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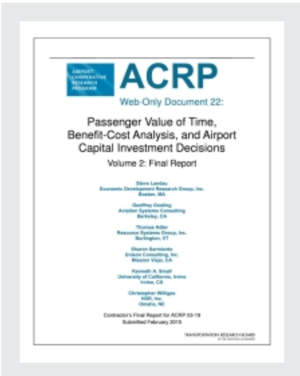
ACRP
Web-Only Document 22:
Passenger Value of Time, Benefit-Cost Analysis, and Airport Capital Investment Decisions
Volume 2: Final Report

Passenger Value of Time, Benefit-Cost Analysis and Airport Capital Investment Decisions, Volume 2: Final Report

DETAILS

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Advisers to the Nation on Science, Engineering, and Medicine

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1 INTRODUCTION

Airport sponsors and airport managers are often called upon to weigh the costs and benefits of capital investment decisions. Alternatives considered may be different designs of a single improvement or alternative projects. For example, one set of alternatives could include deciding among runway extensions of varying lengths of the same runway, as well as new runways of varied configurations. Often these projects are also packaged with different mixes of complementary investments, which could range from land acquisition to new or improved aprons. Decisions such as these regularly involve prioritizing resources among different types of investments, such as evaluating trade-offs between a runway extension and improved passenger access from parking lots to a terminal. These decisions become even more complicated if state or regional agencies are deliberating over investment decisions across multiple airports.

A series of analytical tools and techniques are available to airport sponsors, managers and state officials to help them make decisions for funding capital investments. Many of these tools assess a financial feasibility—determining which project (or which alternative) can be afforded. Other tools/techniques are used to estimate the economic impacts of projects. Economic impact studies may be used to educate the public about the significant economic contributions of a project and to build public support for it.

Techniques often used for decision making include Benefit-Cost Analysis (BCA) and calculation of Net Present Value (NPV). Fundamentally, these computations are used to determine whether an investment will generate benefits that will exceed its costs. This analysis is accomplished by expressing all current and future benefits and costs on an equivalent basis, which is their "present value" (PV).

A project is considered economically justified if it has a positive "Net Present Value" (calculated as the PV of benefits minus the PV of costs). In a BCA, a project is considered economically justified if the benefit/cost (B/C) ratio exceeds one (calculated by dividing benefits by costs). [1]

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[1] While a NPV and BCA analysis is a valuable tool for analyzing proposed projects or comparing alternatives that will have costs and benefits realized across multiple years, a BCA is mandatory for applications for more than $10 million in discretionary funds from the Federal Aviation Administration's (FAA) Airport Improvement Program (AIP). The FAA also reserves the right to ask for a BCA for less costly projects. See http://www.faa.gov/airports/aip/bc_analysis/

1.1 Value of Time

The passenger value of time is a major component of benefit analyses in capital improvement considerations at commercial airports. This broad category of analyses may include evaluation of projects that will provide the benefits of travel speed improvements or travel delay reductions. It may also apply to projects that will enable airlines to offer improved air service that will allow travelers to use a closer airport, a faster or more frequent service, or a service with fewer connections or less time spent in changing modes (e.g., from surface transportation to air travel). Or, it may apply to projects that will provide faster circulation within an airport, including improved efficiency of security screening, reduced time required for proceeding from security screening to gates, or less time spent between connecting flights.

Historically, Federal Aviation Administration (FAA) guidance for the passenger value of time to be used in an airport BCA has conformed to the U.S. Department of Transportation (DOT) guidance that provides single values for business travelers and personal travelers—and a third value ("all purposes"), which is a hybrid of business and personal travelers. The guidance distinguishes between surface travel and air or high speed rail travel. The most recent values for air and high speed rail travel are $32.60 for personal travelers, $60.00 for business travelers, and $43.70 for all purposes. These values are also expressed as plausible ranges, shown in Table 1 (U.S. DOT, 2014).

Table 1. U.S. DOT Guidance on Passenger Value of Time for Air and High Speed Rail Travel by Trip Purpose

Trip Purpose	Recommended Values	Plausible Range	
		Low	High
Business	$60.00	$48.00	$72.00
Personal	$32.60	$28.00	$41.90
All Purposes	$43.70	$36.10	$54.10

Source: U.S. Department of Transportation, Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, July 9, 2014.

Whether by ranges or as single rates, these values do not take into account differences in travelers' willingness to pay (WTP) for segments of an air trip that are more or less onerous than others. For example, time spent waiting at the gate and waiting in a security line may be valued differently by an air traveler. While not to dismiss any potential discomfort involved, time waiting at a gate for a flight or in nearby concessions can be spent productively (working) or enjoyably (listening to music, reading, watching a movie, or eating and drinking). As technology has evolved from pay phones to smartphones and tablets, options for passengers have increased in both the number of possible activities and potential efficiency. However, there are very limited other activities available to passengers while spending time in a security line.

