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Modeling Intrastate Air Travel: A Case Study of the State of Florida

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Modeling Intrastate Air Travel: A Case Study of the State of Florida

by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
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DEDICATION

I am grateful that God granted me the opportunity to be a student at the University of South Florida in the US. He provides me with joys, and allows me to overcome challenges that have resulted on my development and growth both as a person and as a professional.

This thesis is dedicated to my family and friends. First of all, I would like to express a special feeling of gratitude to my loving husband, Jie Zhang. Thank you for the support, the fun, and the love you have given me in this process. I would also like to express my most sincere gratitude to my mother, Xueqiong Wu, for her unconditional encouragement, inspiration and support which have enabled me to reach this stage.

In addition, I would like to offer special thanks to my friends, Wenge Wei and Qiong Zhang, for their help and concern in daily life matters.

Finally, I would like to thank those who have helped me in this process.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Florida is a state in the southeastern region of the United States. Its infrastructure allows for several travel modes including: rail, automobile, bus, aircraft, and ship. However, most intrastate travelers in Florida are limited to two practical choices: travel by car (ground mode) or travel by air (air primary mode). Due to the dramatic growth of Florida's population over recent years, traffic has become a critical factor that impacts Florida's development. This thesis focuses on intrastate air primary mode and develops decision making models that could aid government and airline companies to better understand travelers need and as such plan to provide economical and feasible alternatives for passengers. In addition, this work presents a model to assist individual travelers to evaluate various mode alternatives and better plan for upcoming trips.

In the first part of this thesis, two decision models are discussed: Time-Based and Cost-Based models. For each model, two scenarios are considered. Break-even air flight lengths for the commercial airport pairs in Florida are calculated. The results suggest that some airport pairs should open intrastate nonstop flights based on time and cost factors.

In the second part of this thesis, a forecasting methodology is applied to predict demand of intrastate air passengers in Florida. Firstly, factors affecting demand are introduced and relevant data are collected. Gravity models are built through linear regression method. The results show that there is a potential increase on the demand for intrastate travel for some airport pairs in Florida. Findings from the forecasting tool support the results obtained by the mathematical models developed in the first part of this work.

The third component of this thesis is an interactive comparison system built using Excel VBA. The tool allows a passenger to specify personal preferences related to time, cost in order to suggest which travel mode would be more effective based on the individual's specified parameters.

CHAPTER 1: INTRODUCTION

1.1 Background and Motivations

New residents come to Florida every day. According to the U.S. Census Bureau state population estimates released on December 23, 2014, Florida became the nation's third most populated state [1]. Population of Florida has steadily increased year after year and most projections support a continuation of this trend as shown in Figure 1-1 [2]. By 2040, Florida's inhabitants are estimated to reach the 26 million [2]. With an increase in population, intrastate demand of travel will rise. Besides, approximately 15% ($114.7 billion) of Florida's Gross State Product, is from Florida's airports [3].

Table 1-1 [4] shows the mode distribution by travel type in Florida. Intrastate travel includes trips that the origin and destination is located in Florida, while interstate travels means that either an origin or destination is located in another state [4]. Generally speaking, distances of intrastate trips are longer than that of interstate trips. For intrastate trips, Car type occupies the majority percentage, followed by Bus type, and Airplane type takes the third place. When looking at Figure 1-2 [4], for Work and Family/Personal Business purpose, Airplane type occupies a larger percentage than Bus type. Whatever travel modes the travelers choose, they desire a rapid and convenient transportation system with sufficient connectivity, capacity and travel mode options in Florida [5].

Among all travel modes on the transportation system in Florida, the intrastate business travelers mainly have two practical choices, travel by car (ground mode) or travel by air (air primary mode). In terms of the ground mode, figure 1-3 shows congested corridors on Florida's Strategic Intermodal System (SIS). Congestion on Florida's highways is increasing currently and is highly likely to grow in the future [5]. Moreover, as shown in Figure 1-4 [6], percent change in public road centerline miles in Florida was small from 1992 to 2013, and trend of the percent change is not optimistic. As mentioned before, with the rise of the intrastate travel, demand of intrastate air service will increase as well. Air travel and aviation facilities will become a critical part to satisfy the demand of Florida intrastate travel. How to plan transportation investments to improve the transportation system in Florida is a key point to meet the growing demand. However, compared to mature and saturated ground transportation, Florida lacks a robust intrastate air service network.

Hence it is important to understand current Florida intrastate air service status, figure out the factors that influence travelers' choice, and obtain useful information about the intrastate air service.

1.2 Objectives and Organization of the Thesis

The overall objective of this thesis is to examine demand of the potential intrastate air passengers for air service in Florida, so that it can offer the government useful information to improve intrastate air service and help them plan transportation investments to improve the transportation system in Florida. In order to achieve this goal, this thesis focuses on two main methodologies: Modeling and Forecasting. This thesis includes 6 chapters, and they are organized as follows:

- Chapter 2 introduces a Time-Based Travel Mode Decision Model. The assumptions were made and relevant data were collected. The process of building the model was discussed. Finally, Matlab codes were used to simulate two scenarios of this decision model.

- Chapter 3 introduces a Cost-Based Travel Mode Decision Model. The assumptions were made and relevant data were collected. The process of building the model was discussed. Finally, Matlab codes were used to simulate two scenarios of this decision model.
- Chapter 4 evaluates demand of the potential intrastate air passengers using forecasting methods. Relevant historical data were collected and utilized to build linear regression models. The best linear regression model was used to project the future demand of the intrastate air passengers.
- In order to adapt the two decision models presented in Chapter 2 and Chapter 3 to address individual passengers' needs, a comparison system was developed. Chapter 5 presents this system and illustrates the application with a real example.
- Finally, Chapter 6 concludes the current research and points out recommendations for future work.

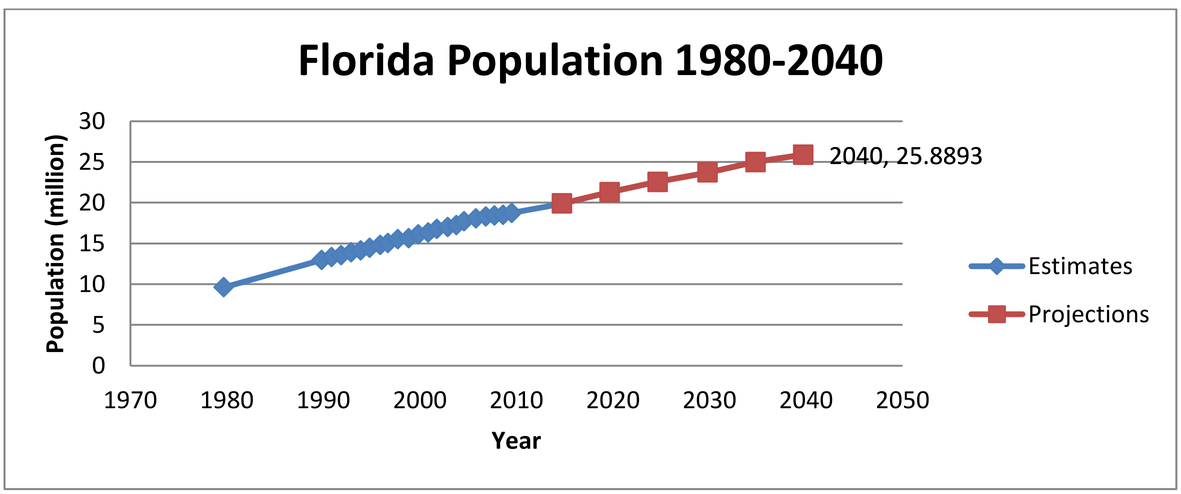


Figure 1-1 Projections of Florida Population [2].

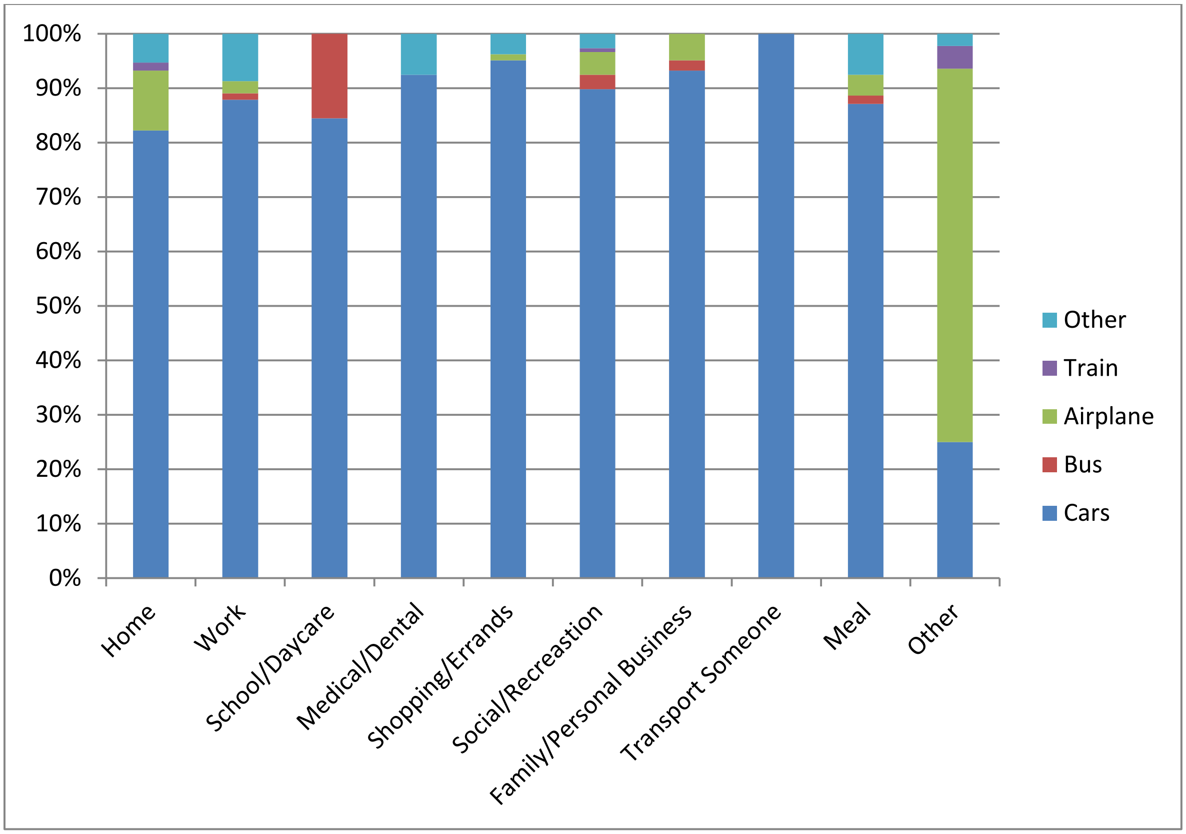


Figure 1-2 Mode Share by Trip Purpose [4].

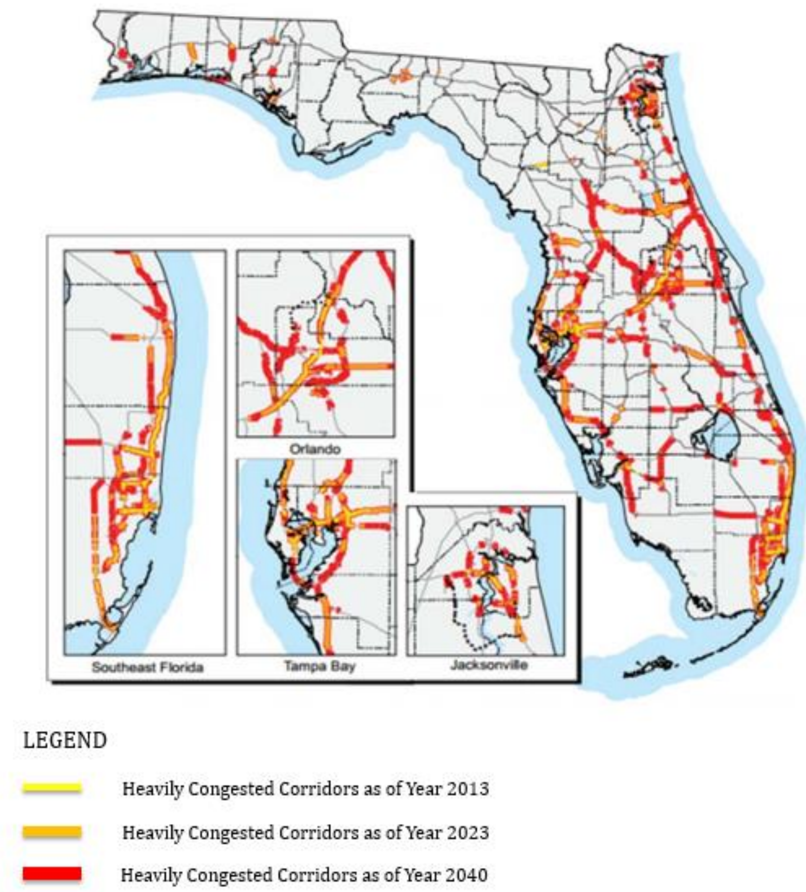


Figure 1-3 Florida Congested Corridors 2013 [5]. Note: from A Report on Florida Transportation Trends and Conditions: Impact of Transportation and the Economy. (p. 10) by the Florida Department of Transportation Office of Policy Planning. Copyright 2015 by the State of Florida, Department of Transportation. Reprinted with permission.

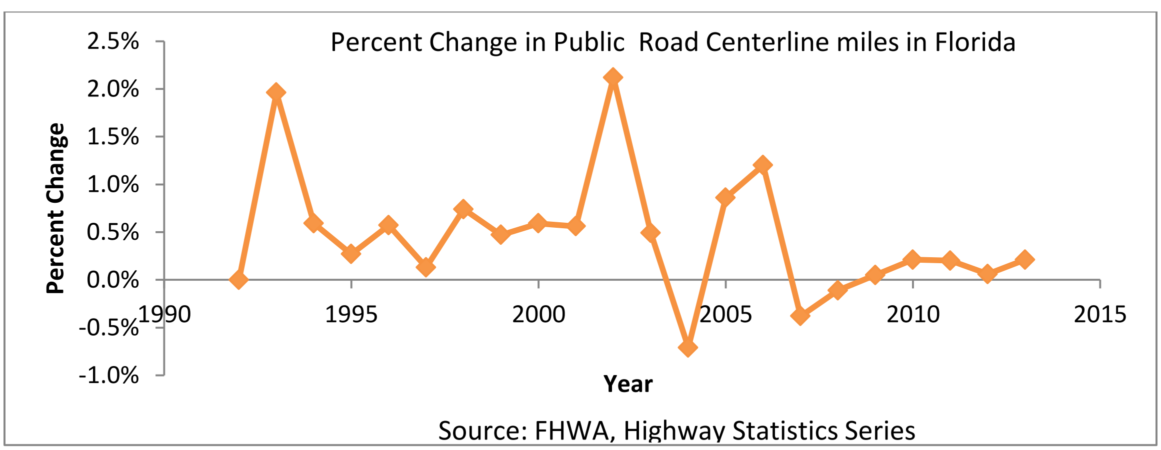


Figure 1-4 Percent Change in Public Road Centerline Miles in Florida [6].

Table 1-1 Share of Travel Mode of Intra and Interstate Long-distance Trips.

	Cars	Bus	Airplane	Train	Other	Total
Intrastate	684	10	5	4	27	730
(%)	93.7	1.4	0.7	0.6	3.7	100
Interstate	99	2	43	0	12	156
(%)	63.5	1.3	27.6	0.0	7.7	100

CHAPTER 2: TIME-BASED TRAVEL MODE DECISION MODEL

2.1 Introduction

As mentioned before, Florida's infrastructure allows for several travel modes including: rail, automobile, bus, aircraft and ship. The intrastate business travelers in Florida mainly have two practical choices, travel by car (ground mode) or travel by air (air primary mode). Currently, Florida has a broad system of 129 public-use airports that serve the needs of its residents, businesses, and visitors. In 2013, this system of airports consists of 19 commercial service and 110 general aviation airports [7]. This thesis is mainly concentrated on 19 commercial airports. Table 2-2 [8] shows Florida commercial airport pairs' ground and air distances.

Since most people mainly consider time (business travelers) or cost (leisure travelers) factors, when they are facing a choice of transportation modes, the modeling will be built with time and cost as major attributes.

Two models are as follows:

- Time-Based Travel Mode Decision Model;
- Cost-Based Travel Mode Decision Model.

Generally speaking, business travelers are more concerned about time than cost, because their travel costs are compensated [4]. Chapter 2 considers time factor and discusses Time-Based Travel Mode Decision Model. It presents assumptions, modeling, data collection, application of modeling, and results and discussion.

2.2 Preliminary and Methodology

Time-Based Travel Mode Decision Model calculates the travel times of two different modes (air primary mode and ground mode), and then determines the break-even air flight length D_{BE_b} at which air primary mode becomes more attractive, i.e., when the travel time of the air primary mode is equal to that of the ground mode.

Time-Based Travel Mode Decision Model follows some assumptions below:

- Travelers are individual travelers;
- Air travel is one way and involves no en-route stopovers;
- Ground travel is one way;
- Unexpected air transportation delays are not considered;
- The air primary mode traveler applies ground transportation from starting home or office to the departure airport and from the arrival airport to the ultimate destination [9];

The ground mode traveler uses a personal vehicle for travel from the starting point (home or office) to the ultimate destination, while the air primary mode traveler uses a personal vehicle for travel from the starting point (home or office) to the departure airport and uses a rental car for travel from the arrival airport to the ultimate destination.

2.2.1 Travel Geometry Model

In order to simplify the analysis, Travel Geometry Model will be used in this study, as shown in Figure 2-1. A represents the starting point (home or office), B represents the center of departure ASA (Airport Service Area, here it is considered as a circle), and C represents common exit points from the departure ASA. D denotes common entry points into the arrival

ASA (it is also considered as a circle) for all travel modes, E denotes the center of the arrival ASA, and F denotes the ultimate destination.

As shown in Table 2-1, β represents the total air miles divided by the total ground miles between the system's airport pairs. Since ground travel legs cannot be point to point mostly, they must be adjusted by β. The total air miles (all air distances display in the lower left triangle in Table 2-2) is 37460, and the total ground miles (all air distances display in the upper right triangle in Table 2-2) is 48689. So we can get β value with equation (2.1).

$$\beta = \text{total air miles}/\text{total ground miles} = 0.76937 \tag{2.1}$$

For the calculation in Table 2-1, D_{AB} is the distance between the local starting point (home or office) and the center of the departure airport service area (ASA), i.e., the departure airport, and D_{BC} is the distance between the center of the departure airport service area and the common exit point from the departure ASA. D_{CD} is the distance between the common exit point from the departure ASA and the common entry point into the arrival ASA regardless of modes, and D_{DE} is the distance between the common entry point into the arrival ASA and the center of the arrival ASA, i.e., the arrival airport. D_{EF} is the distance between the center of the arrival ASA and the ultimate destination, D_{AIR} is the total one way distance covered by the air primary mode, and D_{CAR} is the total one way distance covered by ground mode. T_{AIR} is total air travel time, including access and egress times, and T_{CAR} is total ground travel time. R_A is speed rate of travel by air in miles per hour, and R_C is speed rate of travel by ground in miles per hour. W_B is waiting time to transition from ground to air travel at a departure airport, and W_E is waiting time to transition from air to ground travel at an arrival airport. For ground mode, traveler starts at point A. The traveler drives his/her own car through point C and then D, and finally arrives the ultimate destination F. For air primary mode, traveler drives his/her own car from point A to airport B, and takes a flight to destination airport E. Finally, the traveler drives a rental car to ultimate destination F.

2.2.2 Parameter Selection

There are some parameters in Time-Based Travel Mode Decision Model, which need to be established. How to select them is discussed in this section. As mentioned above, R_C is speed rate of travel by ground in miles per hour. According to 2014 Florida Driver's Handbook, Municipal Speed Area Speed limit is 30 mph, and Business or Residential area is 30 mph. Rural Interstate and Limited Access Highways are both 70 mph, and All other Roads and Highways is 55 mph [10]. Assume that travelers go through all of these roads. Here, this study calculates R_C by weighting those three different speeds (70 mph, 30 mph and 55 mph) for the following simulation with the corresponding weights: 0.3, 0.3 and 0.4. Then R_C is equal to 52 mph. R_C can be various for different travelers in different scenarios.

For access and location of airports at the national level, the performance measure in the NPIAS (National Plan of Integrated Airport Systems), uses a 60 minute criteria for scheduled air service airports [11], so D_{BC} and D_{DE} are both set to $R_C * 1$ miles.

This thesis considers 19 commercial airports in Florida, and the maximum air distance between two airports is 530 miles, as shown in Table 2-2. According to the description of [12]—a short-haul domestic flight (where the arrival airport and departure airport are both in the same country) would be classified as having a flight length which aircrafts can finish with one and a half hours. This can be roughly converted to an absolute distance of no more than 500 miles—the short-haul airliners fit well here and maybe some medium-haul airliners can be used as well. There are some short-haul and medium-haul airliners performance listed in Table 2-3 [13]. According to the entry "Economical cruising speed" in Table 2-3, this study considers two different cases of R_A: 220 mph and 520 mph. R_A can be different when travelers take different aircrafts.

