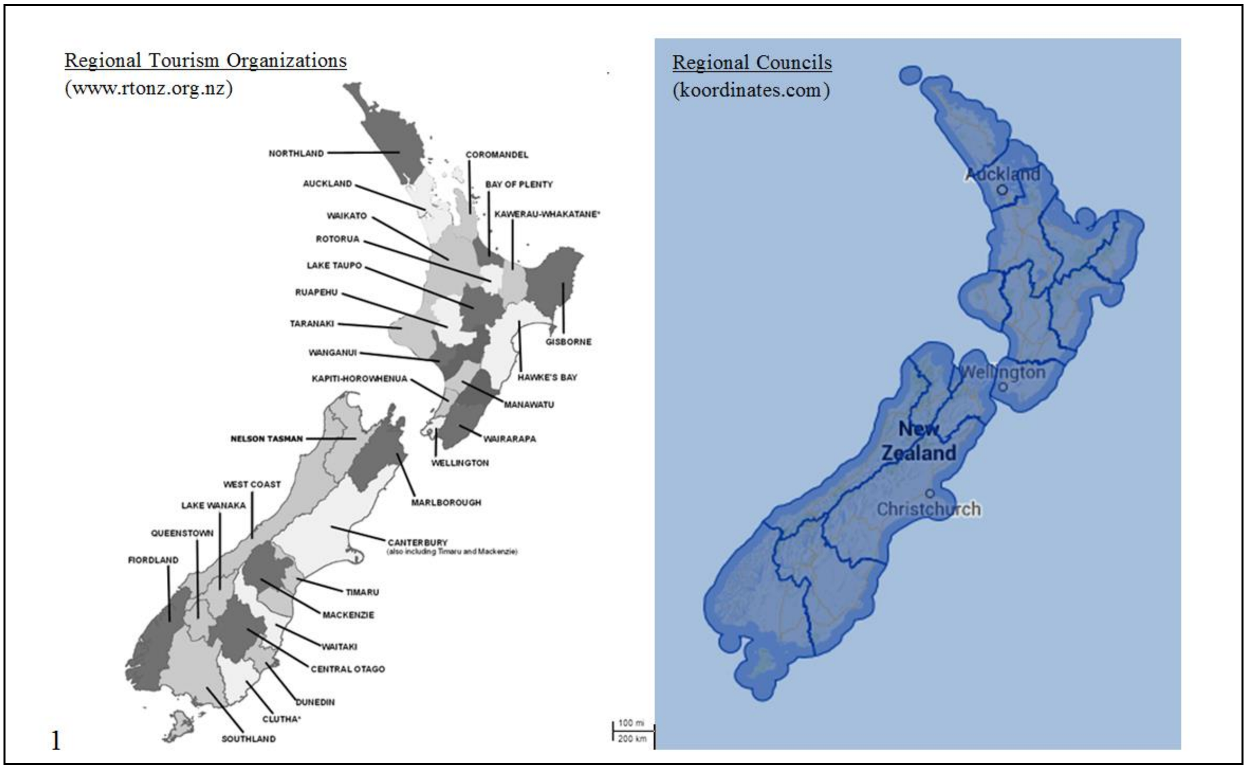

Figure 15: RTO/ RC Comparison

Table 9- Area Comparison

RTO	TA	RC
Northland	Far North	Northland Region
Northland	Kaipara	Northland Region
Northland	Whangarei	Northland Region
Auckland	Auckland City	Auckland Region
Auckland	Franklin	Auckland Region
Auckland	Manukau City	Auckland Region
Auckland	North Shore City	Auckland Region
Auckland	Papakura	Auckland Region
Auckland	Rodney	Auckland Region
Auckland	Waitakere City	Auckland Region
Coromandel	Hauraki	Waikato Region
Coromandel	Thames-Coromandel	Waikato Region
Waikato	Hamilton City	Waikato Region
Waikato	Matamata-Piako	Waikato Region
Waikato	Otorohanga	Waikato Region
Waikato	South Waikato	Waikato Region
Waikato	Waikato	Waikato Region
Waikato	Waipa	Waikato Region
Waikato	Waitomo	Waikato Region
Bay of Plenty	Tauranga City	Bay of Plenty Region
Bay of Plenty	Western Bay of Plenty	Bay of Plenty Region
Rotorua	Rotorua	Bay of Plenty Region
Lake Taupo	Taupo	Waikato Region
Lake Taupo	Taupo	Bay of Plenty Region
Lake Taupo	Taupo	Hawke's Bay Region
Lake Taupo	Taupo	Manawatu-Wanganui Region
Kawerau-Whakatane	Kawerau	Bay of Plenty Region
Kawerau-Whakatane	Whakatane	Bay of Plenty Region
Gisborne	Gisborne	Gisborne Region
Gisborne	Opotiki	Bay of Plenty Region
Taranaki	New Plymouth	Taranaki Region
Taranaki	South Taranaki	Taranaki Region
Taranaki	Stratford	Taranaki Region
Taranaki	Stratford District	Manawatu-Wanganui Region
Hawke's Bay	Central Hawkes Bay	Hawke's Bay Region
Hawke's Bay	Hastings	Hawke's Bay Region
Hawke's Bay	Napier	Hawke's Bay Region
Hawke's Bay	Wairoa	Hawke's Bay Region
Ruapehu	Ruapehu	Manawatu-Wanganui Region
Manawatu	Manawatu	Manawatu-Wanganui Region
Manawatu	Palmerston North City	Manawatu-Wanganui Region
Manawatu	Rangitikei	Manawatu-Wanganui Region

Manawatu	Tararua	Manawatu-Wanganui Region
Wanganui	Wanganui	Manawatu-Wanganui Region
Wairarapa	Carterton	Wellington Region
Wairarapa	Masterton	Wellington Region
Wairarapa	South Wairarapa	Wellington Region
Kapiti-Horowhenua	Horowhenua	Manawatu-Wanganui Region
Wellington	Kapiti Coast	Wellington Region
Wellington	Lower Hutt City	Wellington Region
Wellington	Porirua City	Wellington Region
Wellington	Upper Hutt City	Wellington Region
Wellington	Wellington City	Wellington Region
Marlborough	Marlborough	Marlborough Region
Nelson Tasman	Nelson City	Nelson Region
Nelson Tasman	Tasman	Tasman Region
Canterbury	Ashburton	Canterbury Region
Canterbury	Christchurch City	Canterbury Region
Canterbury	Hurunui	Canterbury Region
Canterbury	Kaikoura	Canterbury Region
Canterbury	Selwyn	Canterbury Region
Canterbury	Waimakariri	Canterbury Region
Canterbury	Waimate	Canterbury Region
Timaru	Timaru	Canterbury Region
MacKenzie	Mackenzie	Canterbury Region
Waitaki	Waitaki	Canterbury Region
Waitaki	Waitaki	Otago Region
West Coast	Grey	West Coast Region
West Coast	Westland	West Coast Region
West Coast	Buller	West Coast Region
Lake Wanaka	Queenstown-Lakes	Otago Region
Queenstown	Central Otago	Otago Region
Central Otago	Dunedin City	Otago Region
Dunedin	Dunedin	Otago Region
Clutha	Clutha	Otago Region
Fiordland	Gore	Southland Region
Southland	Invercargill City	Southland Region
Southland	Southland	Southland Region