This research is intended to improve the application of benefit-cost analysis for airport investment decision-making. This research project takes a first step in improving the breadth of "value of time" measures. In addition, a guidebook on applying the research findings was developed for the aviation community, which could be of immediate use in evaluating capital investments at airports.

In practice, some (but not all) airport capital investments are made specifically to increase capacity and reduce delays occurring in the air or on the ground. The valuation of air passenger time is one part of a broader set of delay-related costs, and even those delay costs differ depending on when and where they occur. However, improving the valuation of passenger travel time and delay, which is the key focus of the data collection conducted for this project, also enables a much broader set of improvements to be made in the entire practice of capital planning assessment. This is further addressed in the Guidebook for Valuing User Time Savings in Airport Capital Investment Decision Analysis, prepared as part of this project.

The value of time in air travel involves many distinct travel segments, each involving time that might be made shorter or longer by actions taken by air carriers or terminal operators. In research for the project, the Research Team identified some likely differences across these components in the values of time and reliability, and—equally important—in the factors that affect those values. This approach led to dividing and valuing the time components of an air trip into separate categories[2], including:

- Ground-side access time to the airport
- Time spent in flight check-in and security
- Time walking to gate
- Time Spent in the gate area before boarding the flight
- In-Aircraft Time, distinguished between scheduled flight time and in-flight delay
- Transfer time to make flight connections
- Baggage pickup and terminal egress time
- Ground-side egress time from the airport

The research explored how air travelers perceive differences in the value of time spent in each of these components. This was conducted through a survey that included multiple stated preference (SP) experiments in which respondents made choices between alternative hypothetical travel options that differed in the time spent in each of these

[2] In order to keep the survey instrument later developed and used in the research to a reasonable level of complexity for respondents to handle, several trip components of this list were consolidated, as discussed in text in subsequent chapters of this report.

components, as well as other characteristics of the trip. Due to practical limits on the size of the survey, the SP experiments did not directly address the arrival end of an air trip, including: time to baggage claim or terminal exit; wait time at baggage claim and exiting the terminal; and airport ground egress time. These travel time components are addressed below.

- *Time to Baggage Claim or Terminal Exit*: It was assumed that the disutility associated with this is the same as that involved in getting to the gate area after clearing security on departure.
- *Wait Time at Baggage Claim and Exit Terminal*: It was assumed that the disutility associated with waiting at baggage claim, claiming bags, and then exiting the terminal is the same as that waiting at check-in, checking in, and walking to security screening.
- *Airport Ground Egress Time:* It was assumed that the value of egress time is similar to that for ground access.

The overarching purpose of this ACRP research project is to develop measures of air passenger value of time for benefit-cost analyses that relate the segmentation of passengers' air trips to the different types of capital improvements that affect the value of time consumed at each segment. In this way, airport sponsors, managers, and funding agencies can incorporate an appropriate passenger value of time for specific facility investments when deciding between projects. Table 2 cross-references categories of capital investments with the type of passenger activity that consumes time during an air trip.

Table 2. Capital Facilities that Affect the Time Spent in Specific Air Passenger Activities

Passenger Air Trip Related Activity	Terminal Landside (Departures)				Terminal Landside (Arrivals)		Airside			
	Passenger Check-in	Passenger Screening (TSA)	People Mover to Gate	Aircraft Gates	People Mover from Gate	Baggage Handling	Air Traffic Control	Runway	Taxiways	Apron Area, Taxilanes and Aircraft Gate Positions
Ground Access										
Terminal Access										
Check-in & Security	✓	✓								
Reach Gate			✓							
At Gate				✓				✓		
Flight Time					✓		✓	✓	✓	✓
Flight Delay					✓		✓	✓	✓	✓
To Baggage Claim or Exit*					✓					
Baggage Claim*						✓				
Ground Egress*			✓							