As mentioned before, W_B is the waiting time, and it is equal to the sum of W_C, W_T, W_S, W_P and W_G. W_C is set as 5 minutes to park a car and make way to the check-in counter, and W_T is set as 26.1 minutes for check-in processing (including check-in processing 13.4 minutes and security processing 12.7 minutes, as shown in Figure 2-2 [14]. Since this thesis considers Florida intrastate air service, immigration and bag delivery time can be ignored here. W_S is set as 5 minutes for going to the departure gate, W_P is set as 20 minutes for aircraft boarding and departure procedures, and W_G is set as 10 minutes for aircraft gate departure, taxi, and takeoff.

W_E is another waiting time and it is equal to the sum of W_A, W_F, W_D, $W_L$and W_R. W_A is set as 10 minutes to adjust speed of aircraft to less than cruise speed, W_F is set as 10 minutes for aircraft post-landing taxi and shutdown, and W_D is set as 10 minutes for deplaning and travel to the baggage area. W_L is set as 10 minutes for luggage collection, and W_R is set as 10 minutes for car rental and loading. The waiting times above can be different for different travelers.

2.2.3 Calculation of Distances

In this thesis, in order to compare two travel modes, centroids of the population of all the counties in Florida are collected, listed in the format of latitude and longitude, as shown in Table 2-4 [15]. They are set as the starting points (A) and ultimate destinations (F) of trips. Meanwhile the site of airports can be converted to latitude and longitude on the website: http://www.latlong.net/convert-address-to-lat-long.html. The airports DAB and FLL pair is taken as an example, as shown in Figure 2-3. The red spots represent airports, and the green spots represent corresponding centroids of the population. The circles represent ASAs. To get all the distances in Time-Based Travel Mode Decision Model, the (latitude, longitude) pairs are converted to distance (X, Y) pairs in a new coordinate system, as shown in Figure 2-4.

Firstly, transformation formula from (latitude, longitude) to distance (X, Y) is shown in (2.2), (2.3) [16].

$$\Delta_{Lat}^{1} = 111132.954 - 559.822\cos 2\emptyset + 1.175\cos 4\emptyset \tag{2.2}$$

$$\Delta_{Long}^{1} = \frac{\pi a \cos\emptyset}{180(1 - e^2 \sin^2\emptyset)^{1/2}} \tag{2.3}$$

where $\emptyset$ is geodetic latitude and a is equatorial radius (6,378,137.0 meter); $e^2$is eccentricity squared (0.00669438); Δ_{Lat}^{1} represents the distance of one unit latitude; Δ_{Long}^{1} represents the distance of one unit longitude. The airports that are considered in this thesis are all Florida commercial airports, and from Table 2-4 we know that the maximum latitude of Florida commercial airports and counties is +30.542829, while the minimum latitude is +24.556987. Then Δ_{Lat}^{1} varies from 110.766 km (68.827 miles) to 110.861 km (68.886 miles), while Δ_{Long}^{1} varies from 101.309 km (62.950 miles) to 95.956 km (59.625 miles). Since the ranges of Δ_{Lat}^{1} and Δ_{Long}^{1} are both narrow, this study uses the latitude +27 to calculate both of them. And then Δ_{Lat}^{1} and Δ_{Long}^{1} are utilized to convert the airports and centroids of the population to a new coordinate.

The new coordinate is shown in Figure 2-5, and A, B, E, F points are known here and they are projected onto the new coordinate. From the knowledge above, B, C, D, E are in a line as shown in Figure 2-5, and D_{BC} and D_{DE} are known. In order to get C and D coordinates, geometrical relationships are used here. We set B(x_b, y_b) , C(x_c, y_c), D(x_d, y_d) and E(x_e, y_e). C(x_c, y_c). (2.4) and (2.5) are the equations to calculate C(x_c, y_c) and D(x_d, y_d).

$$\begin{cases} \dfrac{y_c - y_e}{y_b - y_e} = \dfrac{D_{CE}}{D_{BE}} \\ \dfrac{x_e - x_c}{x_e - x_b} = \dfrac{D_{CE}}{D_{BE}} \\ x_c = \dfrac{D_{CE}(y_b - y_e)}{D_{BE}} + y_e, y_c = \dfrac{D_{CE}(y_b - y_e)}{D_{BE}} + y_e \end{cases} \tag{2.4}$$

$$\begin{cases} \dfrac{y_d - y_e}{y_b - y_e} = \dfrac{D_{DE}}{D_{BE}} \\ \dfrac{x_e - x_d}{x_e - x_b} = \dfrac{D_{DE}}{D_{BE}} \\ x_d = \dfrac{D_{DE}(y_b - y_e)}{D_{BE}} + y_e, y_d = \dfrac{D_{DE}(y_b - y_e)}{D_{BE}} + y_e \end{cases} \tag{2.5}$$

Since every distance in the model is known, according to the equations in Table 2-1, break-even air flight length can be calculated here. Taking JAX and TLH airport pair as an example, the values of the parameters are listed in Table 2-5. The values of the parameters can be changed according to different travelers, different places and different time periods. Here, k is the choice of R_a (number 1 represents that 220 mph is chosen, while number 2 represents that 520 mph is chosen). Mode represents the choice of Time-Based Travel Mode Decision Model or Cost-Based Travel Mode Decision Model (number 1 represents that Time-Based is chosen, number 2 represents that Cost-Based is chosen). Cost-Based Travel Mode Decision Model is discussed in Chapter 3. Table 2-6 displays Florida commercial airports and their corresponding counties.

It is easy to notice that the discussion above considers the airport pairs which have no overlapped ASAs. However, overlapped ASAs would happen in reality, so it is necessary to present models of them. Schematic diagram of overlapped ASAs is shown in Figure 2-6. In this case, only the motion mode of ground mode changes, while that of air primary mode is still the same. For the ground mode, a traveler starts at A point, he/she drives his/her own car through point C, and finally arrives ultimate destination F. Table 2-7 displays the calculation for overlapped ASAs situation.

2.3 Results and Discussion

Matlab is utilized to make the codes, and flow diagram of the codes is shown in Figure 2-7. Taking JAX and TLH airport pair as an example, the values of the parameters are listed in Table 2-5.

The result of break-even air flight length D_{BE_b} is 119.21 miles. Comparing with original distance (160 miles) in Table 2-2, D_{BE_b} is smaller, so the conclusion is that if a traveler plans to travel from the place of centroid of the population in Duval County to the place of centroid of the population in Leon County, air primary mode is more time effective than ground mode based on Time-Based Travel Decision Model.

Besides, when $\mathrm{R_a}$ is set as 520 miles per hour (k=2), the break-even air flight length becomes 105.66 miles. Comparing to the result before, the larger $\mathrm{R_a}$ becomes, the more attractive air primary mode is. It means airliners can attract travelers to choose air primary mode through increasing speed rate of travel by air. As shown in Figure 2-8, the larger Rc, We, Wb become, the more attractive ground mode is. It means if speed rate of travel by ground or waiting time of air primary mode increase, travelers are more attractive to ground mode. Finally, elasticity analysis is shown in Figure 2-9. Elasticity of Rc, We, Wb are all smaller than 1 within the setting range, which means they are all inelastic to break-even air flight length D_{BE_b}.

Figure 2-1 Travel Geometry Model.

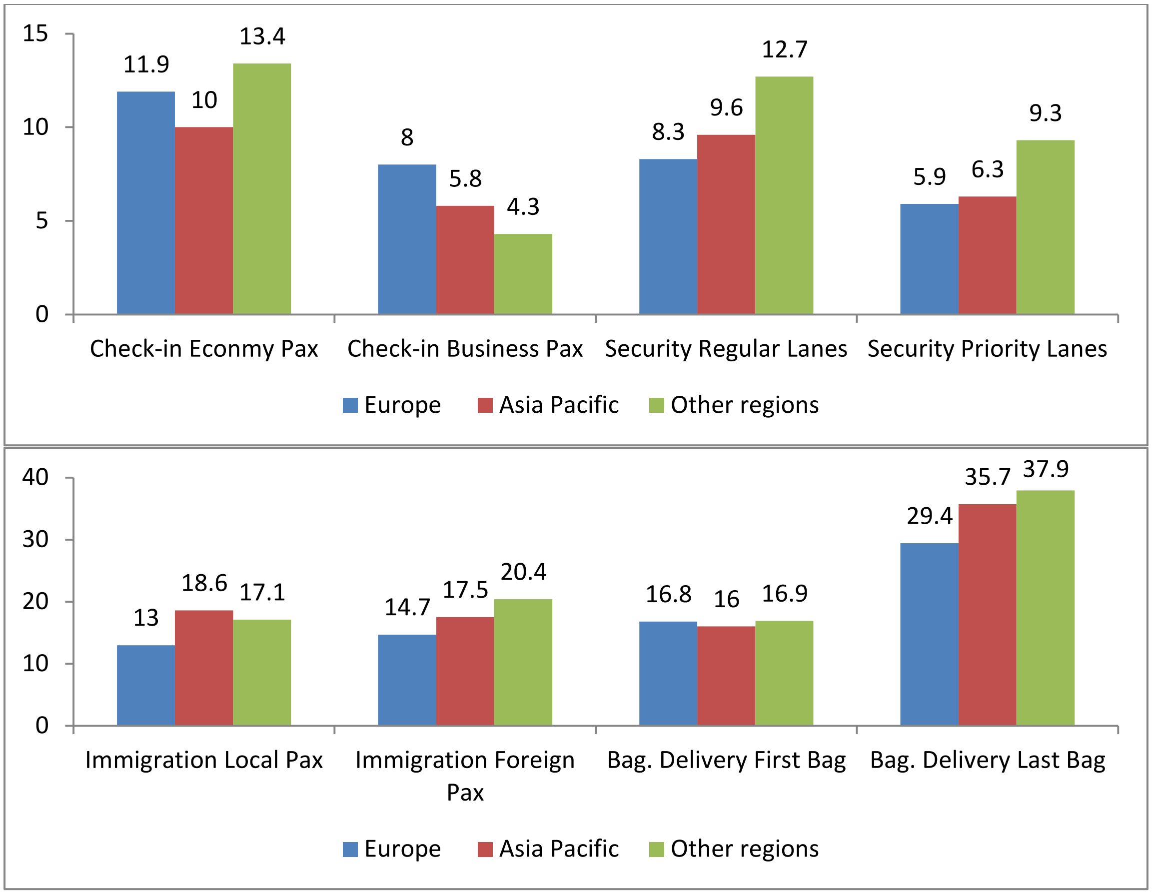


Figure 2-2 Standard Waiting Time by Region [14].

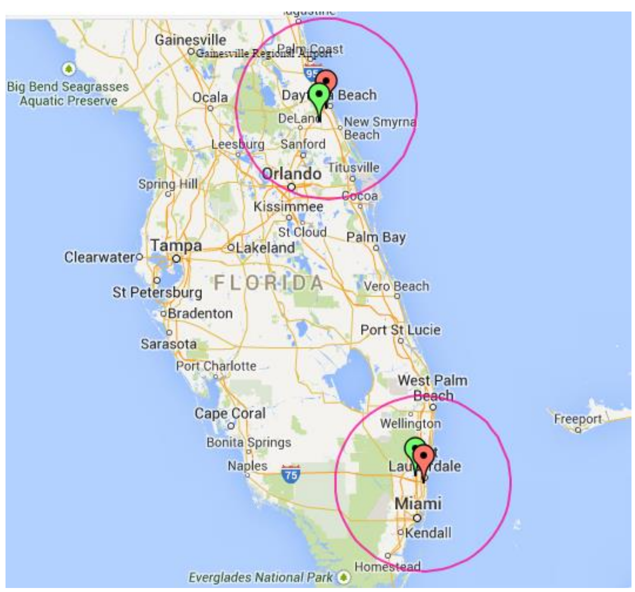


Figure 2-3 DAB and FLL Geometry Distribution.

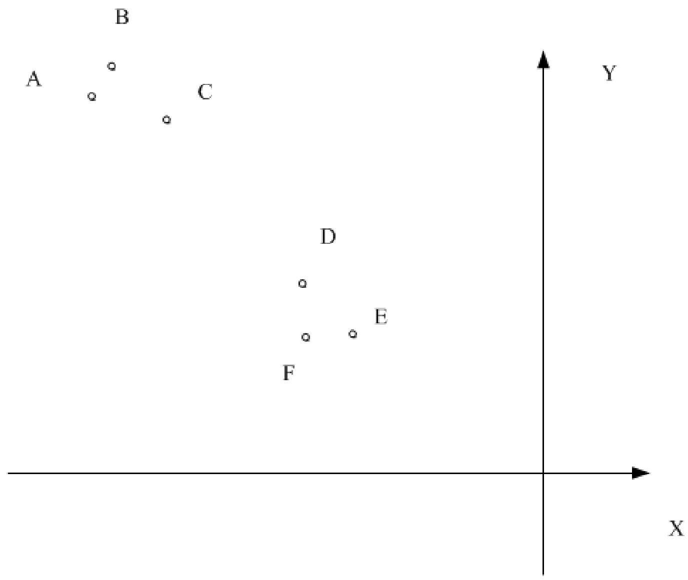


Figure 2-4 Schematic Diagram of Figure 2-3.

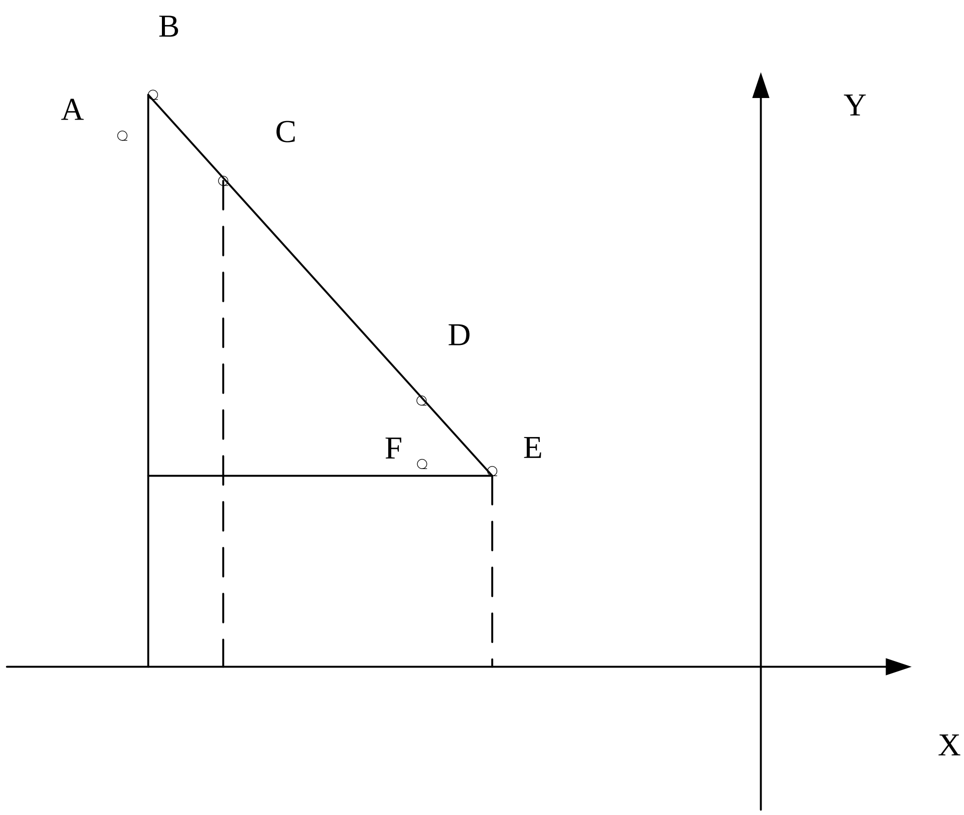


Figure 2-5 Geometry Distribution of DAB and FLL Scenario.

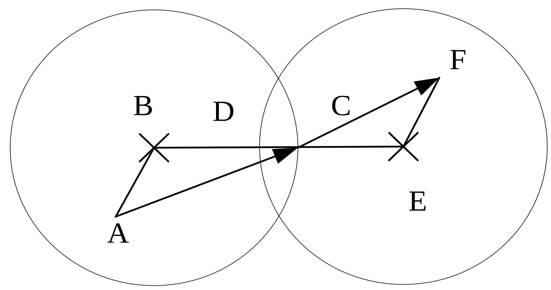


Figure 2-6 Schematic Diagram of Overlapped ASAs.

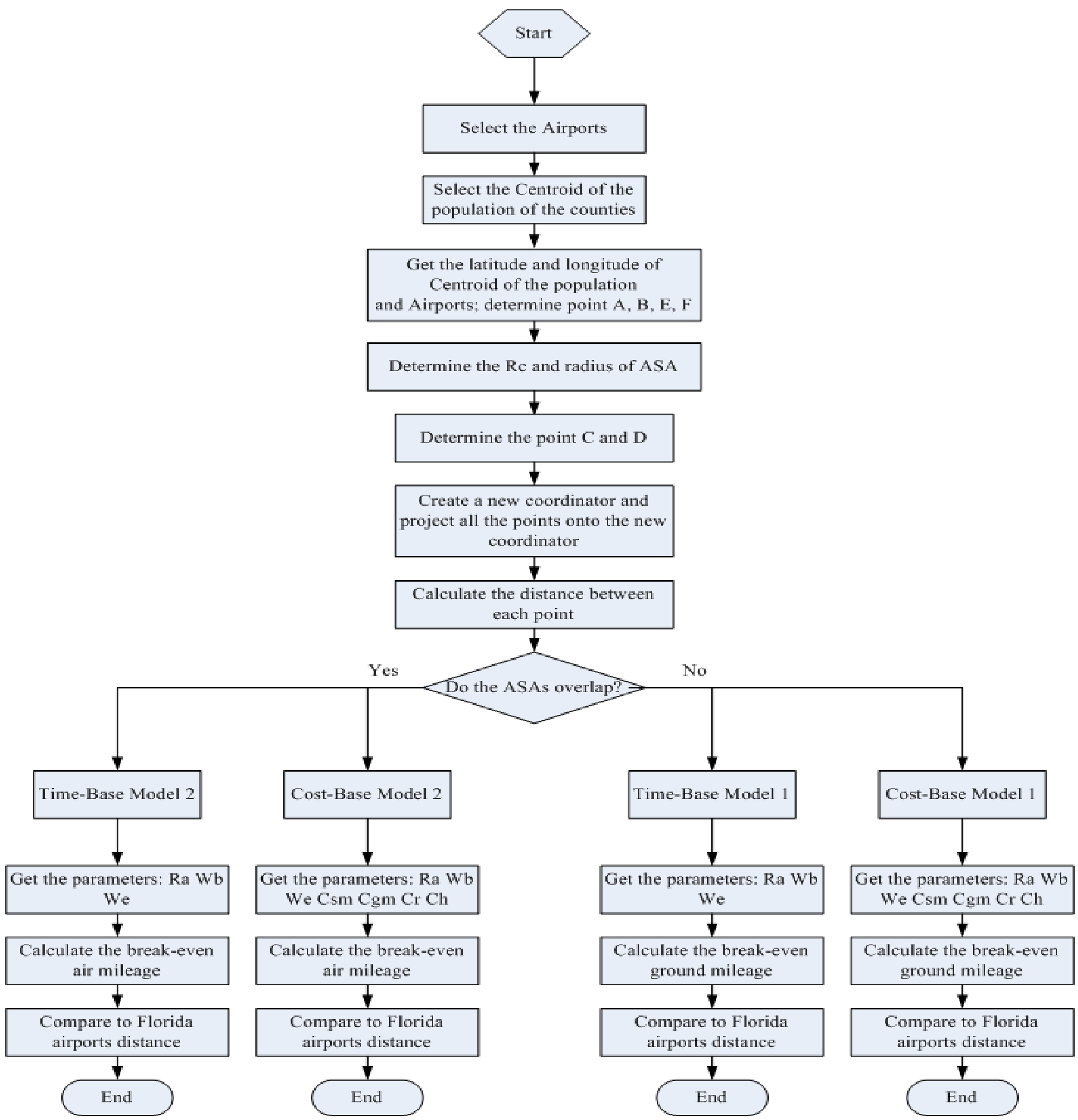
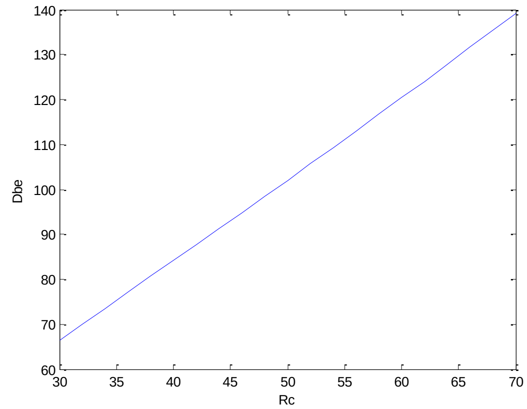
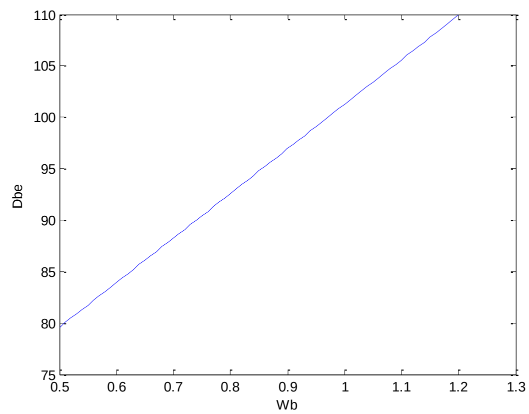


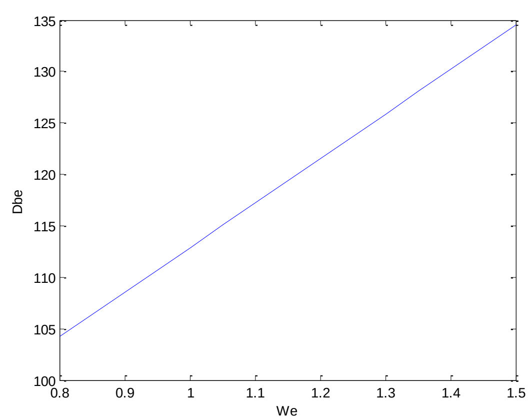
Figure 2-7 Flow Diagram of the Codes in Matlab.