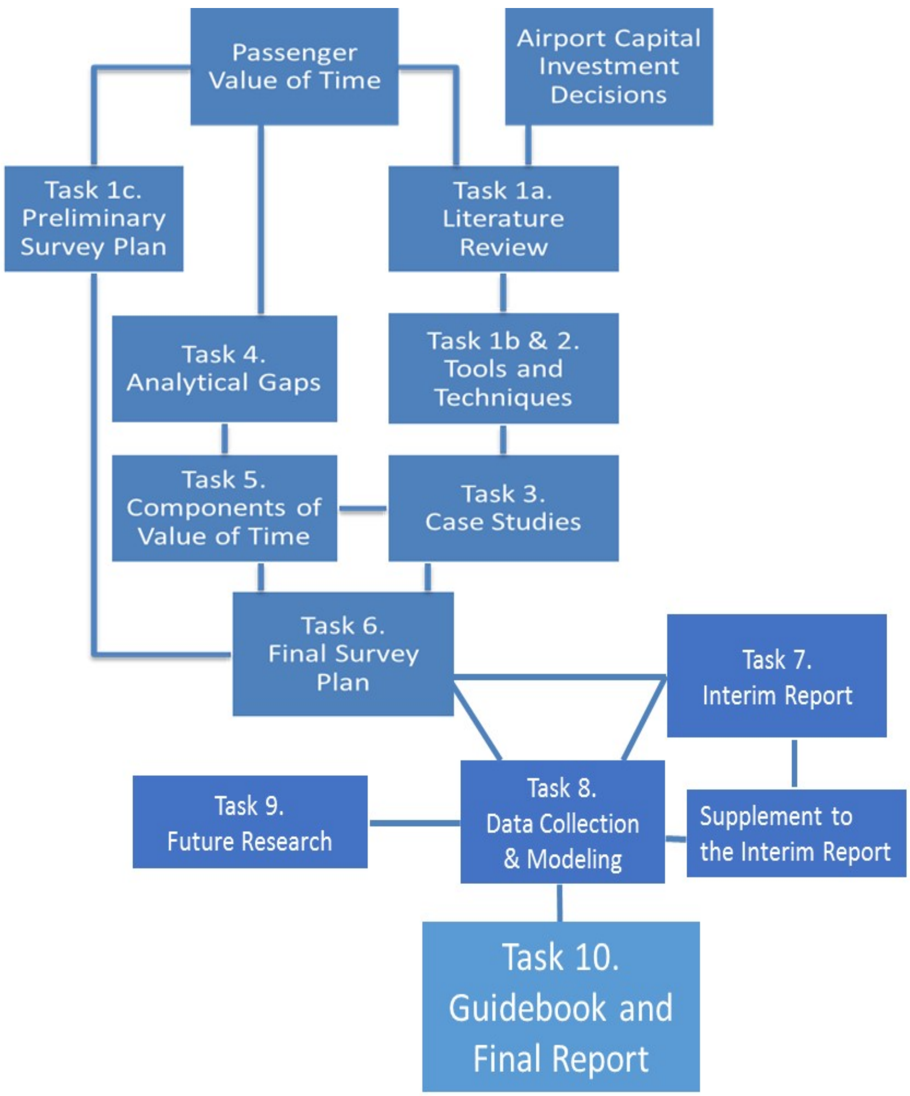
Table 2. Capital Facilities that Affect the Time Spent in Specific Air Passenger Activities (Continued)

Passenger Air Trip Related Activity	Groundside					
	Access Road to Airport	People Mover Access to Airport Terminal (from Transit, Rental Car or Parking Facilities)	Parking Lot/Garage	Central Bus or Train Transfer Facility to/from Airport Terminal	Airport Circulation Improvements for Taxis	Drop-off & Pickup Areas by Terminal Curbfront
Ground Access	✓					
Terminal Access		✓	✓	✓	✓	✓
Check-in & Security						
Reach Gate						
At Gate						
Flight Time						
Flight Delay						
To Baggage Claim or Exit*						
Baggage Claim*						
Ground Egress*		✓	✓			

1.2 Research Approach

The Research Team performed an extensive review of airport project evaluation activities and techniques. From the larger set of activities and techniques identified in the review, the Research Team chose to pursue a smaller set of more focused aspects. Figure 1 illustrates the flow of research tasks that led to the development of the guidebook.

Figure 1. Flow of Research for the Project



Flow of Research

Tasks 1 and 2 comprise the foundation of the research described in this report. In Task 1A, the Research Team identified published guidance concerning passenger value of time, benefit-cost analysis and airport capital investment decisions. The literature review is provided in Appendix A.1 of this report. Literature was reviewed on the following topics:

- **U.S. airport capital investments.** These references were helpful in identifying the different types of airport capital investment projects and the types of analysis that may be required for different types of projects, depending upon funding sources.
- **Benefit-cost analysis and other methods for evaluating capital investment decisions.** The references on methodology are grouped according to the following sub-topics: (1) BCA and (2) other methods of evaluating capital investment decisions.
- **Benefit-cost analysis transportation applications.** References on actual BCA applications to airports and other transportation modes provide illustrations of the application of BCA and other approaches to economic valuation of different types of benefits and costs associated with airport capital investments.
- **Economic valuation.** These references cover both theory and empirical estimation of the following economic values relevant to the evaluation of airport capital investments:
    - Value of travel time
    - Value of statistical life
    - Valuation of noise effects
    - Valuation of climate and air quality effects

  Although the focus of the research project was not on evaluating the safety contribution or environmental consequences of capital investment projects, because these aspects do have to be considered in project evaluation, they were included in the literature review for completeness.

In Task 1B, four methodologies and associated techniques for evaluating airport capital investment decisions were researched. These methodologies are: (1) economic analysis, (2) financial analysis - investment decision rules, (3) financial analysis - airport financial planning techniques, and (4) economic impact analysis. Analysts can use one or all of these methodologies, each involving different analytical techniques, depending upon the nature and objective of the airport capital investment, the source of funding, and the parties involved in decision making, among other factors. Appendix A.1 documents the findings of this review and also discusses approaches to addressing uncertainty in any of the methodologies for evaluating capital investment decisions.

The purpose of Task 2 was to summarize the key information identified in Task 1B. Task 2 provided a synopsis (in the form of the five reference tables included in Appendix A,2) that summarizes methodologies and techniques for use in evaluating airport capital investment decisions. This synopsis provides guidance for identifying, measuring and valuing benefits in airport benefit-cost analysis. The first two tables provide quick references on the use of each of the four methodologies and associated techniques reviewed in Task 1 of the research: (1) economic analysis, (2) financial analysis – investment decision rules, (3) financial planning – airport financial planning, and (4) economic impact analysis. The last three tables present relevant information from the FAA BCA Guidance – with updates to certain source references – on the types, measurement and valuation of benefits for airport capital projects in benefit-cost analyses submitted to the FAA to support requests for Airport Improvement Program (AIP) discretionary grants and Letters of Intent (LOIs).

Case studies and Identification of Analytical Gaps

In Task 3 and Task 4, the Research Team reviewed the tools and techniques profiled in the preceding tasks by: (1) conducting five case studies of capital investments at airports to illustrate the practical aspects of how tools are currently used; and (2) examining the extent to which gaps exist in the available guidance, as well as the steps required to fill those gaps.

The case studies undertaken in Task 3 profile (a) the analytical tools used in decision-making, (b) how tool selection varies based on the project motivation and funding sources being sought, and, in particular, (c) how the value of passenger time factors into the investment decision.[3] The case study projects encompass both capacity enhancement projects and non-capacity related investments. Projects described by the cases include terminal modernization projects intended to improve passenger flow and airport safety, and accommodate more aircraft at the terminal buildings. Other projects focus on runway improvements and taxiways intended to add capacity for more flights, reduce delays, and increase safety. The airports that undertook the case study projects include one small hub, two medium hubs and two large hubs. The case studies are documented in Appendix A.3 of this report.

In Task 4, the Research Team looked at the analytical needs that are not addressed by the established techniques documented in Tasks 1 and 2. These gaps take one of two forms. The first is a lack of adequate guidance on how to address particular aspects of benefit-cost or other capital investment analysis. The second is a lack of data or other information needed to effectively address particular issues in applying analytical techniques to airport capital investment decisions. Moreover, some issues involve both types of gap, where there is not only a lack of guidance on how to address the issue but also a lack of the underlying data needed to adequately address the issue. The findings of Task 4 are presented in Appendix A.4 of this report.

[3] The case studies did *not* assess how well the evaluation techniques were applied or if these are worthwhile projects.

Deconstructing Passenger Value of Time

Starting in Task 5, the research conducted for the project moved from looking at the role of passenger value of time in how airports make capital investment decision, to how to improve the technique of applying passenger value of time to benefit-cost analysis.

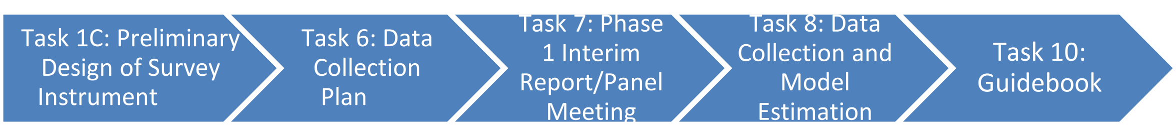
The first step in this phase of the project was to summarize the most prominent current theories that explain how value of time and value of reliability in air travel are determined, with attention to how they vary with specific factors. Such travel involves many distinct travel segments, each involving time that might be made shorter or longer by actions taken at airports. In turn, this leads to likely differences across these components in the values of time and reliability and in the factors that affect those values. Lastly, strategies to empirically measure the values of time and reliability of these components were identified and described.