(a)

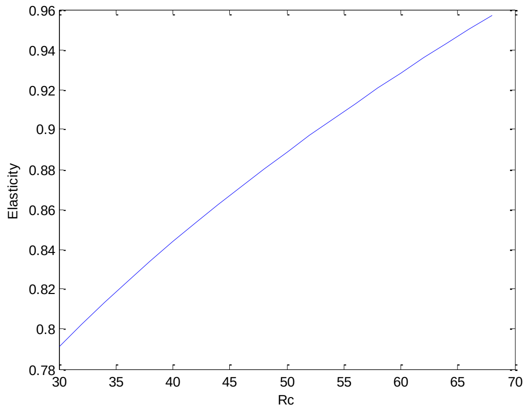


(b)

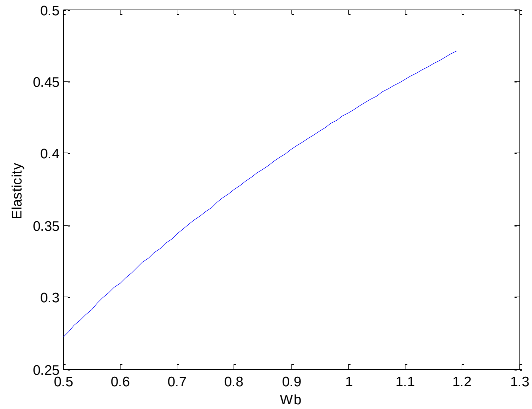


(c)

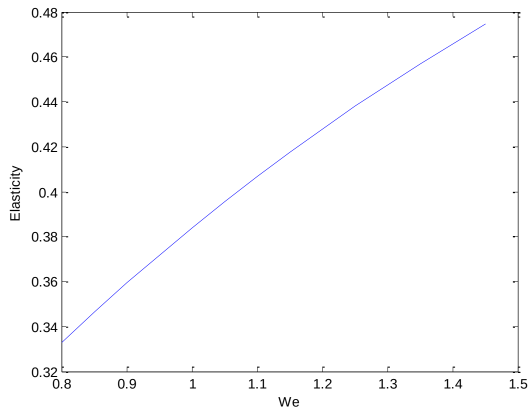
Figure 2-8 The Influence of (a) R_c, (b) W_b, and (c) W_e on Decision Making.



(a)



(b)



(c)

Figure 2-9 Elasticity Analysis of (a) R_c, (b) W_b, and (c) W_e for the Time-Based Travel Mode.

Table 2-1 The Calculation of the Time-Based Travel Mode Decision Model.

Inputs: β D_{AB} D_{AC} D_{BC} D_{DE} D_{DF} D_{EF} R_A R_C W_B W_E
$D_{AIR} = D_{AB} + D_{BC} + D_{CD} + D_{DE} + D_{EF}$ $D_{CAR} = (1/\beta)(D_{AC} + D_{CD} + D_{DF})$ $T_{AIR} = \left(D_{AB}/(\beta . R_C)\right) + W_B + \left(\frac{D_{BC}}{R_A}\right) + \left(\frac{D_{CD}}{R_A}\right) + \left(\frac{D_{DE}}{R_A}\right) + W_E + \left(D_{EF}/(\beta . R_C)\right)$ $T_{CAR} = \frac{D_{AC} + D_{CD} + D_{DF}}{\beta R_C}$ $T_{AIR} = T_{CAR}$
$D_{CD} = \frac{R_A(D_{AB} + D_{EF} - D_{AC} + D_{DF}) + \beta R_C R_A (W_B + W_E) + \beta R_C (D_{BC} + D_{DE})}{(R_A - \beta R_C)}$ $D_{CAR} = (1/\beta)(D_{AC} + D_{CD} + D_{DF}$ $D_{BE\_b} = D_{BE} = D_{BC} + D_{CD} + D_{DE}$
Outputs: D_{CD} D_{CAR} D_{BE} D_{BE_b}

Table 2-2 Florida Commercial Airport Pairs' Ground and Air Distances.

	DAB	FLL	RSW	GNV	JAX	EYW	MLB	MIA	MCO	SFB	ECP	PNS	PGD	SRQ	PIE	TLH	TPA	VPS	PBI
DAB		244	219	99	109	416	87	261	71	39	360	447	183	176	152	267	142	409	199
FLL	222		132	326	345	185	159	27	216	230	587	655	161	219	259	457	267	620	50
RSW	187	105		266	338	290	188	141	174	198	526	595	35	93	133	415	141	561	128
GNV	82	281	220		79	498	187	344	129	144	255	342	234	182	152	161	144	305	282
JAX	99	319	273	66		520	189	362	174	145	295	363	304	256	225	183	218	330	302
EYW	322	145	137	355	409		333	162	386	404	742	828	319	381	405	648	430	795	228
MLB	79	144	128	148	177	254		178	62	75	428	515	175	184	160	334	152	489	118
MIA	238	21	105	295	335	126	161		234	248	605	673	172	231	271	502	282	639	71
MCO	55	178	134	105	144	269	46	193		34	390	458	132	125	101	278	92	424	174
SFB	30	198	158	89	122	293	59	214	24		405	472	163	156	132	293	124	436	188
ECP	297	454	361	217	246	471	348	461	302	296		120	478	442	394	101	404	64	540
PNS	379	525	428	300	329	527	428	530	381	377	84		559	515	482	191	472	66	608
PGD	166	128	30	192	247	164	116	131	112	136	331	400		63	103	383	112	530	137
SRQ	154	175	78	159	220	202	127	179	104	125	284	352	48		43	330	51	476	196
PIE	133	202	111	126	188	239	126	208	91	107	253	325	81	36		302	14	448	222
TLH	215	393	310	134	160	433	274	403	228	219	87	170	280	234	199		292	158	429
TPA	123	197	111	120	181	241	116	205	81	97	257	330	80	40	10	200		440	214
VPS	341	493	398	261	289	502	391	499	345	340	45	39	369	322	292	130	297		573
PBI	182	42	104	246	280	180	104	63	142	161	430	504	119	160	181	364	175	471	

Table 2-3 Aircrafts Performance.

Aircraft	Type	Economical cruising speed	Capacity
1) <72 seats			
The Aerospatiale N-262 Fregate & Mohawk 298	Short range turboprop commuter airliner	Fregate : 408km/h (220kt)—253.519mph Mohawk 298: 385km/h (208kt)--233mph	Standard seating layout for 26 passengers.
The Douglas DC-3	Short range airliner and utility transport (piston engines)	266km/h (143kt)-- 165.3mph	Seating for between 28 and 32 passengers at four abreast or 21 three abreast.
2) >=72 seats			
The Airbus A320	Short to medium range airliner (turbofans)	840km/h (454kt)—522mph	Main cabin can accommodate a maximum of 179 passengers in a high density layout.
The BAC 111 One-Eleven	Short haul airliner (turbofans)	742km/h (400kt)—461.06mph	Srs 500 - Typical seating for 97-109 passengers, max seating for 119.
The Boeing 717	Short to medium range airliner (turbofans)	Cruising speed 811km/h (438kt)--504mph	Typical two class seating for 106 passengers at five abreast in main cabin. Single class seating for 117.
The Boeing 727-200	Short to medium range narrowbody airliner(turbofans)	865km/h (467kt)-- 537.5mph	Max seating for 189 at six abreast and 76cm (30in) pitch, typical two class seating for 14 premium class and 131 economy class passengers.
The Boeing 737-100/200	Short range narrowbody airliner(turbofans)	852km/h (460kt)-- 529.4mph	737-100 - Typical single class seating for 100.
The McDonnell Douglas DC-9-10/20/30	Short range airliners (turbofans)	885km/h (478kt)—549.9mph	10 - Seating for 80 in a single class at five abreast and 86cm (34in) pitch. Max seating for 90.

Table 2-4 Longitude and Latitude of Airports and Centroid of Population in Florida Counties.

FAA	Latitude and Longitude of Airports	Airport name	Role	Centroid of Population	Florida county
		Commercial service – primary airports			
DAB	+29.179545, -81.056146	Daytona Beach International Airport	P-N	+29.073725,-081.123944	Volusia County
FLL	+26.074234, -80.150602	Fort Lauderdale–Hollywood International Airport	P-L	+26.134058,-080.227135	Broward County
RSW	+26.533705, -81.755308	Southwest Florida International Airport	P-M	+26.574992,-081.858144	Lee County
GNV	+29.686569, -82.276734	Gainesville Regional Airport	P-N	+29.665903,-082.386845	Alachua County

Table 2-4 (Continued).

FAA	Latitude and Longitude of Airports	Airport name	Role	Centroid of Population	Florida county
		Commercial service – primary airports			
JAX	+30.494071, -81.687937	Jacksonville International Airport	P-M	+30.300302,-081.622853	Duval County
EYW	+24.556987, -81.757397	Key West International Airport	P-N	+24.739678,-081.263945	Monroe County
MLB	+28.098596, -80.636925	Melbourne International Airport	P-N	+28.232195,-080.690979	Brevard County
MIA	+25.795865, -80.287046	Miami International Airport	P-L	+25.774565,-080.298888	Miami-Dade County
MCO	+28.431158, -81.308083	Orlando International Airport	P-L	+28.532855,-081.384377	Seminole County
SFB	+28.778812, -81.239737	Orlando Sanford International Airport	P-S	+28.697834,-081.310445	Seminole County
ECP	+30.352934, -85.794270	Northwest Florida Beaches International Airport [nb 1]	P-N	+30.206925,-085.660217	Bay County
PNS	+30.473816, -87.186705	Pensacola International Airport (Pensacola Gulf Coast Regional Airport)	P-S	+30.485314,-087.274788	Escambia County
PGD	+26.929784, -82.045366	Punta Gorda Airport (was Charlotte County Airport)	P-N	+26.954793,-082.119946	Charlotte County
SRQ	+27.395444, -82.554389	Sarasota–Bradenton International Airport	P-S	+27.208205,-082.423893	Sarasota County
PIE	+27.909149, -82.688393	St. Petersburg–Clearwater International Airport	P-N	+27.899794,-082.727651	Pinellas County
TLH	+30.395619, -84.345062	Tallahassee Regional Airport	P-S	+30.466103,-084.270371	Leon County
TPA	+27.983478, -82.537078	Tampa International Airport	P-L	+27.976529,-082.401275	Hillsborough County
VPS	+30.495566, -86.549285	Northwest Florida Regional Airport / Eglin Air Force Base	P-S	+30.542829,-086.567105	Okaloosa County
PBI	+26.685748, -80.092817	Palm Beach International Airport	P-M	+26.617075,-080.146119	Palm Beach County

Table 2-5 The Parameters of Simulation for JAX and TLH Airport Pair.

Airport1	Airport2	k	β	R_a	R_c	W_b	W_e	Highway 70	Local 30	Other 55
5	16	1	0.76937	220/520	52	1.10167	0.83333	0.3	0.3	0.4
W_t	W_c	W_s	W_p	W_g	W_a	W_f	W_d	W_l	W_r	Mode
26.1	5	20	10	5	10	10	10	10	10	1

Table 2-6 Number of Airports and Corresponding Counties.

1--DAB--Daytona Beach International Airport (county 1 9 10)	1--Volusia County
2--FLL--Fort Lauderdale–Hollywood International Airport (county 2 8 19)	2--Broward County
3--RSW--Southwest Florida International Airport (county 3 13)	3--Lee County
4--GNV--Gainesville Regional Airport (county 4)	4—Alachua County
5--JAX--Jacksonville International Airport (county 5)	5--Duval County
6--EYW--Key West International Airport (county 6)	6--Monroe County
7--MLB--Melbourne International Airport (county 7)	7--Brevard County
8--MIA--Miami International Airport (county 2 8)	8--Miami-Dade County
9--MCO--Orlando International Airport (county 1 7 9 10)	9--Orange County
10--SFB--Orlando Sanford International Airport (county 1 7 9 10)	10--Seminole County
11--ECP--Northwest Florida Beaches International Airport [nb 1] (county 11 18)	11--Bay County
12--PNS--Pensacola International Airport (Pensacola Gulf Coast Regional Airport) (county 12 18)	12--Escambia County
13--PGD--Punta Gorda Airport (was Charlotte County Airport) (county 3 13 14)	13--Charlotte County
14--SRQ--Sarasota–Bradenton International Airport (county 13 14 15 17)	14--Sarasota County
15--PIE--St. Petersburg–Clearwater International Airport (county 14 15 17)	15--Pinellas County
16--TLH--Tallahassee Regional Airport (county 16)	16--Leon County
17--TPA--Tampa International Airport (county 15 17)	17--Hillsborough County
18--VPS--Northwest Florida Regional Airport / Eglin Air Force Base (county 12 18)	18--Okaloosa County
19--PBI--Palm Beach International Airport (county 2 19)	19--Palm Beach County

Table 2-7 The Calculation of the Time-Based Travel Mode Decision Model (Overlapped ASAs).

Inputs: β D_{AB} D_{AC} D_{BC} D_{DE} D_{DF} D_{EF} R_A R_C W_B W_E
$D_{AIR} = D_{AB} + D_{BE} + D_{EF}$ $D_{CAR} = (1/\beta)(D_{AC} + D_{CF})$ $T_{AIR} = \left(D_{AB}/(\beta. R_C)\right) + W_B + \left(\frac{D_{BE}}{R_A}\right) + W_E + \left(D_{EF}/(\beta. R_C)\right)$ $T_{CAR} = \frac{D_{AC} + D_{CF}}{\beta R_C}$ $T_{AIR} = T_{CAR}$

Table 2-7 (Continued).

$D_{BE\_b} = D_{BE} = (\frac{(D_{AC} + D_{CF} - D_{AB} - D_{EF})}{\beta R_C} - (W_B + W_E))R_A$
Outputs: D_{BE} D_{BE_b}

CHAPTER 3: COST-BASED TRAVEL MODE DECISION MODEL

3.1 Introduction

Comparing with business travelers, leisure travelers are expected to be more sensitive to travel costs, because they need to pay the costs by themselves [4].

Chapter 2 completes the discussion of Time-Based Travel Mode Decision Model. This Chapter discusses Cost-Based Travel Mode Decision Model. It presents assumptions, modeling, data collection, application of modeling, and results and discussion. In the results and discussion section, break-even results of all commercial airport pairs of two decision models are displayed.

3.2 Preliminary and Methodology

A Cost-Based Travel Mode Decision Model calculates the cost of two different modes (air primary mode travel and ground mode travel), and determines the break-even air flight length D_{BE_b} at which air primary mode travel becomes more attractive, i.e., when the cost of the air primary mode is equal to that of the ground mode.

Cost-Based Travel Mode Decision Model follows some assumptions below:

- Travelers are individual travelers;
- Air travel is one way and involves no en-route stopovers;
- Ground travel is one way;
- Unexpected air transportation delays are not considered;

- The air primary mode traveler applies ground transportation from starting point (home or office) to the departure airport and from the arrival airport to the ultimate destination;
- The ground mode traveler uses a personal vehicle and her/his business travel is reimbursed [9];

The ground mode traveler uses a personal vehicle for travel from the starting point (home or office) to the ultimate destination, while the air primary mode traveler uses a personal vehicle for travel from the starting point (home or office) to the departure airport and uses a rental car for travel from the arrival airport to the ultimate destination.

3.2.1 Travel Geometry Model

In order to simplify the analysis, the geometry model will be used, as shown in Figure 2-1 in Chapter 2.

In this Chapter, Cost-Based Travel Mode Decision Model also considers two scenarios: airport pairs with overlapped ASA and without overlapped ASAs. Cost-Based Travel Mode Decision Model uses the same motion mode as that of Time-Based Travel Mode Decision Model in Chapter 2.

The calculations of the Cost-Based Travel Mode Decision Model without and with overlapped ASAs are shown in Table 3-1 and Table 3-2. C_R is cost of rental car in dollar, and its expression is $C_R = R_{car} + F_{cpg}/M_{pg} * D_{EF}$, where R_{car} is car rental daily rate in dollar. F_{cpg} is fuel price in dollar per gallon, and M_{pg} is fuel consumption in miles per gallon. C_H is cost per hour of the travelers' time in dollar per hour. C_{SM} is cost per seat mile for air travel in dollar per seat mile. C_{GM} is cost per ground mile (reimbursement rate of driving personal vehicle) in dollar per mile. The remaining parameters have the same definitions and explanations as those presented in Chapter 2.

3.2.2 Parameter Selection

There are many parameters in the Cost-Based Travel Mode Decision Model. The selection of these parameters is the main discussion in this section. The result of a survey in Auto Rental News shows some rate quotes in different regions and time periods [17]. Florida belongs to southeast region, so this study picks the rate close to present day and in southeast region. So the value of R_{car} is equal to 36.58 dollars. It may be different when travelers rent different cars in in different regions or different time periods. Fuel price on January 13, 2015 when the simulation was done, is shown in Figure 3-1 [18], so F_{cpg} is equal to 2.213 (dollar per gallon). F_{cpg} may be diverse in different regions or different time periods. According to a report written on February 13, 2013 on Auto Rental news website, 2012 Hyundai Accent was top 1 popular brand [19]. The study sets M_{pg} as 31 miles per gallon, which is in the performance measure of Hyundai Accent (it may be different when travelers drive different cars) [20], as shown in Figure 3-2. As shown in Figure 3-3, VTTS means Value of Travel Time Savings in dollars per hour. VTTS spreads from 2.27 dollars per hour to 79.32 dollars per hour with a mean of around 32 dollars per hour, so C_H takes 32 (it may be different when travelers take different occupations) [21].

According to the website http://www.orbitz.com/flights/, the airfares from JAX to TLH are all high. What's more, there are no nonstop flights between them. It is not suitable to use airfares of stop flights to estimate C_{SM}. The author notices that there are scheduled nonstop flights from TLH to MIA, whose airfares are 406.1 dollars most of the time (the author observed airfares of those flights once a week from 11/19/2014 to 01/22/2015). So the study sets C_{SM} as

1.008 dollar per mile seat based on the information above (406.1 divides 403 miles—original distance between TLH and MIA). C_{SM} may change if travelers take different airport pairs and they can use the actual airfares to get C_{SM}.

In addition, this study assumes that the traveler selects the Sedan as the vehicle model of choice for ground travel. In that case, this study uses Average Sedan data to value the following parameters. C_{GM} is associated with F_{cpg} and M_{pg}. The gas cost per mile is equal to F_{cpg}/M_{pg}, as shown in Figure 3-4 [22]. The method shown in Figure 3-5 [22] is utilized to calculate annual cost per mile C_{GM}. Here, this study uses the data in the average Sedan column and considers 15000 miles per year ownership cost. Finally, C_{GM} is equal to 0.5331 in Table 3-3.

3.3 Results and Discussion

Matlab is utilized to make the codes, and the flow diagram of the code is shown in Figure 2-7. JAX and TLH airport pair is taken as an example as well. The values of the parameters are displayed in Table 3-4. Since we know all the values of the parameters in Table 3-1, break-even air flight length can be calculated.

The result of break-even air flight length D_{BE_b} is 337 miles. Since D_{BE_b} is larger than 160 miles in Table 2-2, the conclusion is that ground mode is more cost effective than air primary mode based on Cost-Based Travel Decision Model.

When R_a is set as 520 (k=2) in the simulation, the result of break-even air flight length changes to 294.22 miles, which is smaller than 337 miles. This indicates that the larger R_a becomes, the more attractive air primary mode is. In addition, as shown in Figure 3-6, the larger C_h and F_{cpg} become, the more attractive air primary mode is. It means when the travelers have a higher wage or fuel cost increases, they are inclined to choose air primary mode. Moreover, the larger C_{SM}, R_c, W_e, W_b, R_{car}, M_{pg} become, the more attractive the ground mode is. It means when airfare, or speed rate of travel by ground, or waiting time of transition for air primary mode, or daily rate of rental car or miles per gallon of car increase, travelers are inclined to choose the ground mode.

Finally, this study performs the elasticity analysis as shown in Figure 3-7. Elasticity of F_{cpg}, W_e, W_b, R_{car}, and M_{pg} are all smaller than 1 within the setting ranges, which means they are all inelastic to break-even air flight length. When R_C is larger than 30 miles per hour, elasticity is larger than 1, which means it is elastic to break-even air flight length. When C_H is larger than 32, elasticity is larger than 1, which means it is elastic to break-even air flight length. When C_{SM} is larger than 0.7, elasticity is larger than 1, which means it is elastic to break-even air flight length.

The results of break-even air flight lengths for all Florida commercial airport pairs of two decision models are displayed in Figure 3-8. Table 3-5 gives the values of the parameters used in this simulation. From the aspect of the Time-Based Travel Mode Decision Model, air primary mode holds a dominant position. From the aspect of the Cost-Based Travel Mode Decision Model, the nonstop air flights of some airport pairs are suggested to be opened as well. When comparing the results of two decision models with the actual opening intrastate nonstop flights in the database of Bureau of Transportation Statistic in 2013, this study suggests 35 airport pairs in Florida should open intrastate nonstop air flights based on time and cost factors. Those airport pairs are listed in Table 3-6.

Florida Fuel Prices				
Prices updated as of 1/13/2015 3:45am				
	Regular	Mid	Premium	Diesel
Current Avg	$2.213	$2.487	$2.691	$2.999
Yesterday Avg	$2.225	$2.496	$2.704	$3.009
Week Ago Avg	$2.299	$2.574	$2.779	$3.086
Month Ago Avg	$2.620	$2.901	$3.105	$3.362
Year Ago Avg	$3.391	$3.626	$3.812	$3.970

Figure 3-1 Florida Fuel Prices F_{cpg} [18].

Manufacturer Model Configuration (trans, eng size,cyl)	MPG		Annual Fuel Cost	GHG Rating	Notes
	City/Hwy	Comb			
HYUNDAI					
Accent					
A-6, 1.6L, 4cyl	28/37	31	$1,150	8	
M-6, 1.6L, 4cyl	28/38	32	$1,100	8	

Figure 3-2 Hyundai Accent M_{pg} [20].

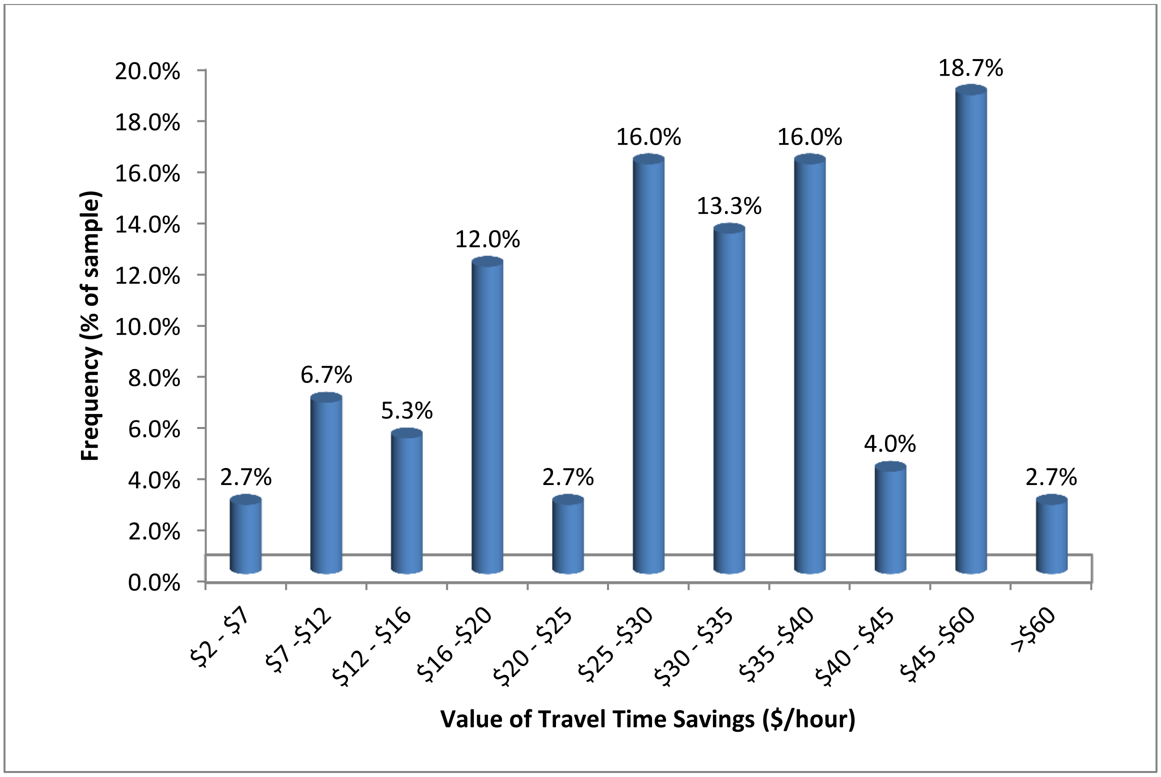


Figure 3-3 VTTS Distribution for Survey Respondents Traveling on I-95 [21].

Gas Cost Per Mile		
gallons	cost*	odometer
full tank		8850
12.4	$40.65	9136
9.5	$31.14	9355
15.7	$51.46	9717
37.6	$123.25	9717
		-8850
	miles driven=	867
miles per gallon:867/37.6=23.1 mpg		
gas cost per mile: $123.25/867=14.22 cents		

*price per gallon $3.278

Figure 3-4 Gas Cost Per Mile [22].

Annual Cost Per Mile

Costs		Yearly totals
Operating costs		
gas per mile	×	
total miles driven	=	
maintenance	+	
tires	+	
total operating costs	+=	
ownership costs		
depreciation		
insurance	+	
taxes	+	
license and registration	+	
finance charges	+	
total ownership costs	+=	
other costs		
(washing, accessories, etc.)	+	
total miles driven costs	=	
total miles driven	÷	
cost per mile	=	

Operating Costs	Medium Sedan per mile	Large Sedan per mile	Average per mile
gas	13.04 cents	15.13 cents	13.00 cents
maintenance	5.06 cents	5.37 cents	5.06 cents
tires	1.00 cents	1.22 cents	0.97 cents
cost per mile	19.1 cents	21.7 cents	19.0 cents
Ownership Costs	per year	per year	per year
full-coverage insurance	$1,007	$1,081	$1,023
license, registration, taxes	$640	$802	$641
finance charges	$3,481	$4,607	$3,510
cost per year	$5,974	$7,573	$6,021
cost per day	$16.37	$20.75	$16.50
Total Cost Per Mile			
10,000 total miles per year	per year	per year	per year
cost per mile × 10,000 miles	$1,910	$2,172	$1,930
cost per day × 365 days	$5,974	$7,573	$6,021
decreased depreciation**	($268)	($294)	($246)
total cost per year	$7,616	$9,451	$7,678
total cost per mile*	76.2 cents	94.5 cents	76.8 cents
15,000 total miles per year	per year	per year	per year
cost per mile × 15,000 miles	$2,865	$3,258	$2,855
cost per day × 365 days	$5,974	$7,573	$6,021
total cost per year	$8,839	$10,831	$8,876
total cost per mile*	58.9 cents	72.2 cents	59.2 cents
20,000 total miles per year	per year	per year	per year
cost per mile × 20,000 miles	$3,820	$4,344	$3,806
cost per day × 365 days	$5,974	$7,573	$6,021
increased depreciation***	$233	$259	$217
total cost per year	$10,027	$12,176	$10,044
total cost per mile*	50.1 cents	60.9 cents	50.2 cents

* total cost year ÷ total miles per year

** decreased depreciation for mileage under 15000 miles annually averaged over 5 years

*** increased depreciation for mileage over 15000 miles annually averaged over 5 years

Figure 3-5 Annual Cost Per Mile [22].

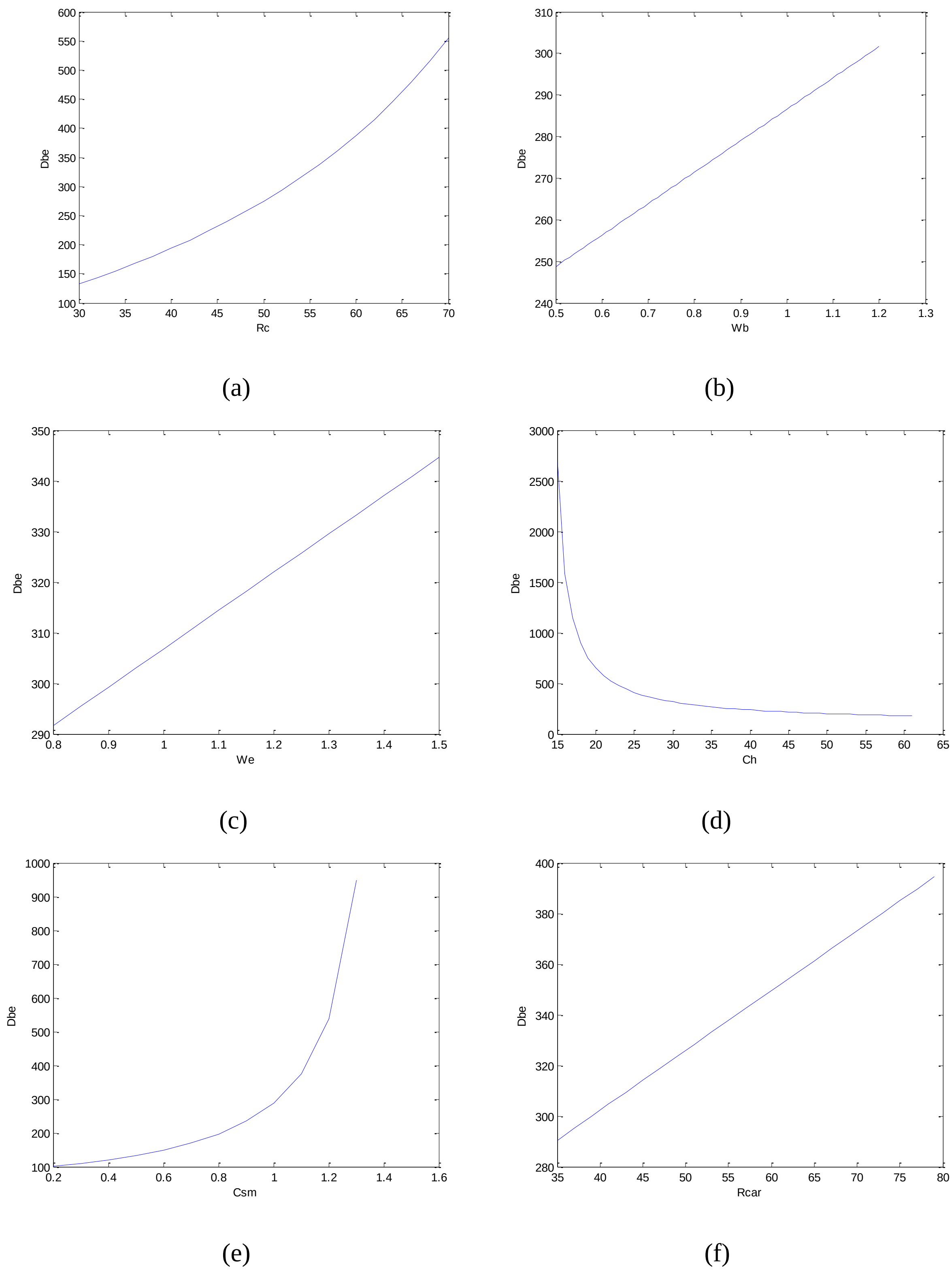
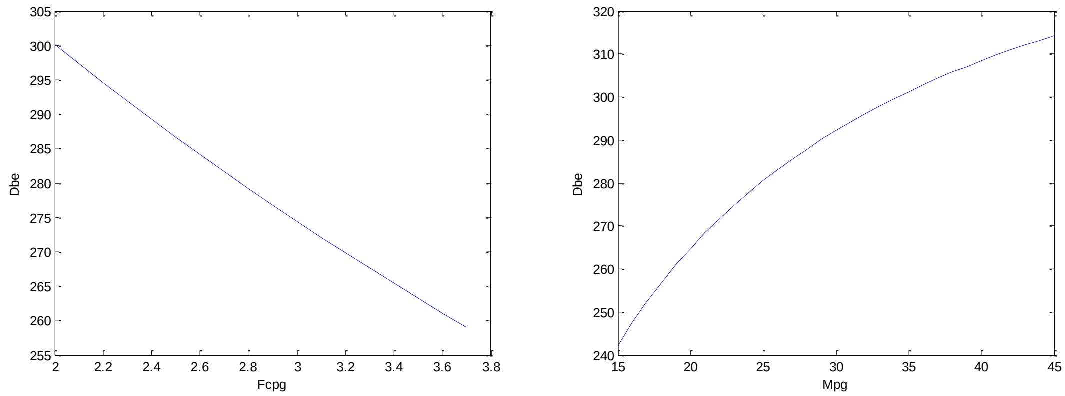
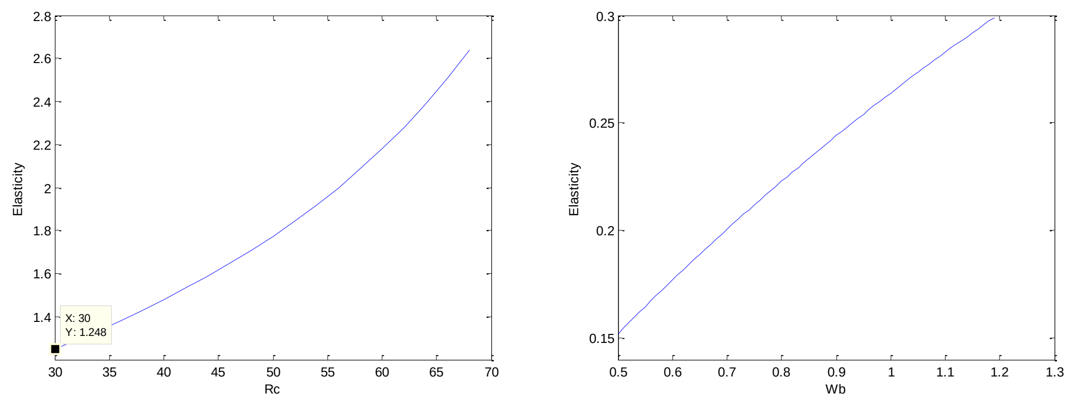


Figure 3-6 The Influence of (a) R_c, (b) W_b, (c) W_e, (d) C_h, (e) C_{sm}, (f) R_{car}, (g) F_{cpg}, (h) M_{pg} on Decision Making.

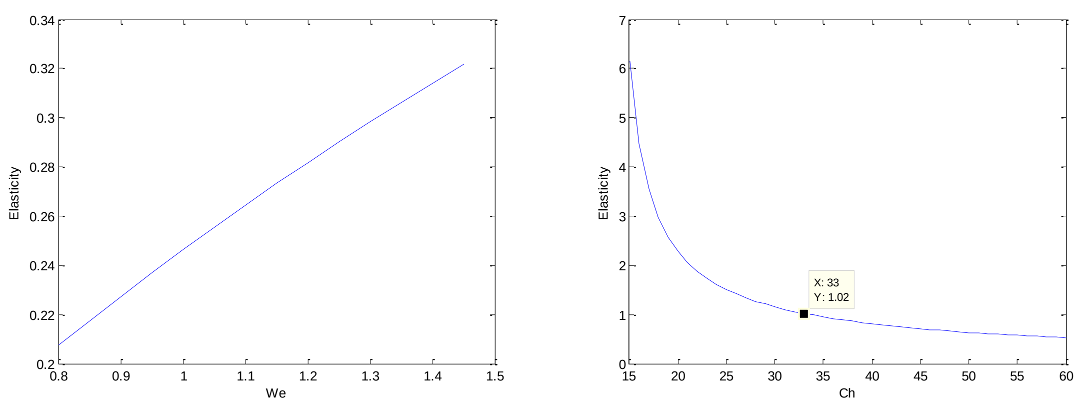


(g) (h)

Figure 3-6 (Continued).

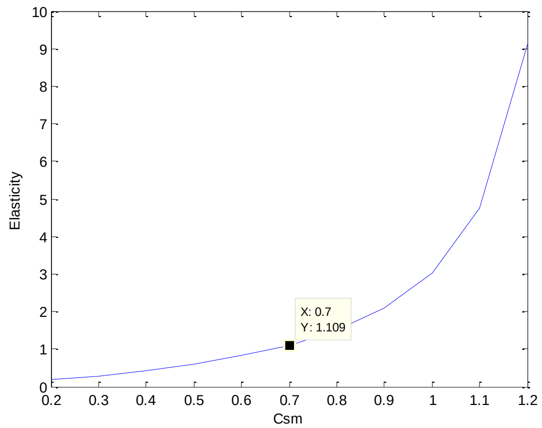


(a) (b)

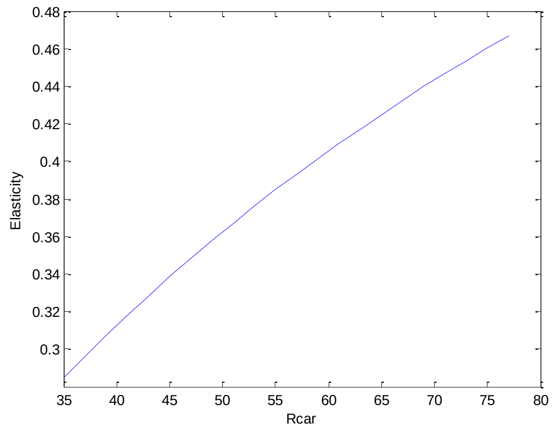


(c) (d)

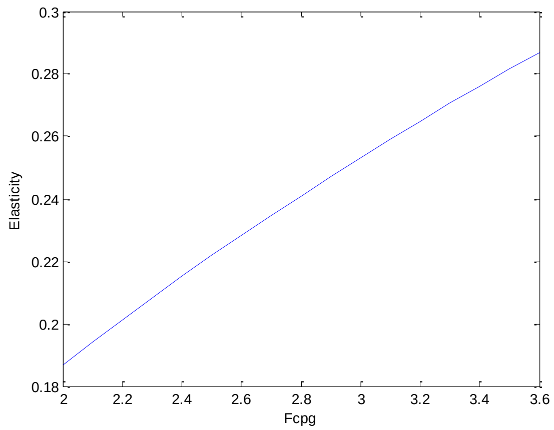
Figure 3-7 Elasticity Analysis of (a) R_c, (b) W_b, (c) W_e, (d) C_h, (e) C_{sm}, (f) R_{car}, (g) F_{cpg}, (h) M_{pg} for the Cost-Based Travel Mode.



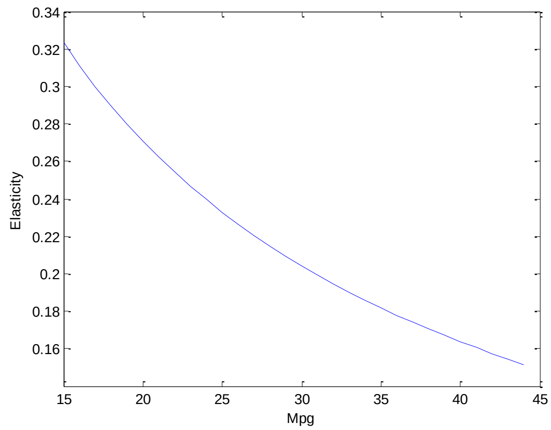
(e)



(f)



(g)



(h)

Figure 3-7 (Continued).