The findings and recommended approach identified in Task 5 are described in the next chapter.

Data Collection to Assess Passenger Value of Time Based on Trip Segments of Air Travelers

Data collection was conducted as Task 8. However, planning for data collection, as well as the actual collection and analysis of the primary data, have taken place at multiple points in the entire research effort, and have been the subject of an ongoing conversation with the ACRP Project Panel starting with Task 1. The flow of interaction on data collection between the Research Team and the Panel is illustrated by Figure 2.

Figure 2. Flow of Interaction between Project Panel and Research Team on Data Collection



Task 1C involved Panel input on the survey component of the project from the beginning of the development of the primary data collection effort. Task 1C provided the Research Team's initial thoughts on the design of a survey instrument. An early task memorandum provided the Panel with an overview of the proposed steps in designing, administering, and analyzing a survey of air travelers. It began the discussion on assembling information on how the perceived value of changes in travel time varies with: (a) traveler characteristics; and (b) circumstances in the different components of the airport and air trip.

In Task 6, the Research Team combined the framework developed in Task 1C and comments received from the Panel, with gaps identified in Task 4 as they pertain to value of time and findings from the case studies conducted in Task 3. The ensuing data collection plan had the objective of identifying the values of time associated with each of the different travel time components. The approach adopted for the data collection involved a web-based survey of respondents who had taken an air trip within the U.S. in the prior six months, the details of which they could recall. The primary purpose of the survey was to collect suitable data to estimate values of the willingness to pay for reductions in the various time components that are part of air travel (defined in Task 5). The proposed survey instrument involved collecting a wide range of information about each respondent's most recent trip, including the times spent in the various components of the trip and the costs involved. Based on the reported details of their trip, the respondents were then presented with a set of stated preference choice experiments that varied the times and costs involved and asked them to choose between these hypothetical alternatives for their trip. Analysis of these choices would allow the implied values of time to be inferred. The data collection plan included a proposed sampling plan, together with a draft survey instrument.

The Research Team submitted the data collection plan developed under Task 6 to the Project Panel in addition to the Interim Report (Task 7). The data collection plan formed the major discussion focus of the Panel meeting on the Interim Report. Subsequent to the Interim Report meeting, in responding to comments from Panel members, the data collection plan was revised. The actual data collection was conducted in Task 8. The major revisions concerned two primary focuses of comments from the Panel:

- The SP survey experiments initially proposed were too complex and the length of the survey would discourage responses due to the time required to complete the survey. The Research Team agreed with these concerns and reduced the length and complexity of the survey by consolidating some trip segments and also by reducing the number of questions related to the respondents' most recent air trip and simplifying the SP experiments. The final stated preference scenarios included 16 observations for each respondent (eight observations from a set of flight itinerary SP choice experiments and eight from a set of time component SP choice experiments – see Appendix B.1).
- The planned sample was too small. In response, the Research Team increased the target sample size from 800 to 1200. Table 3 shows the number of respondents and the breakdown by the purpose of the respondents' most recent domestic air trip.

Survey Implementation

The Research Team developed and implemented a web-based stated preference survey questionnaire that gathered information from a sample of air travelers who had traveled recently by air within the U.S. and were able to recall the details of their trip. The questionnaire collected data on their recent air travel experience and administered the stated preference experiments to collect data that were used to estimate the respondents' willingness to pay for travel time savings for the various time components of their trip. The survey respondents were obtained from a commercial vendor that maintains nationwide panels of individuals willing to participate in online surveys. Screening questions were used to exclude respondents who had not made a domestic air trip within the previous six months, or met a number of other disqualifying criteria.

The survey was conducted in two waves. The first 105 surveys were a "soft launch," with surveying suspended after these initial responses were received. The responses were then analyzed to assure the Research Team that questions were being understood and that the response rates included reasonable numbers of business and personal travelers. After this review, the survey questionnaire was adjusted and the full launch was implemented, which resulted in 1,155 additional responses (see Table 3).

Table 3. Data Collection Summary

	Purpose of Recent Trip		
	Business	**Non-business**	**Total**
Soft Launch	32	73	105
Full Launch	291	864	1,155
Total	323	937	1,260

The "soft-launch" was to evaluate the median and mean survey duration times, as well as whether people were dropping out before completing the survey, in addition to other data quality/integrity checks. This enabled the Research Team to refine the survey to maximize the amount of quality data collected while minimizing the burden placed on respondents.