		1			2			3			4			5			6			7			8			9		
		DAB	Time	Cost	FLL	Time	Cost	RSW	Time	Cost	GNV	Time	Cost	JAX	Time	Cost	EYW	Time	Cost	MLB	Time	Cost	MIA	Time	Cost	MCO	Time	Cost
1	DAB																											
2	FLL	222	125.58	390.66																								
3	RSW	187	124.18	384.43	105	79.74	22.6																					
4	GNV	82	-22	0.89	281	115	351.4	220	115.67	353.83																		
5	JAX	99	-52	-2.8	319	142.72	438.79	273	138.95	425.22	66	-160	-25															
6	EYW	322	162.51	476.46	145	174.52	519.66	137	142.17	403.24	355	142.98	406.14	409	170.98	506.91												
7	MLB	79	-174	-30	144	108.32	322.33	128	105.37	311.71	148	121.13	368.42	177	152.51	481.39	254	150.44	473.96									
8	MIA	238	112.6	352.12	21			105	136.7	32.45	295	101.43	311.93	335	129.15	411.72	126	172.7	568.47	161	95.18	289.44						
9	MCO	55	-236	-43	178	109.25	328.07	134	107.1	320.31	105	119.98	366.67	144	148	467.56	269	143.71	452.09	46	-251	-47	193	95.5	278.56			
10	SFB	30			198	121.65	375.08	158	120.67	371.56	89	19.64	9.9	122	131.53	410.67	293	157.68	504.76	59	-232	-43	214	108.45	327.58	24		
11	ECP	297	134.74	411.69	454	141.41	435.71	361	142.64	440.14	217	138.14	423.94	246	129.47	392.72	471	149.42	464.53	348	144.48	446.77	461	127.65	386.2	302	143.43	442.98
12	PNS	379	107.05	325.34	525	110.53	337.87	428	112.14	343.67	300	110.88	339.12	329	104.96	317.8	527	115.45	355.6	428	114.04	350.51	530	96.98	289.09	381	113.23	347.58
13	PGD	166	120.64	375.3	128	109.7	335.89	30			192	111.93	343.93	247	134.36	424.66	164	136.5	432.35	116	104.14	315.88	131	96.46	288.26	112	104.25	316.3
14	SRQ	154	124.85	372.25	175	144.29	442.21	78	-238	-41	159	108.33	312.78	220	130.02	390.87	202	164.21	513.91	127	123.98	369.12	179	131.81	397.3	104	115.17	337.4
15	PIE	133	114.78	358.45	202	111.14	345.33	111	112.03	348.57	126	107.62	332.68	188	125.76	397.96	239	131.43	418.39	126	108.42	335.54	208	97.43	295.98	91	31	10
16	TLH	215	116.03	355.54	393	116.74	358.08	310	115.4	353.28	134	120.89	373.04	160	119.21	367	433	128.01	398.66	274	124.79	387.09	403	102.26	305.96	228	123.23	381.47
17	TPA	123	131.55	408.4	197	127.85	395.08	111	123.91	380.89	120	115.66	351.22	181	136.8	427.29	241	142.02	446.1	116	129.21	400	205	113.05	341.82	81	-114	-17
18	VPS	341	108.5	334.2	493	110.58	341.7	398	111.59	345.31	261	112.72	349.39	289	107.55	330.79	502	115.87	360.71	391	115.53	359.5	499	96.71	291.74	345	114.66	356.37
19	PBI	182	113.76	349.02	42	-142.24	-24.5	104	85.33	23.23	246	103.63	312.56	280	131.41	412.58	180	175.81	572.39	104	128.25	31.86	63	-140	-23	142	98.57	294.35

Air primary mode
Ground mode
even+/-1mile
wor ASA Overlap

		10			11			12			13			14			15			16			17			18			19
		SFB	Time	Cost	ECP	Time	Cost	PNS	Time	Cost	PGD	Time	Cost	SRQ	Time	Cost	PIE	Time	Cost	TLH	Time	Cost	TPA	Time	Cost	VPS	Time	Cost	PBI
1	DAB																												
2	FLL																												
3	RSW																												
4	GNV																												
5	JAX																												
6	EYW																												
7	MLB																												
8	MIA																												
9	MCO																												
10	SFB																												
11	ECP	296	134.38	410.41																									
12	PNS	377	105.83	320.93	84	31	11																						
13	PGD	136	117.14	362.68	331	137.74	436.85	400	107.12	326.6																			
14	SRQ	125	122.64	364.29	284	126.7	378.9	352	96.35	269.66	48																		
15	PIE	107	111.59	346.95	253	130.88	416.38	325	100.25	306.15	81	-52	-6	36															
16	TLH	219	113.42	346.16	87	-51	-6	170	97.12	287.49	280	110.67	336.26	234	99.8	297.13	199	103.96	312.08										
17	TPA	97	-49	-4	257	127.7	394.56	330	96.1	280.8	80	-97	-14	40			10			200	104.11	309.64							
18	VPS	340	106.92	328.52	45			39			369	106.72	327.77	322	95.81	288.5	292	100.23	304.44	130	99.74	302.65	297	96.72	291.8				
19	PBI	161	109.88	335.04	430	132.28	415.67	504	102.23	307.5	119	104.65	316.22	160	134.68	424.32	181	102.91	309.98	364	107.68	327.15	175	120.93	374.85	471	102.28	307.72	

Air primary mode
Ground mode
even+/-1mile
wor ASA Overlap

Figure 3-8 Break-Even Results of All Commercial Airport Pairs (R_a=220).

		1			2			3			4			5			6			7			8			9		
		DAB	Time	Cost	FLL	Time	Cost	RSW	Time	Cost	GNV	Time	Cost	JAX	Time	Cost	EYW	Time	Cost	MLB	Time	Cost	MIA	Time	Cost	MCO	Time	Cost
1	DAB																											
2	FLL	222	111.31	313.2																								
3	RSW	187	110.07	308.2	105	188.48	24.38																					
4	GNV	82	-52.34	0.966	281	101.93	281.72	220	102.53	283.67																		
5	JAX	99	-124.5	-3.07	319	126.49	351.78	273	123.15	340.91	66	-379	-27															
6	EYW	322	144.04	381.98	145	154.68	416.61	137	126.02	323.28	355	126.73	325.61	409	151.54	406.4												
7	MLB	79	-411.68	-32.32	144	96.01	258.42	128	93.4	249.9	148	107.36	295.37	177	135.18	385.93	254	133.35	379.98									
8	MIA	238	99.8	282.3	21	-21.84	2.02	105	323.11	35	295	89.9	250.08	335	114.47	330.08	126	153.07	455.75	161	84.37	232.05						
9	MCO	55	-558	-46	178	96.84	263.02	134	94.92	256.79	105	106.34	293.96	144	131.19	374.85	269	127.37	362.44	46	-594	-50	193	84.64	223.32			
10	SFB	30			198	107.82	300.71	158	106.96	297.88	89	46	10	122	116.58	329.24	293	139.75	404.68	59	-548	-46	214	96.12	262.62	24	-162.88	-9
11	ECP	297	119.42	330.06	454	125.33	349.31	361	126.43	352.87	217	122.44	339.88	246	114.75	314.85	471	132.43	372.42	348	128.06	358.18	461	113.15	309.62	302	127.13	355.15
12	PNS	379	94.88	260.83	525	97.97	270.88	428	99.39	275.52	300	98.28	271.88	329	93.03	254.79	527	102.33	285.08	428	101.08	281.01	530	85.96	231.77	381	100.36	278.66
13	PGD	166	106.93	300.88	128	97.23	269.29	30	-354	-28	192	99.21	275.74	247	119.09	340.46	164	120.98	346.62	116	92.3	253.24	131	85.5	231.1	112	92.4	253.58
14	SRQ	154	110.66	298.44	175	127.89	354.53	78	-564	-44	159	96.02	250.76	220	115.25	313.37	202	145.54	412	127	109.89	295.93	179	116.83	318.52	104	102.08	270.5
15	PIE	133	101.73	287.37	202	98.5	276.85	111	99.3	279.46	126	95.39	266.72	188	111.46	319.05	239	116.49	335.43	126	96.09	269.01	208	86.35	237.29	91	72.74	11.12
16	TLH	215	102.84	285.04	393	103.47	287.08	310	102.28	283.26	134	107.15	299.07	160	105.66	294.22	433	113.46	319.61	274	110.61	310.34	403	90.63	245.3	228	109.23	305.83
17	TPA	123	116.6	327.42	197	113.32	316.74	111	109.82	305.36	120	102.52	281.58	181	121.25	342.56	241	125.88	357.64	116	114.53	320.68	205	100.2	274.04	81	-269.72	-19
18	VPS	341	96.17	267.94	493	98.01	273.94	398	98.9	276.84	261	99.91	280.11	289	95.33	365.2	502	102.7	289.19	391	102.4	288.22	499	85.71	233.89	345	101.63	285.71
19	PBI	182	100.83	279.82	42	-336.204	-26.42	104	201.7	25.05	246	91.85	250.58	280	116.48	330.77	180	155.83	458.89	104	303.14	34.36	63	-332	-25	142	87.37	235.99

Air primary mode
Ground mode
even+/-1mile
wor ASA Overlap

		10			11			12			13			14			15			16			17			18			19
		SFB	Time	Cost	ECP	Time	Cost	PNS	Time	Cost	PGD	Time	Cost	SRQ	Time	Cost	PIE	Time	Cost	TLH	Time	Cost	TPA	Time	Cost	VPS	Time	Cost	PBI
1	DAB																												
2	FLL																												
3	RSW																												
4	GNV																												
5	JAX																												
6	EYW																												
7	MLB																												
8	MIA																												
9	MCO																												
10	SFB																												
11	ECP	296	119.11	329.03																									
12	PNS	377	93.8	257.3	84	74.5	11.84																						
13	PGD	136	103.83	290.77	331	122.09	350.23	400	94.94	261.84																			
14	SRQ	125	108.7	292.05	284	112.3	303.77	352	85.4	216.2	48	-360	-24																
15	PIE	107	98.9	278.15	253	116	333.82	325	88.86	245.44	81	-124	-7	36	-163	-12													
16	TLH	219	100.53	277.52	87	-122	-6.5	170	86.08	230.48	280	98.09	269.58	234	88.46	238.21	199	92.14	250.2										
17	TPA	97	-115	-4	257	113.19	316.32	330	85.18	225.12	80	-231	-15	40	-277	-21	10	8.54	8.28	200	92.28	248.24							
18	VPS	340	94.77	263.38	45	-353	-30	39	-193	-13	369	94.59	262.78	322	84.92	231.3	292	88.84	244.07	130	88.4	242.64	297	85.73	233.94				
19	PBI	161	97.39	268.6	430	117.24	333.24	504	90.61	246.53	119	92.75	253.51	160	119.37	340.18	181	91.22	248.51	364	95.45	262.28	175	107.19	300.52	471	90.66	246.7	

Air primary mode
Ground mode
even+/-1mile
wor ASA Overlap

Figure 3-9 Break-Even Results of All Commercial Airport Pairs (R_a=520).

Table 3-1 The Calculation of the Cost-Based Travel Mode Decision Model.

Inputs: β D_{AB} D_{AC} D_{BC} D_{DE} D_{DF} D_{EF} R_A R_C W_B W_E C_{SM} C_{GM} C_R C_H
$T_{AIR} = \left(D_{AB}/(\beta . R_C)\right) + W_B + \left(\frac{D_{BC}}{R_A}\right) + \left(\frac{D_{CD}}{R_A}\right) + \left(\frac{D_{DE}}{R_A}\right) + W_E + \left(D_{EF}/(\beta . R_C)\right)$ $T_{CAR} = \frac{D_{AC} + D_{CD} + D_{DF}}{\beta R_C}$ $C_{CAR} = C_{GM} D_{CAR} + C_H T_{CAR}$ $C_{AIR} = \frac{C_{GM} D_{AB}}{\beta} + C_{SM}(D_{BC} + D_{CD} + D_{DE}) + C_R + C_H T_{AIR}$ $C_{AIR} = C_{CAR};$
$D_{CD} = \frac{R_C R_A C_{GM}(D_{AC} + D_{DF} - D_{AB}) + C_H R_A (D_{AC} + D_{DF} - D_{AB} + D_{EF}) - \beta R_C R_A C_{SM}(D_{BC} + D_{DE}) - C_H \beta R_C (D_{BC} + D_{DE}) - \beta R_C R_A C_R - C_H R_A \beta R_C (W_B + W_E)}{\beta R_C R_A C_{SM} + C_H \beta R_C - R_C R_A C_{GM} - C_H R_A}$ $D_{CAR} = (1/\beta)(D_{AC} + D_{CD} + D_{DF})$ $D_{BE\_b} = D_{BE} = D_{BC} + D_{CD} + D_{DE}$
Outputs: D_{CD} D_{CAR} D_{BE} D_{BE_b}

Table 3-2 The Calculation of the Cost-Based Travel Mode Decision Model (Overlapped ASAs).

Inputs: β D_{AB} D_{AC} D_{BC} D_{DE} D_{DF} D_{EF} R_A R_C W_B W_E C_{SM} C_{GM} C_R C_H
$T_{AIR} = \left(D_{AB}/(\beta . R_C)\right) + W_B + \left(\frac{D_{BE}}{R_A}\right) + W_E + \left(D_{EF}/(\beta . R_C)\right)$ $T_{CAR} = \frac{D_{AC} + D_{CF}}{\beta R_C}$; $D_{CAR} = (1/\beta)(D_{AC} + D_{CF})$ $C_{CAR} = C_{GM} D_{CAR} + C_H T_{CAR}$ $C_{AIR} = \frac{C_{GM} D_{AB}}{\beta} + C_{SM} D_{BE} + C_R + C_H T_{AIR}$ $C_{AIR} = C_{CAR}$
$D_{BE\_b} = D_{BE} = [C_{GM}(D_{AC} + D_{CF}) + C_H \frac{D_{AC}+D_{CF}}{\beta R_C} - (\frac{C_{GM} D_{AB}}{\beta} + C_R) - C_H(\frac{D_{AB}}{\beta R_C} + W_B + W_E + \frac{D_{EF}}{\beta R_C})]/(C_{SM} + \frac{C_H}{R_A})$
Outputs: D_{BE} D_{BE_b}

Table 3-3 The Calculation of C_{GM}.

Cost	Average Sedan
Operation costs	Per mile
gas per mile	7.1387
maintenance	5.06
tires	0.97
cost per mile	13.1687
Ownership costs	Per year
full-coverage insurance	1023
license, registration, tax	641
depreciation	3510
finance charges	847
cost per year	6021
cost per day	16.4959
15,000 miles a year	
cost per mile*15,000 miles	1975.3065
cost per day * 365 days	6021
total cost per year	7996.3065
total cost per mile	0.5331

Table 3-4 The Parameters of Simulation for JAX and TLH Airport Pair.

Airport1	Airport2	k	β	R_a	R_c	W_b
5	6	1	0.76937	220/520	52	1.10167
Highway 70	Local 30	Other 55	W_t	W_c	W_s	W_p
0.3	0.3	0.4	26.1	5	20	10
W_e	C_{sm}	C_{gm}	C_h	R_{car}	F_{cpg}	M_{pg}
0.83333	1.008	0.53309	32	36.58	2.213	31
W_g	W_a	W_f	W_d	W_l	W_r	Mode
5	10	10	10	10	10	2

Table 3-5 The Parameters of Simulation for the Commercial Airport Pairs in Florida.

k	β	R_a	R_c	W_b	W_e	C_{sm}	C_{gm}	C_h	R_{car}	F_{cpg}	M_{pg}	
1	0.76937	220/520	52	1.10167	0.83333	1.008	0.53309	32	36.58	2.213	31	
Highway 70	Local 30	Other 55	W_t	W_c	W_s	W_p	W_g	W_a	W_f	W_d	W_l	W_r
0.3	0.3	0.4	26.1	5	20	10	5	10	10	10	10	10

Table 3-6 Nonstop Flights of Airport Pairs Should Be Opened.

Airport Pairs		Airport Pairs		Airport Pairs		Airport Pairs	
DAB	PNS	JAX	PNS	PIE	VPS	RSW	VPS
DAB	VPS	MCO	VPS	PIE	PNS	SFB	VPS
FLL	GNV	MIA	ECP	PNS	PBI	SRQ	VPS
FLL	ECP	MIA	VPS	PNS	SRQ	TLH	PBI
FLL	PNS	MLB	PNS	PNS	EYW	TLH	EYW
FLL	VPS	MLB	VPS	PNS	RSW	TPA	VPS
GNV	EYW	PGD	TLH	PNS	SFB	VPS	PBI
GNV	PNS	PGD	VPS	RSW	ECP	VPS	EYW
JAX	EYW	PGD	PNS	RSW	TLH		

CHAPTER 4: FORECASTING THE DEMAND OF FLORIDA INTRASTATE AIR PASSENGERS

4.1 Introduction

Findings from Chapters 2 and 3 suggest that some intrastate nonstop air flights should be opened for the air passengers in Florida. In this section, we expand the previous analysis, which only considered time and cost factors, and use linear regression methods to create gravity models and better forecast the demand of potential intrastate air passengers in Florida. Along with the conclusion of Chapter 3, the conclusion of this chapter can assist government or airline companies in making decisions on whether more intrastate nonstop air flights are needed or not.

Previous research that focuses on predicting air passengers' demand use gravity models [23, 24, 27], but few consider intrastate air transportation. This chapter presents how to forecast the demand of intrastate air passengers. The next sections describe the parameters considered, the data collection process as well as the modeling and forecasting techniques utilized.

4.2 Factors Affecting Air Passenger Demand

The factors that can impact air passenger demand can be categorized as service-related variables and geo-economic variables [23, 25]. Therein service-related variables include air fares, travel time and ground access time, while geo-economic variables include geographic and economic variables, such as geographical distance population, population density, gross domestic product, and per capita personal disposal income. The factors considered in this thesis are discussed in the next section along with the data source.

4.3 Driving Factors and Data Source

The driving factors considered in this thesis are as follows:

- Geographical Distance: The distance is measured by the great circle distance formula, as shown in Table 2-2.
- Population: Population of Metropolitan Statistical Area (MSA) referring only to MSA where the airports of concern are located.
- Private employment by MSA: People that are employed by private total industries, excluding federal government, state government and local government total industries.
- Area of MSA: The size of MSA surrounding a particular airport that would have potential air passengers.
- Population density: The concentration of people within MSA. The equation is: Population density = (Population of MSA) / (Area of MSA).
- Per Capita Personal Income (PPI): Per Capita Personal Income is calculated as the total personal income of the residents of a MSA divided by the population of that MSA [26].
- Gross Domestic Product (GDP) by MSA: It indicates the economic performance of a country. Here, use the data within MSA.
- Per Capita Gross Domestic Product by MSA: Divides the GDP above by the number of people in the same MSA.

All the explanatory variables and relevant information are listed in Table 4-1. In the "notation" column, the variable in parentheses with letter L represents the data after making a logarithmic transformation of the original data.

The explanatory variable data are collected from 2011 to 2013 annually. Annual air passengers between airport pairs in Florida are provided by T-100 Domestic Segment from Bureau of Transportation Statistic. There were 95 observations in all. Airport pairs with origin and destination airports within the same MSA, were discarded. Similarly, pairs with demands below 1000 passengers were not included.

4.4 Modeling Analysis and Regression Results

In order to reflect the influence of multiple airports that are close to each other, the study considers other three variables which represent the spatial characteristics. These variables are: Number of competing airports N (LNN), Average distance of competing airports C (LCC), and Number of competing airports weighted by their distance W (LWW) [27].

Gravity models are the earliest causal models [28] and most widely used models for traffic forecasting [24]. Gravity models imitate gravitational interaction according to the gravitational law. Here, a simple formulation of a gravity model for human spatial interaction between two sites a and b is listed below [24]:

$$The\ passengers\ volume\ between\ a\ and\ b = k\frac{(A_a A_b)^{\propto}}{D_{ab}^{\gamma}} \tag{4.1}$$

It is used to predict travel demand between a and b. Where k is a constant, and A_a and A_b represent attraction factors of a and b, and D_{ab}^{γ} denotes the distance between a and b. γ is a parameter that reflects the influence of the distance and $\propto$ is a parameter that reflects the influence of the attraction factors. Generally speaking, the different factors included in the model can have more than one variable [24]. In order to get the coefficients in equation (4.1), logarithmic transformation method is adopted, so that the equation is converted to linear equation. Then the coefficients can be obtained using linear regression method.

Two types of gravity models are built for passenger demand estimation in this thesis. The first one is a basic gravity model - BM (Basic Models), while the second one includes the three variables introduced before - EM (Extended Models). Before the final models were selected the following analytical procedures was executed.

- Apply the correlation to the independent variables;
- Use best subsets analysis;
- Perform the linear regression in Minitab.

For the BM (using all 95 observations), correlation analysis was applied to recognize the relationship of all explanatory variables. As shown in Table 4-2, LPP and LEmploy are highly correlated with four of the rest variables, while LGDP are highly correlated with three of the rest variables. So LPP, LEmploy and LGDP are removed. Then LD, LArea, LDen, LPPI are left. Best subsets regression is a method that helps determine which variables should be included in regression models by giving the subset of predictors which has the smallest residual sum of square [29]. The next step is to perform the best subsets regression in Minitab with LY as response, LD as the predictor in all models, and LArea, LDen, LPPI as free predictors. As shown in Table 4-3, the last method which includes all variables is the best one: Mallows Cp is smallest and it is approximately equal to the number of variables added. In addition, R-Sq is the largest. Models are chosen are based on this rule: Mallows Cp is good and uses the smallest number of the explanatory variables to get higher R-Sq. BM is shown in equation (4.2) including Geographical Distance, Area of MSA, Per Capita Personal Income and Population density.

$$\begin{aligned} &\mathit{Total\ annual\ passengers\ between\ two\ airports}\ (y) \\ &= (D)^A \times (Area_O \times Area_D)^B \times (PPI_O + PPI_D)^C \\ &\times (Den_O \times Den_D)^D \end{aligned} \tag{4.2}$$

The results of linear regression for BM are displayed in Table 4-4 and Table 4-5. The R-sq shows to be 51.51% which is not high. Thus, to improve the performance of the result for the forecasting model, more variables are introduced. Firstly, three extended variables mentioned before are added to build EM1. According to the correlation analysis shown in Table 4-6, the model takes out three variables—LPP, LEmploy, and LGDP, and then perform the best subsets analysis with the rest of the variables. Three of the results where Mallows Cps are equal to 2.9, 3.4 and 5 are the best ones, as shown in Table 4-7. However, when LPCG and LWW are included, the results of linear regression show that P-Values of some variables are larger than 0.05, which means they are not significant. Thus, for EM1, LD, LNN, LArea, LDen are the explanatory variables, as shown in equation (4.3). The results are displayed in Table 4-8 and Table 4-9. The R-sq is now 52.02%, which although marginally improved, still low.

$$\begin{aligned} &\mathit{Total\ annual\ passengers\ between\ two\ airports}\ (y) \\ &= (D)^A \times (N_O \times N_D)^B \times (Area_O \times Area_D\ )^C \times (Den_O \times Den_D)^D \end{aligned} \tag{4.3}$$

Therefore, to improve model performance further, the study looks into some other factors. Firstly, the study takes the features of airports into account. In Florida, there are 4 hub airports: Miami International Airport (MIA), Ft. Lauderdale-Hollywood International Airport (FLL), Orlando International Airport (MCO) and Tampa International Airport (TPA). In order to reflect 'hub influence', a dummy variable, called Double Hub (DH) is added. It is set equal to 1 when both original and destination airports are hub airports; otherwise, it is 0. Secondly, the study considers another dummy variable, called Distance 100 (D100) which is 1 when D is larger than 100 miles (the author tries some other distances, and 100 miles is the best one); otherwise, it is 0. Finally, the observations whose number of passengers is smaller than 10000 are removed. After several trials and simulations it was found that a value of "10000" rendered the best performance.

As a result, the number of observations is reduced to 58. The result of best subsets regression is displayed in Table 4-10. There are 17 different subsets and the study performs the linear regression among the subsets of the number 11, 13, 15 and 16. Analysis shows number 11 as the best, where P-Values are all smaller than 0.05, as shown in Table 4-12.

$$\begin{aligned} &Total\ annual\ passengers\ between\ two\ airports\ (y) \\ &= (D)^A \times (N_O \times N_D)^B \times (W_O + W_D)^C \times (\ Den_O \times Den_D)^D \\ &\times (GDP_O \times GDP_D)^E \times (DH_O \times DH_D)^F \times (D100_O \times D100_D)^G \end{aligned} \tag{4.4}$$

For EM2, LD, LNN, LWW, LDen, LPCG and LGDP are taken as the explanatory variables, as shown in equation (5-3). The results are displayed in Table 4-11 and Table 4-12. For this instance, the R-sq increases to 77.71% which reflects a more robust forecasting model. In general, there are three significance levels that have been used: 0.05, 0.01 and 0.001 [30]. If the 0.05 significance level is used, P-Values of all variables are all smaller than 0.05, so in this model explanatory variables are all significant. If the 0.01 significance level is used, P-Values of all variables are all smaller than 0.01, except for LGDP variable. Here, the study uses the 0.01 significance level. Then the results after removing LGDP are shown in Table 4-13 and Table 4-14. The R-sq becomes 74.78%, which still reasonable and promising.

$$\begin{aligned} &Total\ annual\ passengers\ between\ two\ airports\ (y) \\ &= (D)^A \times (N_O \times N_D)^B \times (W_O + W_D)^C \times (\ Den_O \times Den_D)^D \\ &\times (DH_O \times DH_D)^E \times (D100_O \times D100_D)^F \end{aligned} \tag{4.5}$$

As shown in Table 4-14, for Geographical Distance variable, the coefficient is 0.837, which indicates the demand of annual air passengers is directly in proportion to distance. If the distance of two airports is longer, there will be more annual air passengers. The coefficient of LNN shows that the more competing airports, the higher demand of annual air passengers. The negative coefficient of LWW suggests that the closer the proximity of the airports, the lower demand of annual air passengers. The more density of a MSA where airports locate, the higher demand of annual air passengers becomes. The coefficient of Double Hub (DH) is 0.926, suggesting that if both airports are hub airports, there would be more annual air passengers. The coefficient of Distance 100 (D100) is positive, which means when Geographical Distance is larger than 100, it has a positive influence on annual air passengers.

4.5 Forecasting

As discussed before, the equation (4.6) is used as the forecasting model in this study. In order to forecast the demand of air passengers of this pair, projection data such as the geographic distance between airport pair, the number of competing airports (N), the number of competing airports weighted by their distance (W), the population of the MSA, and the area of the MSA must be collected. The projection data used in this study is from 2020.

$$\begin{aligned} \mathrm{LY} = -16.13 + 0.837 * \mathrm{LD} + 2.728 * \mathrm{LNN} - 2.599 * \mathrm{LWW} + 1.596 * \mathrm{LDen} \\ + 0.926 * (\mathrm{DH}) + 1.278 * (\mathrm{D100}) \end{aligned} \tag{4.6}$$

A total of 35 airport pairs should open intrastate nonstop air flights according to the Time-Based Travel Mode Decision Model and the Cost-Based Travel Mode Decision Model, as shown in Table 3-6. Here, the forecasting model above is utilized to forecast the demand of annual air passengers of 30 among 35 airport pairs above in 2020. Table 4-15 shows the results by the order from large “Annual Air Passenger” to small (removing the airport pairs including EYW airport, because EYW doesn’t belong to any MSAs and is located in a special place). The result indicates it is beneficial to open most of the airport pairs, because their forecasting demand of annual air passengers are all more than 10000, especially PNS-PBI, whose forecasting demand is about 338,304. These results support previous conclusions attained and discussed in Chapters 2 and 3.

Table 4-1 Explanatory Variables and Data Source.

Explanatory Variables	Notation	Units	Data Source
Geographical Distance	D (LD)	mile	Bureau of Transportation Statistic
Population	P (LPP)	\	U.S. Census Bureau
Private employment	E (LEmploy)	Person	Bureau of Labor Statistics
Area of MSA	Area (LArea)	Square mile	U.S. Census Bureau
Population density	Den (LDen)	Persons/ Square mile	\
Gross Domestic Product	GDP (LGDP)	dollar	Bureau of Economic Analysis
Per Capita Gross Domestic Product	PCG (LPCG)	dollar	Bureau of Economic Analysis
Per Capita Personal Income	PPI (LPPI)	dollar	Bureau of Economic Analysis

Table 4-2 Correlation of Explanatory Variables in BM.

	LD	LPP	LArea	LDen	LPPI	LGDP	LPCG
LPP	-0.095						
LArea	0.251	0.824					
LDen	-0.397	0.837	0.379				
LPPI	0.133	0.55	0.302	0.606			
LGDP	-0.049	0.992	0.853	0.795	0.539		
LPCG	0.198	0.635	0.741	0.322	0.279	0.727	
LEmploy	-0.108	0.994	0.843	0.808	0.493	0.995	0.684

Table 4-3 Result of Best Subsets Regression of BM.

Vars	R-Sq	R-Sq (adj)	R-Sq (pred)	Mallows Cp	S	LArea	LDen	LPPI
1	47.4	46.3	44.3	8.6	0.59968		X	
1	35.9	34.5	32	29.9	0.66186	X		
2	49.9	48.3	45.5	6	0.58837	X	X	
2	49.8	48.1	45.7	6.2	0.58919		X	X
3	51.5	49.4	46.2	5	0.58212	X	X	X

Table 4-4 Model Summary of BM.

S	R-sq	R-sq(adj)	R-sq(pred)
0.582116	51.51%	49.36%	46.23%

Table 4-5 Coefficients of BM.

Term	Coef	SE Coef	T-Value	P-Value
Constant	17.9	16.1	1.12	0.267
LD	2.105	0.341	6.18	0.000
LArea	0.413	0.23	1.8	0.076
LDen	1.571	0.326	4.81	0.000
LPPI	-6.1	3.55	-1.72	0.089

Table 4-6 Correlation of Explanatory Variables in EM1.

	LD	LPP	LArea	LDen	LPPI	LGDP	LPCG	LEmploy	LNN	LAA
LPP	-0.095									
LArea	0.251	0.824								
LDen	-0.397	0.837	0.379							
LPPI	0.133	0.55	0.302	0.606						
LGDP	-0.049	0.992	0.853	0.795	0.539					
LPCG	0.198	0.635	0.741	0.322	0.279	0.727				
LEmploy	-0.108	0.994	0.843	0.808	0.493	0.995	0.684			
LNN	-0.597	-0.057	-0.238	0.137	-0.516	-0.065	-0.051	0		
LAA	-0.13	-0.389	-0.155	-0.486	-0.608	-0.373	-0.218	-0.329	0.283	
LWW	-0.545	0.212	-0.136	0.477	-0.176	0.187	0.036	0.234	0.871	-0.135

Table 4-7 Result of Best Subsets Regression of EM1.

Vars	R-Sq	R-Sq (pred)	Mallows Cp	S	LNN	LAA	LWW	LArea	LDen	LPPI	LPCG
1	47.4	44.3	7.4	0.59968				X			
1	35.9	32	28.4	0.66186				X			
2	49.9	45.5	4.7	0.58837				X	X		
2	49.8	45.7	5	0.58919					X	X	

Table 4-7 (Continued).

Vars	R-Sq	R-Sq (pred)	Mallows Cp	S	LNN	LAA	LWW	LArea	LDen	LPPI	LPCG
3	52	46.9	2.9	0.57906	X			X	X		
3	51.5	46.2	3.8	0.58212				X	X	X	
4	52.8	46.5	3.4	0.5774	X			X	X		X
4	52.3	45.8	4.3	0.58038	X	X		X	X		
5	53	45.1	5	0.57943	X		X	X	X		X
5	53	45.3	5.1	0.57973	X	X		X	X		X
6	53	44.1	7	0.58264	X		X	X	X	X	X
6	53	43.7	7	0.58267	X	X	X	X	X		X
7	53.1	42.6	9	0.58596	X	X	X	X	X	X	X

Table 4-8 Model Summary of EM1.

S	R-sq	R-sq(adj)	R-sq(pred)
0.579064	52.02%	49.89%	46.92%

Table 4-9 Coefficients of EM1.

Term	Coef	SE Coef	T-Value	P-Value
Constant	-11.28	1.73	-6.53	0.000
LD	2.155	0.34	6.33	0.000
LNN	0.532	0.268	1.99	0.05
LDen	1.213	0.23	5.28	0.000
LArea	0.51	0.225	2.27	0.026

Table 4-10 Result of Best Subsets Regression of EM2.

	Vars	R-Sq	R-Sq (pred)	Mallows Cp	S	LNN	LAA	LWW	LArea	LDen	LPCG	LGDP	Double Hub	Distance 100
1	1	45.2	39.1	81.7	0.40672					X				
2	1	44.5	36.6	83.6	0.40955							X		
3	2	58.1	52	52.2	0.35886							X		X
4	2	52.6	46.9	65.7	0.38183								X	X
5	3	64.5	57.8	38.7	0.33358							X	X	X
6	3	63.5	57.1	41	0.33806					X			X	X
7	4	66.4	57.8	36	0.32754					X	X		X	X
8	4	66	57.6	37	0.32953	X						X	X	X
9	5	74.8	67.5	17.6	0.28661	X		X		X			X	X
10	5	67.9	58.6	34.3	0.32322	X		X				X	X	X
11	6	77.7	69.3	12.4	0.27215	X		X		X		X	X	X
12	6	76.7	67	14.9	0.27829	X		X	X	X			X	X
13	7	79.4	70.5	10.4	0.26448	X	X	X		X		X	X	X
14	7	77.9	67.9	13.9	0.27368	X		X	X	X		X	X	X
15	8	80.2	70.8	10.2	0.2615	X	X	X	X	X		X	X	X
16	8	80.2	71.9	10.4	0.26197	X		X	X	X	X	X	X	X
17	9	80.8	71.8	11	0.26084	X	X	X	X	X	X	X	X	X

Table 4-11 Model Summary of EM2.

S	R-sq	R-sq(adj)	R-sq(pred)
0.272145	77.71%	74.59%	69.27%

Table 4-12 Coefficients of EM2.

Term	Coef	SE Coef	T-Value	P-Value
Constant	-15.13	3.05	-4.97	0.000
LD	1.552	0.384	4.04	0.000
LNN	4.066	0.762	5.33	0.000
LWW	-4.292	0.841	-5.1	0.000
LDen	3.312	0.707	4.68	0.000
DH	1.491	0.261	5.71	0.000
D100	1.154	0.212	5.45	0.000
LGDP	-0.809	0.316	-2.56	0.013

Table 4-13 Model Summary of EM3.

S	R-sq	R-sq(adj)	R-sq(pred)
0.286606	74.78%	71.82%	67.47%

Table 4-14 Coefficients of EM3.

Term	Coef	SE Coef	T-Value	P-Value
Constant	-16.13	3.18	-5.07	0.000
LD	0.837	0.277	3.02	0.004
LNN	2.728	0.585	4.66	0.000
LWW	-2.599	0.547	-4.75	0.000
LDen	1.596	0.239	6.68	0.000
DH	0.926	0.147	6.28	0.000
D100	1.278	0.217	5.89	0.000

Table 4-15 Annual Air Passenger Forecasts.

Airport 1	Airport 2	Annual Passenger Forecast	Weekly Passenger Forecast	Airport 1	Airport 2	Annual Passenger Forecast	Weekly Passenger Forecast
PNS	PBI	338304.4	6505.9	FLL	ECP	47325.6	910.1
TLH	PBI	182117.6	3502.3	FLL	GNV	46530.6	894.8
JAX	PNS	175025.2	3365.9	PGD	PNS	25811.7	496.4
MLB	PNS	139105.5	2675.1	RSW	VPS	22803.5	438.5
PNS	RSW	138911.6	2671.4	MLB	VPS	22498.7	432.7
DAB	PNS	97734.9	1879.5	MCO	VPS	19309.7	371.3
PNS	SFB	97206.5	1869.4	MIA	VPS	17252.6	331.8
RSW	ECP	85914.3	1652.2	DAB	VPS	15607.2	300.1
FLL	PNS	75979.0	1461.1	SFB	VPS	15553.4	299.1
RSW	TLH	74959.5	1441.5	PGD	TLH	13536.3	260.3
PNS	SRQ	68440.9	1316.2	TPA	VPS	12967.6	249.4
MIA	ECP	65103.4	1252.0	FLL	VPS	12575.1	241.8
VPS	PBI	55766.3	1072.4	SRQ	VPS	11835.2	227.6
GNV	PNS	50731.8	975.6	PIE	VPS	8089.4	155.6
PIE	PNS	50717.4	975.3	PGD	VPS	4209.0	80.9

CHAPTER 5: IMPLEMENTING TRAVEL MODE DECISION MODEL INTO EXCEL

5.1 Introduction

Chapter 2 and Chapter 3 present a comprehensive description of the intrastate air service in Florida and discuss useful results for two decision models. This information is promising for government and airline companies. However, it is unclear how an independent traveler could benefit from this information. Therefore, in this chapter we extend the information and models presented to directly impact the traveler's decision making process. For example, if an individual plans to travel from a location, say: "University of South Florida, FL" to the address of "6163-6253 St Joe Rd, Tallahassee, FL 32311", how can he/she determine the best travel mode and make the best use of the information resulting from these two decision models?

A comparison system for intrastate travelers is created using Excel VBA. This Chapter introduces it, and provides an example of its application.

5.2 Introduction of the Interface

The main interface is shown in Figure 5-1. There are two buttons: "Start" and "Exit" in this interface. If a traveler clicks on "Start", a sub interface appears as shown in Figure 5-2, while selecting "Exit" withdraw the traveler from the comparison system. These are the instructions followed after clicking on "Start":

- As shown in Figure 5-2, there is a box for "Search Radius" on top, where the traveler can choose the radius of a circle in miles from drop-down menu. The center of the circle is the travelers' starting point or ultimate destination.

- In the second row, the traveler would type the starting point following an address format and an ultimate destination address.
- The traveler clicks on "Search for Departure Airports", and available departure airports would show up in the list box below. Again, he/she clicks on "Search for Arrival Airports" and available arrival airports would show up in the list box below.
- The traveler can choose one desirable departure and one arrival airport from available ones in the last step.
- There are three options for R_a and the one "Default" represents 220 miles/hour.
- For the parameters Rc, We, Wb, Rcar, Mpg, Ch, Fcpg, the traveler can enter any reasonable values he/she wants according his/her actual situation.
- Some parameters with * in their notes, such as Beta (β) and Cgm, the traveler can just click on "Get parameters" button to get them.
- For Airfare and Csm, since they are the same parameters to decide airfare, the travel can choose either one to type.
- If the traveler doesn't know what data to type, some parameters have the recommended values in their notes.
- "Travel Time and Cost" button is set for travelers who would like to know the time and cost they will spend on the way. When the traveler clicks on this button, one sub interface appears, as shown in Figure 5-3.
- When the traveler clicks on the button "Calculation", his/her travel time and cost would show up in the corresponding textbox.

In addition, travelers can also get the information about generalized cost which combines the cost of the value of travel time and other cost.

5.3 An Example Showing How to Use the Interface

An example is demonstrated in this section. If a traveler stays in Tampa, FL and plans to go to Tallahassee, FL, how can he/she use the comparison system? These are the steps followed to use this system:

- Open the file on “Comparison System Version 13.xlsx”, and Figure 5-1 would show up.
- Select “Start” and Figure 5-2 would show up.
- Decide the radius of the circle for searching for the departure and arrival airports. For example, the traveler chooses 50 as the radius.
- Type “University of South Florida, FL” in “From” box and “6163-6253 St Joe Rd, Tallahassee, FL 32311” in “To” box.
- Click on “Search for Departure Airports”, and available departure airports would show up below and click on “Search for Arrival Airports”, and available arrival airports would show up below.
- Choose desirable airports to departure and arrive. As shown in Figure 5-4, there are three available airports—SRQ, PIE and TPA, and the traveler can choose anyone to departure, while there is only one airport—TLH, from which the traveler can choose to arrive. This simulation assumes the traveler chooses TPA and TLH by clicking on them. As shown in Figure 5-5, TPA and TLH appear in the box in the next two rows.
- Type the values of the rest of the parameters and gets the values of the general parameters.
- Select R_a from drop-down menu, as shown in Figure 5-6.

- Click on the button “Travel Time and Cost”, and a sub interface appears, as shown in Figure 5-3.
- Click on the button “Calculation” in this interface, and the traveler would get the time and cost data, as shown in Figure 5-7.

The total time of air primary mode is 3.28 hour, which is smaller than that (4.79 hour) of ground mode, while the generalized cost of air primary mode is 350.9 dollar, which is larger than that (288.04 dollar) of ground mode. In addition, this system also tells travelers the information about their airfares and Fuel costs.

Travelers can make their travel decisions referring to information obtained from this comparison system. If a traveler is a business traveler, time may be a major factor influencing his/her decision. According to the information obtained from the example above, it is highly possible that the traveler chooses air primary mode. Conversely, if a traveler is a leisure traveler, time may be a secondary factor influencing his/her decision, compared to cost. It is highly possible that the traveler chooses ground mode.

Figure 5-1 Interface of Florida Comparison System for Air and Ground Travel.

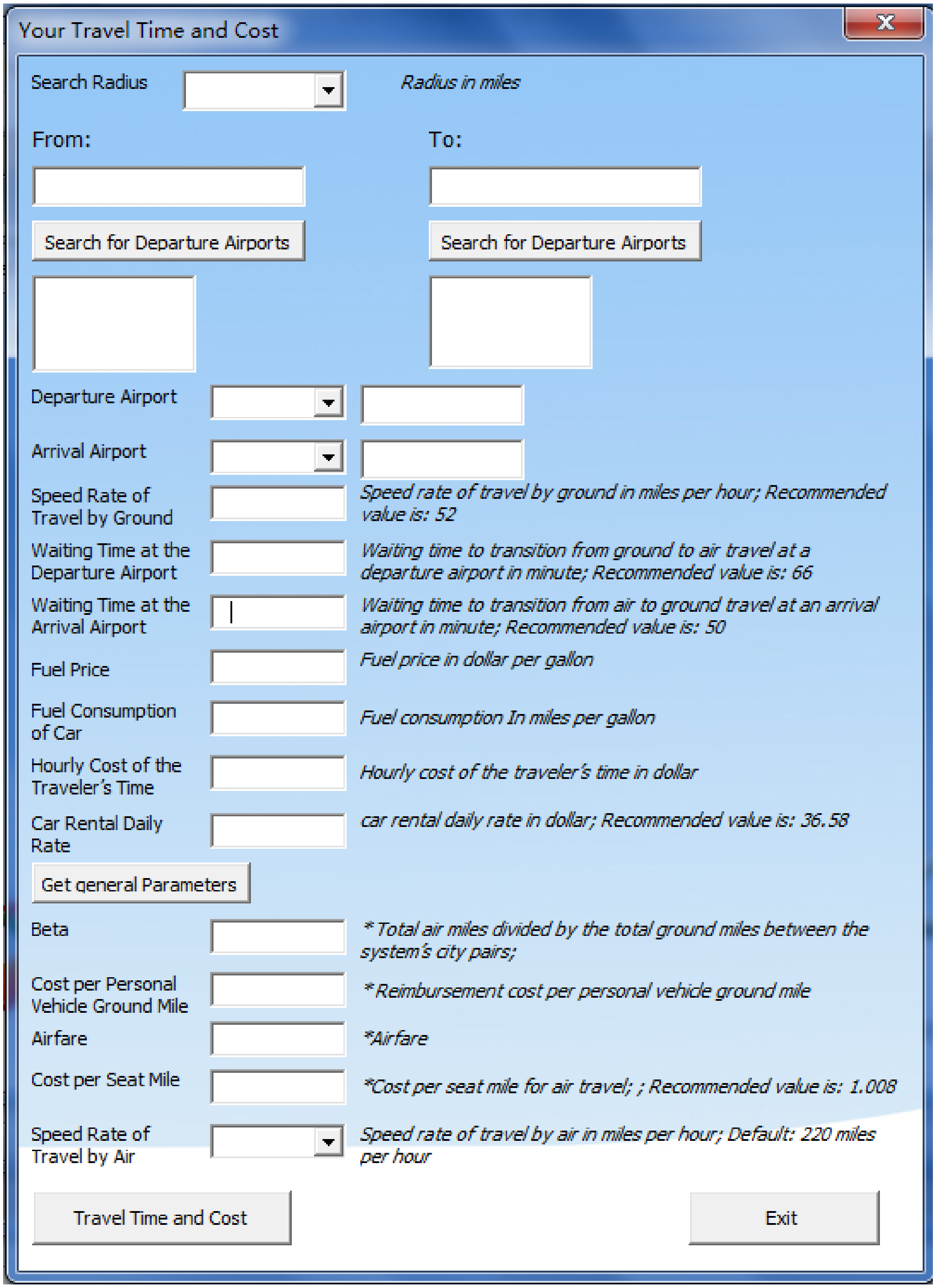


Figure 5-2 Interface of Travel Time and Cost.