The stated preference survey experiments were customized for each respondent by presenting values for the travel time components and costs of the airfare or ground access trip and modifying wording based on respondents' previous answers. The Research Team used the stated preference choice experiment data to estimate discrete choice models that explained the choices made in the SP experiments between alternatives in terms of the times and costs used in the experiments and other aspects of the hypothetical trip options (such as the number of flight connections involved). The SP experiments led to a "willingness-to-pay" analysis. The willingness to pay for travel time savings, or value of time, is defined as the marginal rate of substitution between time and money (i.e. the amount of money that a person would be willing to exchange for a reduction in travel time, or some specific component of travel time, while maintaining the same level of utility, or satisfaction), and can be determined from the estimated time and cost coefficients of the discrete choice models.

A detailed discussion of the data collection and modeling is provided in Chapter 3 below.

1.3 Guidebook

The Research Team prepared the *Guidebook for Valuing User Time Savings in Airport Capital Investment Decision Analysis* for use by airport sponsors, managers and consultants based on the findings of the research undertaken in Tasks 1 through 8. The Guidebook provides updated travel time values that are specific to ten different segments of airport trips, differentiating between business and leisure travelers, and allowing income levels to be taken into consideration. It describes a process for using travel time valuations in estimating the relative benefit or cost effectiveness of proposed airport capital investments. The process allows for decision makers to screen whether particular airport projects warrant the use of the more detailed values of time presented in the Guidebook and to identify the types of travel time savings that are likely to occur for particular types of projects.

The Guidebook is a separate document from this report, which documents the research required for its preparation, and may be found at www.trb.org/Main/Blurbs/172472.aspx.

1.4 Future Research

Practical considerations of scope and budget limited the aspects that could be addressed in this project. As a result, a number of issues identified in the research would benefit from more intensive data collection and modeling than was possible under this project. In order to increase the understanding of how the values assigned by air passengers to savings of travel time and reduced delay vary across the different components of air trips, future research is needed to supplement and extend the findings of this project. Just as the resources of this project were maximized by leveraging previous research, future research should be expected to leverage the data collection techniques and findings from this project and subsequent or ongoing research.

Chapter 4 below provides a discussion of the future research needs identified in the course of the research.

1.5 Organization of the Final Report

This report is organized as chapters that emphasize the final outcomes of the value of time research that was conducted in the course of the research. Accordingly, the chapters below are not organized in order of task. Table 4 shows the correspondence between the chapter titles and report appendices to the original research tasks and technical memoranda that formed the basis of each segment of the research.

Table 4. Correspondence of Report Chapters and Appendices and Research Tasks

Chapter	Task
1. Introduction	N/A
2. Components of Air Trip Travel Time	Task 5
3. Data Collection and Modeling	Task 8, including discussion of the data collection plan in Tasks1C, 6 and the Interim Report (Task 7). Chapter 3 also includes additional analysis requested from Panel members when these Tasks were reviewed.
4. Future Research Needs	Task 9
5. Conclusions	N/A
Appendices	**Task**
A. Background Research	
1. Literature Review	Task1A
2. Tools and Techniques for Evaluating Capital Investments	Tasks 1B and 2
3. Case Studies	Tasks 3A and 3B
4. Research Gaps	Task 6
B. Stated Preference Survey	
1. Survey Screen Captures	Task 8, (Appendix 1 to the Task 8 technical memo)
2. Survey Tabulations	Task 8, (Appendix 2 to the Task 8 technical memo)
3. Additional Analysis	The additional analysis was undertaken in response to (a) issues raised in the Task 8 technical memo for further analysis, and (b) response to Panel comments on the draft Task 8 technical memo.

2 DEFINING THE COMPONENTS OF VALUE OF TIME

Analysis of the value of time can seem very complicated. People spend their time in many ways during travel—in a vehicle, walking, waiting, and so forth—and they do so under many different situations (for example, travel to work, travel to leisure or personal business activities, or travel in the course of work). A given time saving might occur at the beginning or the end of a trip, during a short or a long trip, or during an outbound, intermediate, or return leg of a trip. There are good reasons to think that all of these factors have strong implications for how that time saving is valued by the traveler. Furthermore, it is now widely recognized that uncertainty in travel time for a given trip is a very important factor to people, and that they place value on reducing that uncertainty, which can be quite variable and sometimes very high. Similarly, while uncertainty deals with unexpected changes in travel time (and hence arrival time), another important time component to consider is known differences between the preferred and actual (scheduled) timing of a trip, known as schedule delay.

Fortunately, many of these complexities can be encompassed within a few sensible, theoretical precepts regarding how people use their time and what constraints they face. While it is true that working out the implications of such theory leads to complexity, this disadvantage is compensated for by the fact that the principles are common across many different types of travel. Studies of urban travel are the source of the greatest number of results and empirical measurements, and many results from the analyses of value of time of urban travel can be adapted to air travel.

This section begins with a summary of the most prominent current theories explaining how value of time and value of reliability are determined, with attention to how they vary with specific factors. It is followed by a discussion of the attributes of air travel that are specifically relevant in light of these concepts, which are systematically applied by decomposing air trips into distinct components. The Research Team uses the theories on the values of time and reliability to describe how various factors affect travelers' valuations of both the typical time required (value of time) and the uncertainty in that time (value of reliability) of these distinct components. This section concludes with an explanation of derived implications for strategies to empirically measure the values of time and reliability of these components.

2.1 Theory of Value of Time

The most prominent approach to the value of time relies on a series of models (each successively more complete) by Becker (1965), Oort (1969), and DeSerpa (1971), with further extensions by Jara-Díaz (2000, 2003), De Borger and Van Dender (2003), and De

Borger and Fosgerau (2008). Convenient unified expositions are contained in Jara-Díaz (2007, chapter 2) and Small and Verhoef (2007, section 2.6). Small and Verhoef also develop a mathematical theory of how travelers would value reliability of travel, the latter based especially on Noland and Small (1995) and Bates et al. (2001).

The basic theory of valuation of travel time begins with a traveler who values purchased goods, time spent working, and time spent in several other specific activities, including leisure pursuits and various phases of travel. The traveler faces a budget constraint: goods must be purchased out of unearned plus earned income. Also, the traveler, or the household to which he or she belongs, faces an overall time constraint: total time available for work, travel, and other activities is limited. Finally, each travel activity requires a minimum amount of time determined by the nature of the transportation system. The objective is to determine how much the traveler would be willing to pay for a reduction in one of the required travel times which might occur, for example, due to a terminal upgrade at an airport.

A key result is that the value of time for any travel activity consists of two components, each of which has an intuitive interpretation. The first component is the monetary reward for time spent working, typically assumed equal to the after-tax wage rate. This component is based on the traveler's potential ability to use any travel time savings to work more. In practice, of course, the flexibility to change work hours is often limited; however, in the long run it is never completely absent because one can seek to change to a different job with more or fewer hours.[4] (Another interpretation of this flexibility is that if the traveler is part of a family, changes in the traveler's overall time budget may impact other household members, for example, through household chores, and cause them to enter or exit the workforce.) Furthermore, even in the short-term, when it might be impractical to change work hours, the traveler will probably have to trade-off household chores or leisure time against changes in travel time, and these have value to the worker, which are also closely tied to the wage rate.

The second component is the monetary equivalent of the traveler's dislike of time spent traveling relative to that spent working. That is, in the conceptual trade-off of spending less time traveling and more time working, the traveler will account for the possibility that he or she enjoys one more than the other. If work is more onerous than travel (i.e. requiring more mental or physical effort), then this component of the value of travel time will be negative—meaning it lowers the value of travel time. Empirical estimates suggest that this is typically the case for most urban travel, since the measured value of travel time is typically less than the after-tax wage rate.

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[4] When flexibility is limited, this component of the value of time is modified according to a term that is positive if the person is constrained to work more hours than he or she would prefer given the current wage rate and travel time constraints; and negative in the opposite case (Small and Verhoef 2007, Section 2.6.3).

There are several crucial implications of this theory:

- *The value of time can be expected, on average, to rise with the wage rates of the traveler or of other members of the traveler's household.* If, as is common, the available measure is household income rather than the wage rate, the value of time is likely to rise with income. However, there is no presumption that this relationship should be proportional.
- *The value of time in any particular travel activity depends on factors that determine how much that time is enjoyed.* Travelers will value time savings more in onerous travel situations than in situations where they are relaxed and happy, because they want to reduce the amount of time they spend unpleasantly. This implies the following corollary:
    - *The value of time is strongly influenced by environmental conditions and by stress-inducing aspects of travel.* Examples of environmental conditions are noise, discomfort, and physical exertion. Examples of stress-inducing aspects are lack of safety (perceived or actual), worry about missing connections, unfamiliarity leading to fear of making wrong choices, and high levels of crowding, to name but a few.

2.2 Theory of Value of Reliability

Reliability refers to how certain the traveler can be of the time required to complete a trip. Thus, reliability is inversely related to "travel time uncertainty," and the two terms are often used synonymously when defining valuation. Just as value of time is defined as the amount a traveler would pay to reduce travel time, the value of reliability (or the value of travel time uncertainty) can be defined as the willingness to pay to reduce that uncertainty.