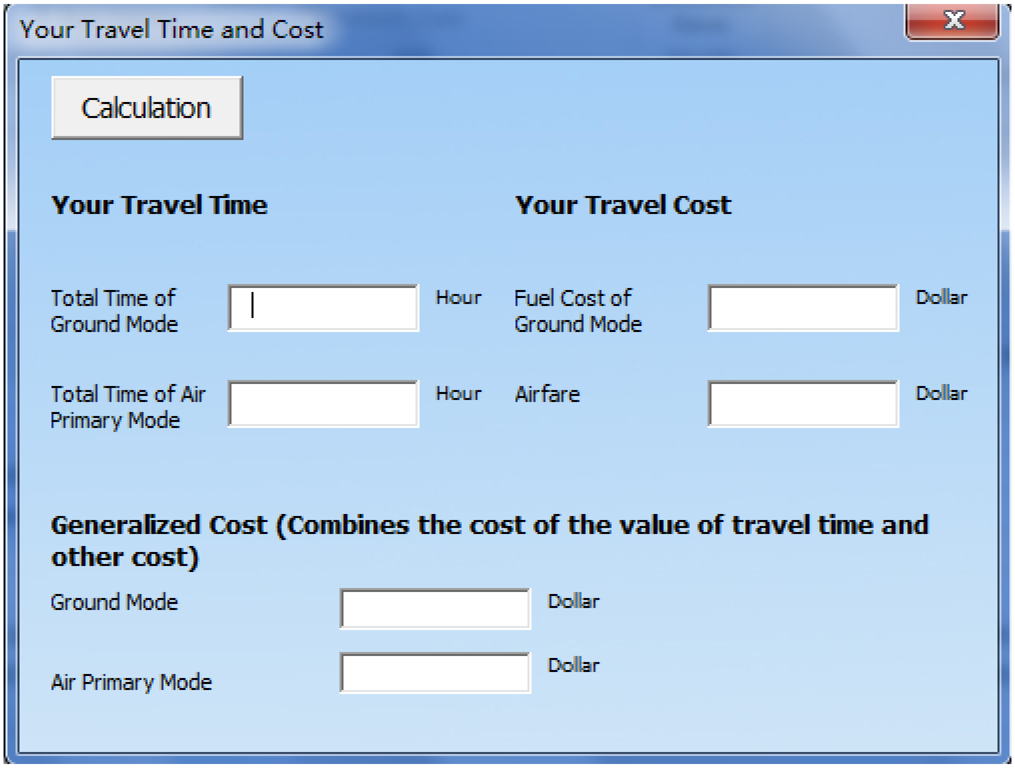


Figure 5-3 Sub Interface of Travel Time and Cost.

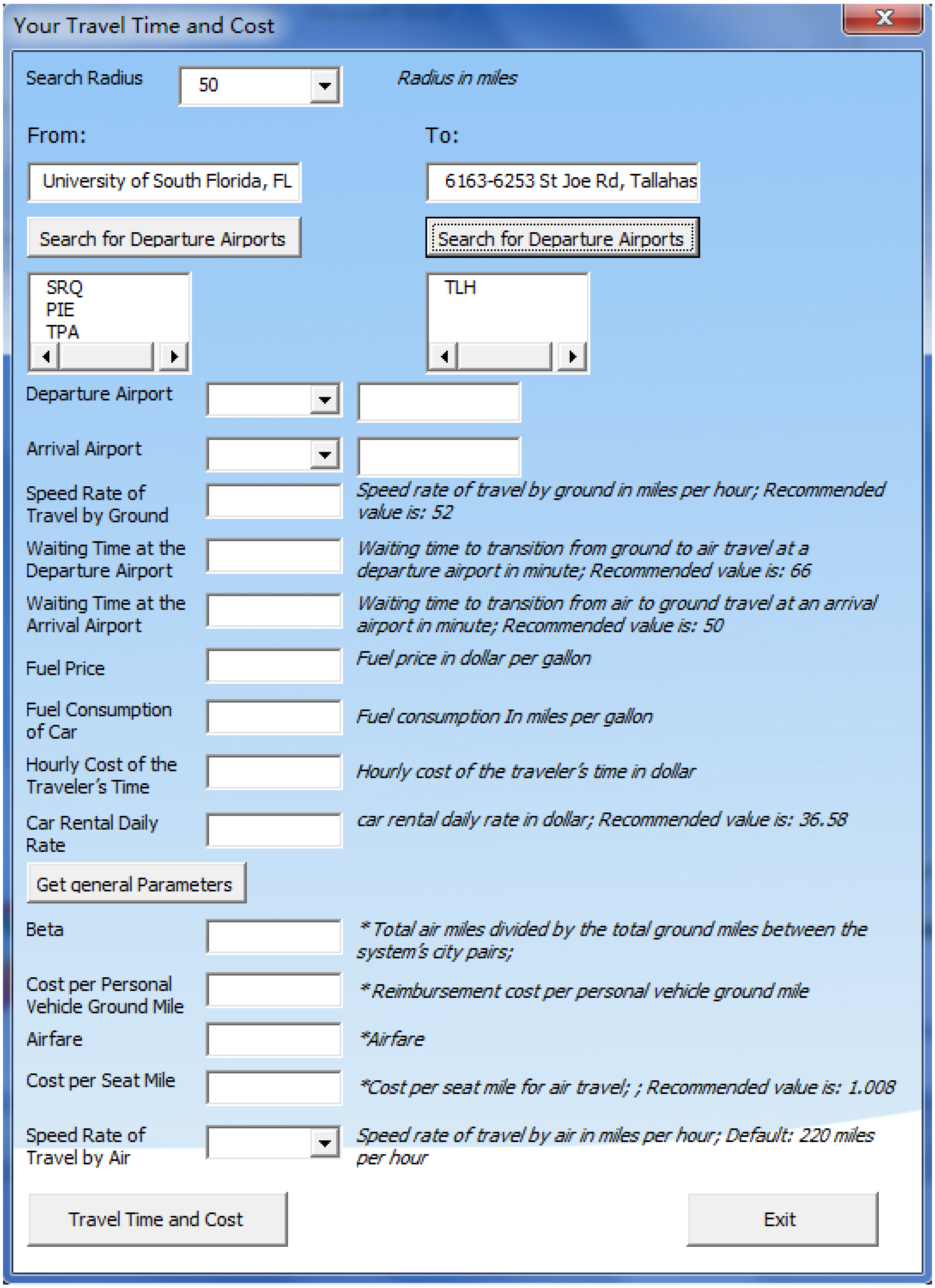


Figure 5-4 Searching for Airports in Travel Time and Cost.

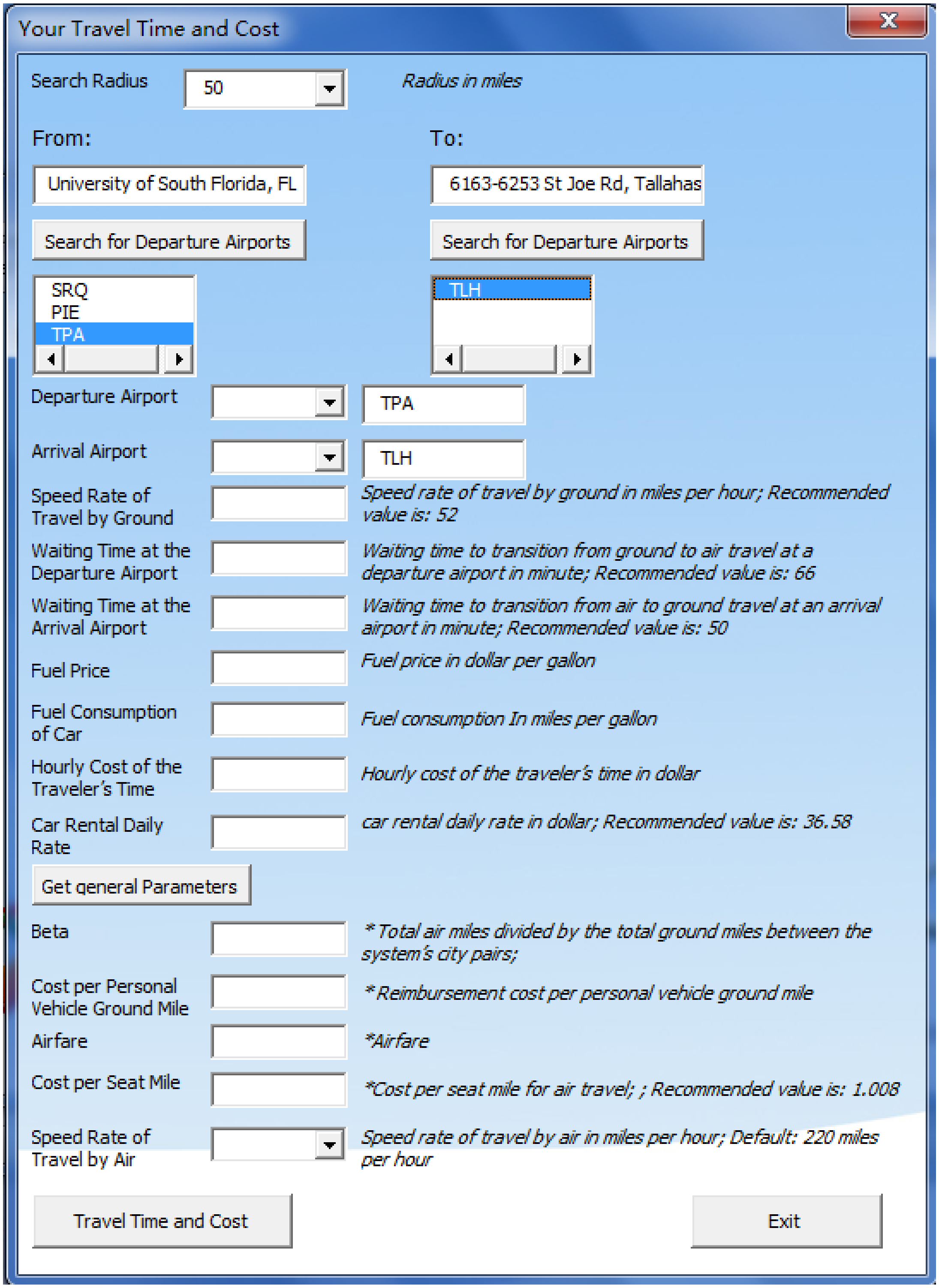


Figure 5-5 Decision of Arrival and Departure Airports in Travel Time and Cost.

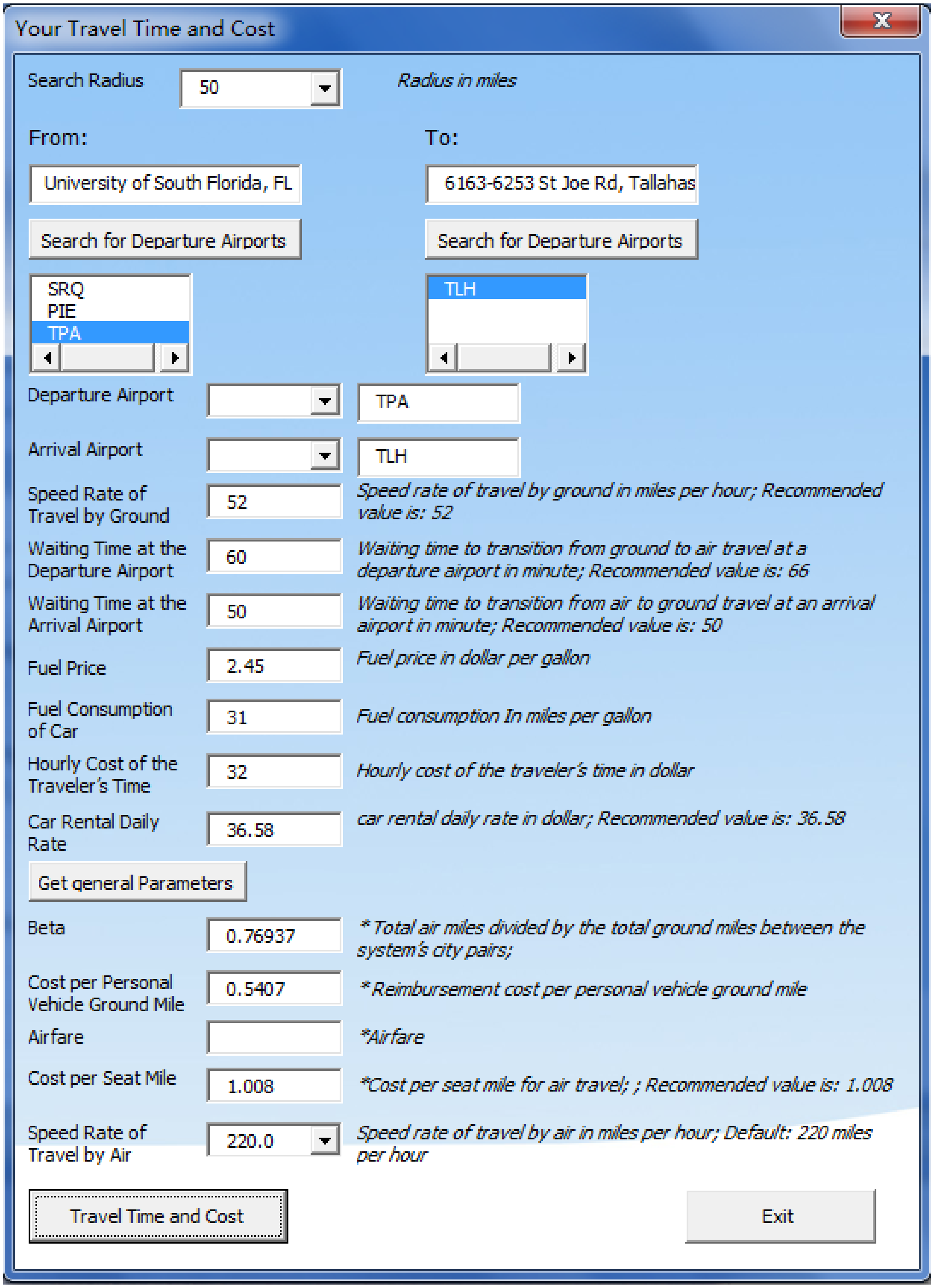


Figure 5-6 Settings in Travel Time and Cost.

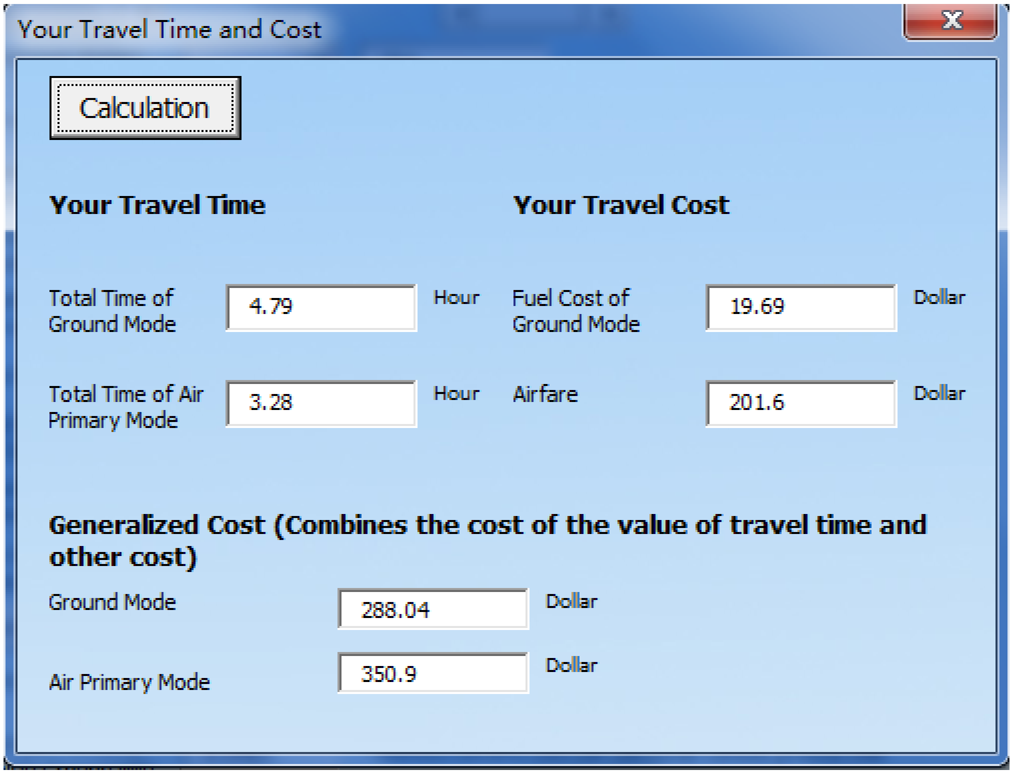


Figure 5-7 Final Result of Travel Time and Cost.

CHAPTER 6: CONCLUSIONS AND EXTENSION FOR RESEARCH

This study focuses on Florida intrastate air travel demand. Although Florida intrastate air service network is generally limited, this study reflects great potential for an increased demand of intrastate air passengers. The major contributions of this work are as follows.

First, under the general conditions and parameters, results indicate that there are opportunities to grow more intrastate nonstop flights in Florida and serve passengers. Results also indicate that *air*, as a primary mode, becomes more attractive for large values of speed rate of travel by air, hourly cost of the traveler's time, and fuel price, while *ground* is the preferred mode for large values of cost per seat mile for air travel, speed rate of travel by ground, waiting time to transition from ground to air travel at a departure airport, waiting time to transition from air to ground travel at an arrival airport, daily rate of rental car, and fuel efficiency.

Second, this work develops a method and a tool that allows individual travelers to evaluate and decide among various travel modes considering both time and cost as factors.

Finally, this study corroborates that air travel demand can be affected by various geo-economic factors including population density, per capita income, etc. As such, a forecasting tool was developed to understand impact of these factors on air passenger demand and explore benefits of increasing the number of intrastate nonstop flights offered.

Opportunities to expand this research include:

- Including not only commercial airports, but also general aviation airports, in order to have a more comprehensive understanding that could aid government’s decision making.
- Expanding models to consider round trip air, ground travel, and multiple, nonhomogeneous travelers. It is anticipated that for multiple travelers (which would be the case for business partners and families traveling together), the cost for flights will increase faster than the cost of ground mode, and the break-even air flight length will become longer. In that case, the travelers would be more inclined to choose ground mode.
- Considering environmental factors – the presented models did not explore the impact of environmental conditions, such as greenhouse gas emission, as a factor that influences choice and investment of different travel modes. Due to environmental policies these factors could also play an important role in the decision making process.

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APPENDICES

Appendix A: Parameters and Notation

β (Beta)	Total air miles divided by the total ground miles between the system's city pairs
C_{SM} (Csm)	Cost per seat mile for air travel
C_{GM} (Cgm)	Cost per ground mile (Reimbursement rate of driving personal vehicle)
C_{R} (Cr)	Cost of car rental
C_{H} (Ch)	Hourly cost of the traveler's time
D_{AB} (Dab)	The distance between local start travel point and the center of the departure airport service area (ASA), i.e., the departure airport
D_{BC} (Dbc)	The distance between the center of the departure airport service area and the exit point of the departure ASA
D_{CD} (Dcd)	The distance between the exit point of the departure ASA and the common entry point into the arrival ASA regardless of modes
D_{DE} (Dde)	The distance between the common entry point into the arrival ASA and the center of the arrival ASA, i.e., the arrival airport
D_{EF} (Def)	The distance between the center of the arrival ASA and the ultimate destination
D_{AIR}	The total one way distance covered by the air primary mode
D_{CAR} (Dcar)	The total one way distance covered by ground mode
D_{BE_b}	Break-even air flight length
Dbe_break	Break-even air flight length
F_{cpg}	Fuel price in dollar per gallon
M_{pg}	Fuel efficiency in miles per gallon
T_{AIR}	Total air travel time, including access and egress times
T_{CAR} (Tcar)	Total ground travel time

R_A (Ra) Speed rate of travel by air in miles per hour

R_C (Rc) Speed rate of travel by ground in miles per hour

R_{Car} (Rcar) Daily rate of rental car

W_B (Wb) Waiting time to transition from ground to air travel at a departure airport

W_E (We) Waiting time to transition from air to ground travel at an arrival airport

Appendix B: Main Codes of Matlab

B.1 The Calculation of Break-Even Flight Length

```
%%%%%%%%%%%%%%%%%%%%%%
%%Set the parameters
%%%%%%%%%%%%%%%%%%%%%%

clc
clear all
close all
%%%%%%%%%%%%%%%%%%%%%%
%%Set the parameters
%%%%%%%%%%%%%%%%%%%%%%
[num1, txt1]= xlsread('D:\Work\USF work\Air Service\Intrastate Air Service\Data
collection\Variable parameters.xlsx',2);

Airport1=num1(1,1);
Airport2=num1(1,2);
County1=num1(4,1);
County2=num1(4,2);

Beta=num1(1,4);

k=num1(1,3);
```

```
Ra=[num1(1,5) num1(2,5)];%%short-haul <72 seats mph rate travel by air in miles per hour
%%short-haul >72

Rc=num1(1,6);%%mph rate travel by car in miles per hour

Wb=num1(1,7);%% W_B=W_C+W_T+W_S+W_P+W_G+W_M hour wait time to transition
from ground to air travel at a departure airport
We=num1(1,8);%% W_E=W_A+W_F+W_D+W_L+W_R hour wait time to transition from air
to ground travel at a small departure airport

Csm=num1(1,9);%0.1413;
Cgm=num1(1,10);%0.592;
Ch=num1(1,11);%% a range8.76:1:61.76;

Rcar=num1(1,12);%% car rental daily rate
Fcpg=num1(1,13);%% Fuel cost per gallon
Mpg=num1(1,14);%%miles per gallon

Cpm=Fcpg/Mpg;

[Dab, Dac, Dbe, Dbc, Dde, Def, Ddf, Dcf]=Break_even(Airport1,Airport2, County1,
County2,Rc);
Cr=Rcar+Cpm*Def/Beta;
```

```
mode=num1(1,15);
if Dbe>(Dbc+Dde)
   Time_Dbe=Time_Based_Model1(k,Beta,Ra, Rc, Wb, We,Dab, Dac, Dbc, Dde, Def,Ddf)
   Cost_Dbe=Cost_Based_Model1(k,Beta,Ra, Rc, Wb, We, Dab, Dac, Dbc, Dde, Def, Ddf, Csm,
Cgm, Ch, Cr)
    if mode==1
        Dbe_p=Time_Dbe
    end
    if mode==2
        Dbe_p=Cost_Dbe
    end
end

if Dbe<=(Dbc+Dde)
    Time_Dbe=Time_Based_Model2(k,Beta,Ra, Rc, Wb, We,Dab, Dac, Def,Dcf)
    Cost_Dbe=Cost_Based_Model2(k,Beta,Ra, Rc, Wb, We,Dab, Dac,Dcf, Def,Csm,Cgm,Ch, Cr)
    if mode==1
        Dbe_p=Time_Dbe
    end
    if mode==2
        Dbe_p=Cost_Dbe
    end
end
```

B.2 Break-Even Function

```
function [Dab, Dac, Dbe, Dbc, Dde, Def, Ddf,Dcf]=Break_even(Airport1,Airport2,County1,
County2, Rc)%, Beta, Ra, Rc, Wb, We
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%calculate longitude and latitude
%%% http://en.wikipedia.org/wiki/Latitude
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
lat_Xita=27*pi/180; %%angle to rad latitude 27
lon_Xita=-081.123944*pi/180; %%angle to rad

Dis_long= pi* 6378137.0*cos(lat_Xita)/(180*sqrt((1-0.006694*sin(lat_Xita)*sin(lat_Xita))));
Dis_lat= 111132.954-559.822*cos(2*lat_Xita)+cos(4*lat_Xita);

%%convert from km to miles
Dis_long_mile=Dis_long*0.621371/1000;
Dis_lat_mile=Dis_lat*0.621371/1000;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%calculate distance between each point
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
[num, txt]= xlsread('D:\Work\USF work\Air Service\Intrastate Air Service\Data
collection\Florida City Pair Distance (Commercial airports).xlsx',3);
```

```
for i=3:21
    skip=txt{i,3};
    skip1=str2num(skip);
    skip2=skip1(1);
    skip3=skip1(2);
    Airlat(i-2)=skip2;
    Airlon(i-2)=skip3;



    skip4=txt{i,6};
    skip5=str2num(skip4);
    skip6=skip5(1);
    skip7=skip5(2);
    Cenlat(i-2)=skip6;
    Cenlon(i-2)=skip7;
end

%%%Calculate C and D dot
%%set per lat 110.8km=68.8501miles per long 27 99.25km=61.67411miles
Per_lat=Dis_lat_mile;
Per_long=Dis_long_mile;

Air_choice=[Airport1 Airport2];
```

```
B_dot=[Airlat(Air_choice(1)) Airlon(Air_choice(1))];
E_dot=[Airlat(Air_choice(2)) Airlon(Air_choice(2))];

%%%Centroid of population latitude and longitude
% A_dot=[+29.073725,-081.123944];
% F_dot=[+26.134058,-080.227135];
A_dot=[Cenlat(County1) Cenlon(County1)];
F_dot=[Cenlat(County2) Cenlon(County2)];

Xb=B_dot(2)*Per_long;
Xe=E_dot(2)*Per_long;
 Yb=B_dot(1)*Per_lat;
Ye=E_dot(1)*Per_lat;

%%%calculate Dbe
[arclen,az] = distance(B_dot,E_dot);

dist=arclen*6371*pi*0.621371/180; %%miles google 242  here 221.5984
Dbe=sqrt((Xb-Xe)^2+(Yb-Ye)^2);
 % Dbe=sqrt((Xe-Xb)^2+(Ye-Yb)^2);

Dbc=Rc*1;
Dde=Rc*1;
```

```
% Dbc=51.25;
% Dde=51.25;

%%Calculate C point
Yc=(Dbe-Dbc)*(Yb-Ye)/Dbe+Ye;
Xc=Xe-(Dbe-Dbc)*(Xe-Xb)/Dbe;

%%Calculate D point
 Dbd=Dbe-Dde;

Yd=(Dbe-Dbd)*(Yb-Ye)/Dbe+Ye;
Xd=Xe-(Dbe-Dbd)*(Xe-Xb)/Dbe;

figure(1)
x=[Xb Xc Xd Xe];
y=[Yb Yc Yd Ye];

%%plot ASA
r_ASA=Rc*1;
theta=0:pi/50:2*pi;
x_c=Xb+r_ASA*cos(theta);
y_c=Yb+r_ASA*sin(theta);
plot(x_c,y_c,'-',Xb,Yb,'.');
```

```
axis square;

hold on
x_c=Xe+r_ASA*cos(theta);
y_c=Ye+r_ASA*sin(theta);
plot(x_c,y_c,'-',Xe,Ye,'.');
axis square;

hold on
plot(Xb,Yb,'*r')
t_text=['x=',num2str(Xb)];
y_text=['y=',num2str(Yb)];
%textb=char('B',t_text,y_text);
textb=char('B');
text(Xb+0.03,Yb+0.05,textb)

hold on
plot(Xc,Yc,'*r')
t_text=['x=',num2str(Xc)];
y_text=['y=',num2str(Yc)];
%textb=char('C',t_text,y_text);
textc=char('C');
text(Xc+0.03,Yc+0.05,textc)
```

```
hold on
plot(Xd,Yd,'*r')
t_text=['x=',num2str(Xd)];
y_text=['y=',num2str(Yd)];
%textb=char('D',t_text,y_text);
textd=char('D');
text(Xd+0.03,Yd+0.05,textd)

hold on
plot(Xe,Ye,'*r')
t_text=['x=',num2str(Xe)];
y_text=['y=',num2str(Ye)];
%textb=char('E',t_text,y_text);
texte=char('E');
text(Xe+0.03,Ye+0.05,texte)
%%% Calculate Dab Def

nA_dot=[A_dot(2)*Per_long A_dot(1)*Per_lat];
nF_dot=[F_dot(2)*Per_long F_dot(1)*Per_lat];

Dab=sqrt((nA_dot(1)-Xb)^2+(nA_dot(2)-Yb)^2);
Dac=sqrt((nA_dot(1)-Xc)^2+(nA_dot(2)-Yc)^2);
```

```
Def=sqrt((nF_dot(1)-Xe)^2+(nF_dot(2)-Ye)^2);
Ddf=sqrt((nF_dot(1)-Xd)^2+(nF_dot(2)-Yd)^2);

Dcf=sqrt((nF_dot(1)-Xc)^2+(nF_dot(2)-Yc)^2);
```

3) Time_Based_Model1 Function

```
function [Dbe_break]=Time_Based_Model1(k,Beta,Ra, Rc, Wb, We,Dab, Dac, Dbc, Dde,
Def,Ddf)
%%1 short-haul<72 seats; 2 short-haul >72 seats;

Dcd_p=(Ra(k)*(Dab+Def-
(Dac+Ddf))+Rc*Beta*Ra(k)*(Wb+We)+Rc*Beta*(Dbc+Dde))/(Ra(k)-Rc*Beta);
Dcar=(Dac+Dcd_p+Ddf)/Beta;
Dbe_break=Dbc+Dcd_p+Dde;
```

Appendix C: Quick Start Guide for the Comparison System in Chapter 5

C.1 Introduction

Comparison system provides a tool for travelers who would travel in Florida and consider time and cost factors to choose more effective travel mode.

C.2 How to Start the System

Click on “Comparison System Version 13.xlsm”

C.3 How to Run the System

To use this system, follow the steps below:

1. Click on “Comparison System Version 13”;
2. Click on “Start”, and then go to step 3;
3. Steps for “Start”:
    - Choose “Search Radius” from drop-down menu;
    - Enter addresses and search for departure and arrival airports;
    - Choose desirable departure and arrival airports;
    - Type parameters: R_C W_B, W_E, F_{cpg}, M_{pg}, C_H and R_{Car};
    - Get the general parameters and choose R_A;
    - Click on “Travel Time and Cost”.

Click on “Exit” to end.

C.4 Parameters Declaration

β (Beta) Total air miles divided by the total ground miles between the system’s city pairs

C_{SM} (Csm) Cost per seat mile for air travel

C_{GM} (Cgm) Cost per ground mile (Reimbursement rate of driving personal vehicle)

C_R (Cr) Cost of car rental

C_H (Ch) Hourly cost of the traveler's time

F_{cpg} Fuel price in dollar per gallon

M_{pg} Fuel efficiency in miles per gallon

R_A (Ra) Speed rate of travel by air in miles per hour

R_C (Rc) Speed rate of travel by ground in miles per hour

R_{Car} (Rcar) Daily rate of rental car

W_B (Wb) Waiting time to transition from ground to air travel at a departure airport

W_E (We) Waiting time to transition from air to ground travel at an arrival airport

C.5 Introduction of User Interface

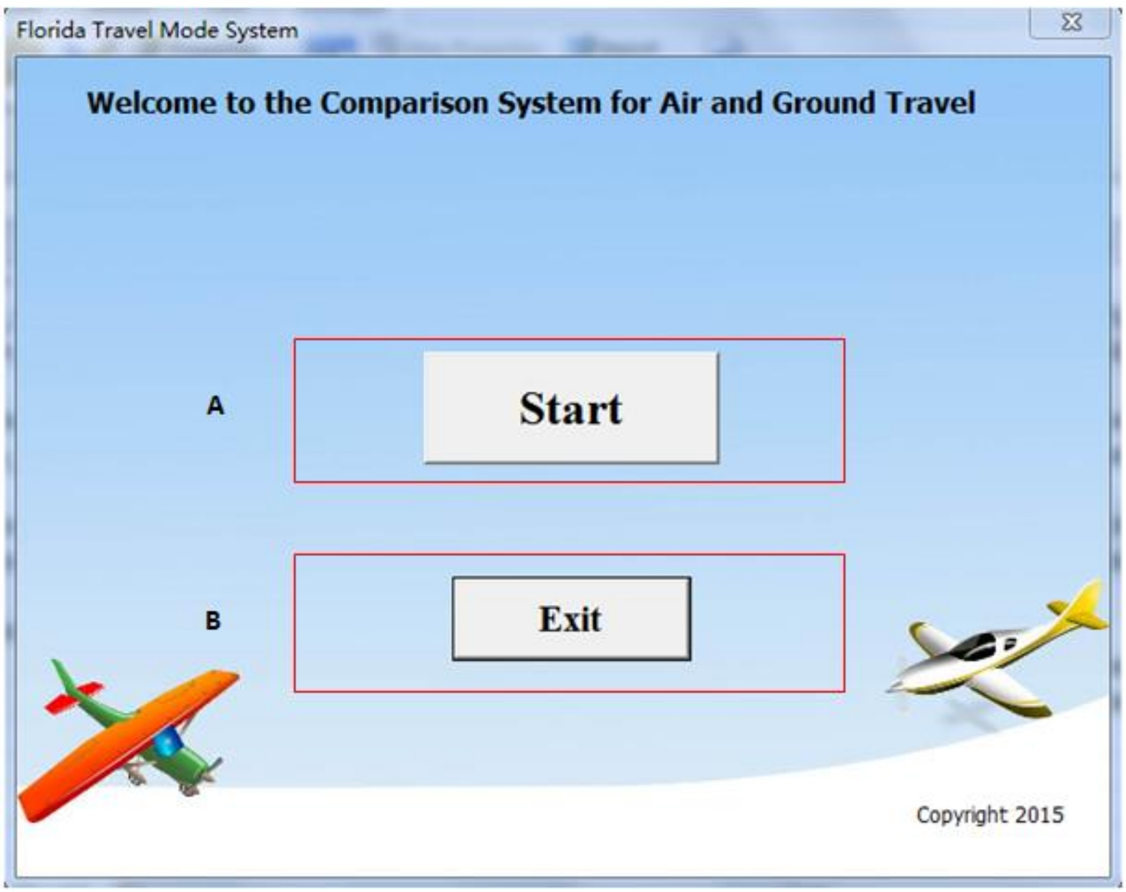

Figure C.1 User Main Interface.

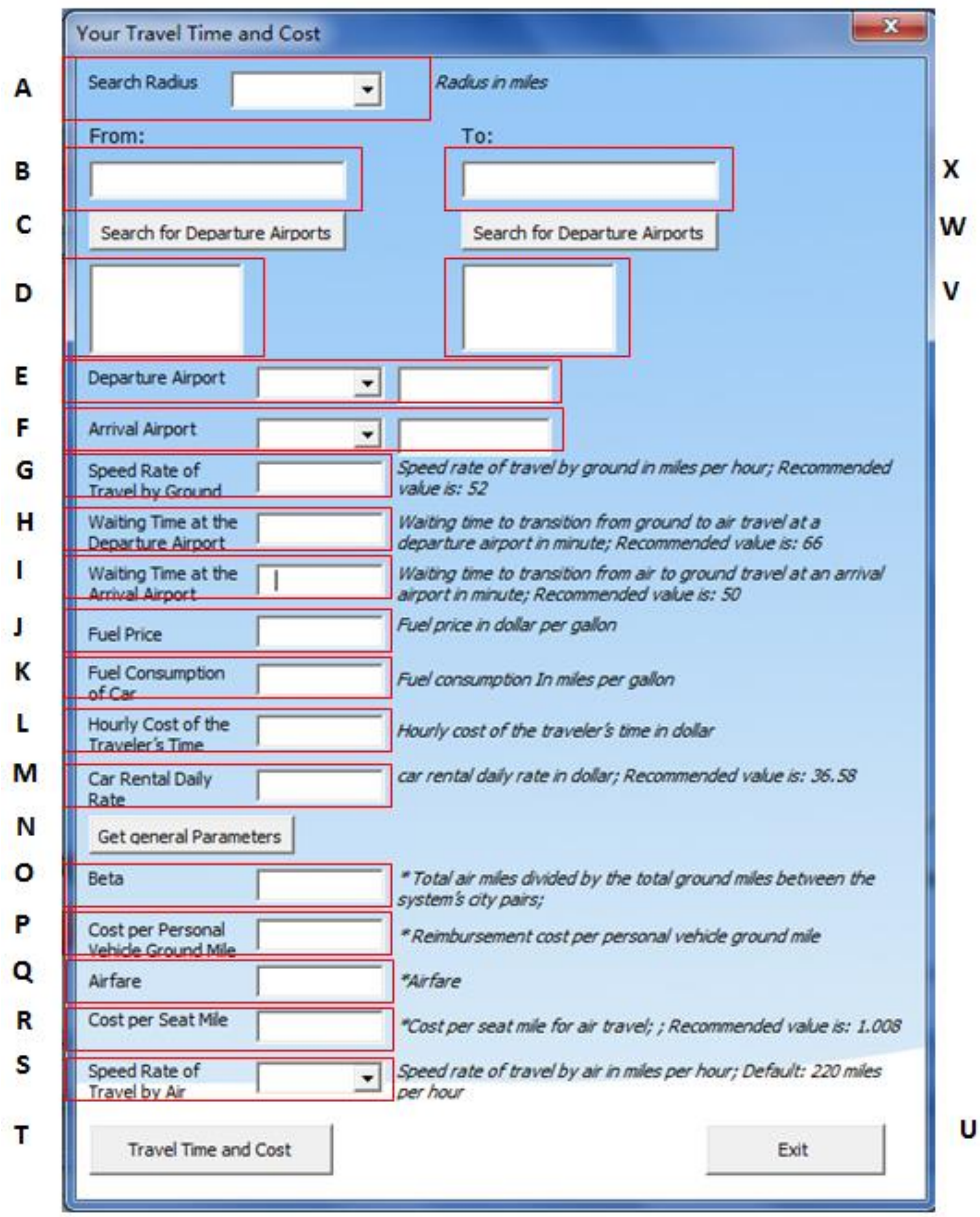

Figure C.2 User Sub Interface of the Traveler Time and Cost.

A Search the radius of Airport Circle from the drop-down menu whose center are Home Address B or Destination Address Q within which Departure and Arrival airports are located.

B Enter Home Address (starting point).

C Click the button searching for Departure airports.

D List all the possible airports to depart.

E The airport which is chosen in D would appear here.

F The airport which is chosen in P would appear here.

G Type speed rate of travel by ground Rc in miles by hour. The recommended value is: 52.

H Type waiting time Wb in miles by hour. The recommended value is: 1.1017.

I Type waiting time We in miles by hour. The recommended value is: 0.8333.

J Type fuel price Fcpg.

K Type fuel consumption Mpg in miles per gallon.

L Type hourly cost of traveler's time Ch in dollar.

M Type car rental daily rate in dollar.

N Click the button to get general parameters.

O Do N, and you would get data β here.

P Do N, and you would get data Cgm here.

Q Type Airfare here; or

R Type Csm. Its recommended value is 1.008.

S Choose Speed rate of travel by air Ra in miles per hour from the drop-down menu.

T Click the button to reach your consuming time and cost interface

U Exit from sub interface.

V List all the possible airports to arrive.

W Press the button searching for Arrival airports

X Enter Destination Address (Destination).

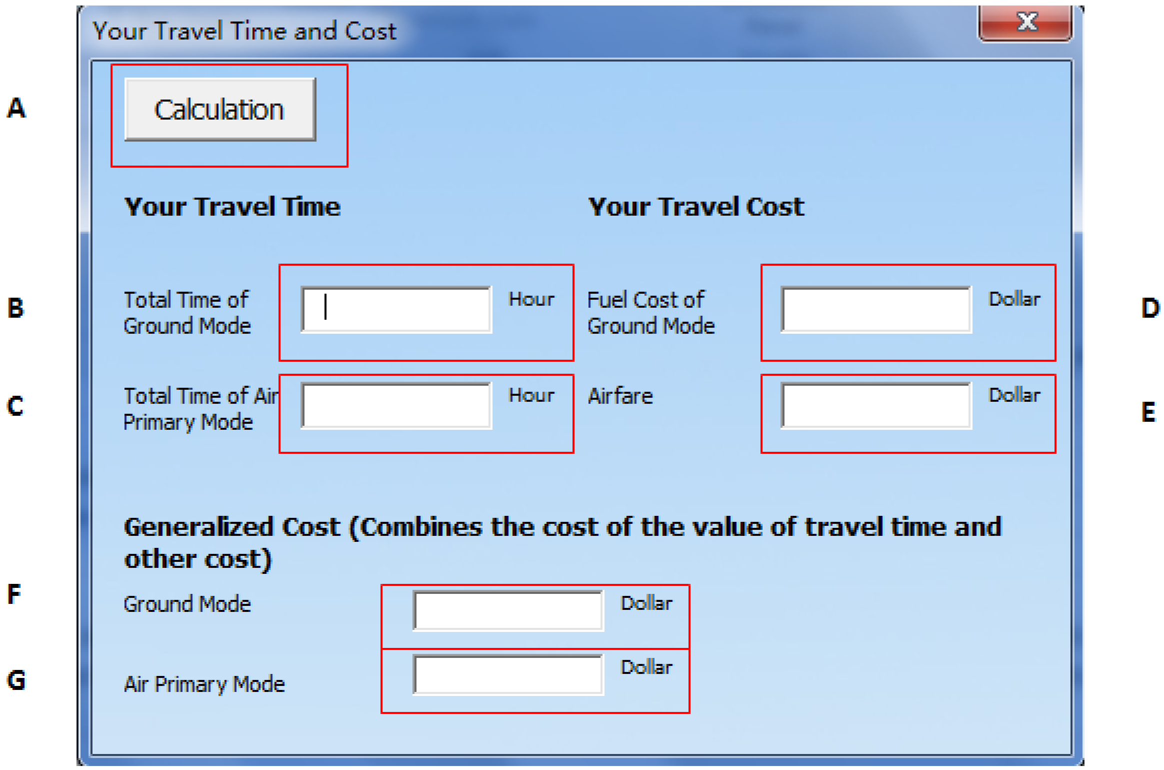

Figure C.3 User Sub Interface of the Result of the Traveler Time and Cost.

A Click the button to calculate the parameters below.

B The total time of ground mode appears in this textbox.

C The total time of air primary mode appears in this textbox.

D The gasoline cost of ground mode appears in this textbox.

E The airfare appears in this textbox.

F The generalized cost of ground mode appears in this textbox.

G The generalized cost of air primary mode appears in this textbox

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