Measuring Reliability

Unlike time, whose units are explicit, here it is important to explicitly define uncertainty. A common definition used by researchers is "the standard deviation of the realized travel times, taken across measurements of otherwise identical trips over different days".[5] Another common set of definitions focuses on the likelihood of being unexpectedly late: for

[5] The standard deviation of a set of numbers (such as travel times encountered over many different days for the same trip) is a measure of how dispersed they are. Specifically, if $\{T_i, i=1,\ldots,n\}$ denotes a set of N such numbers, its standard deviation σ is defined as the square root of the average of the squared deviations from the mean $\overline{T}$: $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(T_i - \overline{T})^2}$. If one considers there to be an infinite number of possible realizations T_i of a random process (*i.e.,*. if T_i is generated by a probability distribution), the same formula applies but with each term multiplied the probability of realizing that value of T_i, and with n tending to infinity (provided this infinite summation exists for the particular probability distribution function).

example, the frequency of being 30 minutes late, or the difference between the median and the 80th percentile of the distribution of travel times across days.[6] Some studies present the percentage of trips falling into different arrival bands (e.g., 20 percent of trips are up to 10 minutes early, 50 percent of trips are on-time, and 30 percent of trips are up to 20 minutes late)[7], while others present a probability of delay along with the mean delay across delayed trips[8]. Other studies present a mean expected travel time alongside a positive or negative incremental value indicating a shift in travel time that travelers can expect to experience across a set of journeys[9]. Finally, in the most complex presentations, travelers are shown a number of possible outcomes (typically ten) in terms of actual travel times for a given journey.[10]

Reliability Based on the Value of Time

One way to understand why people value reliability is based on the theory of value of time just described. If someone is nervous about missing a connection or an important meeting, that time will be more onerous and so the person will pay to reduce it. But there is a more precise way to address reliability, which seems to do quite well in explaining responses to survey questions about more and less reliable options. This is based on scheduling preferences, in particular on the inability of travelers to achieve certain desired schedules in the face of travel time uncertainty (Noland et al., 1998; Bates et al., 2001).

The theory of value of reliability is best developed for the situation where there is a particular desired arrival time at the destination (for example, the time of a meeting, a doctor's appointment, or the start of official work hours). Travelers are assumed to suffer a small penalty for each minute they arrive early (because they would have preferred spending that time at home or in some leisure activity), and a larger penalty for each minute they arrive late. They might also suffer a discrete penalty for being late at all.[11] These penalties are known as "schedule delay costs", although they would better be termed "schedule mismatch costs" because they involve the disadvantages of arriving early as well as late.

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[6] If $\{T_i, i=1,\ldots,n\}$ denotes a set of possible travel times, the median T^m is that value for which half the values T_i are above and half below T^m; the 80th percentile T^{80} is that value for which 20 percent of the values T_i are above and 80 percent are below T^{80}.

[7] See Hensher & Li (2012) for an example of this approach.

[8] See Hess et al. (2012).

[9] See Layton & Hensher (2010) for an example of this approach.

[10] See Bates et al. (2001).

[11] The parallels to air travel here are obvious, though not perfect. Many air trips are for the purpose of meeting someone, and some will involve catching a train or bus that departs at a specific time.

When travel time is uncertain, the traveler cannot precisely choose any arrival time, but instead must choose a travel strategy based on the distribution of uncertain travel times that are faced.[12] For example, a traveler with a strong penalty for arriving late at the destination will often plan on a "buffer" by departing earlier than would otherwise be necessary. The result is that most often the traveler suffers some (relatively small) penalty for arriving early, and occasionally suffers the larger penalty for arriving late (unless the buffer is chosen to be extremely large). The trade-off then becomes how large a buffer to choose.

This kind of theory leads to a mathematical characterization of the traveler's decision. For example, under certain assumptions, the traveler chooses a buffer that makes the chance of being late equal to $\beta/(\beta+\gamma)$, where β and γ are the per-minute penalties for being early and late, respectively (Small and Verhoef 2007, p. 51). This result says that a more generous buffer will be chosen (one with a lower chance of being late) when the penalty for arriving late is large relative to that for arriving early. Other more complicated results can be derived from other assumptions.

In order to go further and predict the value to the traveler of reducing travel time uncertainty, it is necessary to know the distribution of uncertain travel times—that is, the range the travel times take as they vary from day to day, and the frequency with which they take various values within that range. One approach is to assume a general class of such functions, for example the exponential distribution. The problem of measuring the value of reliability as the change in expected scheduling costs has been solved analytically for several such mathematical distributions: results are in Noland and Small (1995) and Koster, Verhoef, and Kroes (2009).

Values of Reliability Drawn From Observed Distributions

Another possible approach is to collect enough data so that the distribution itself can be measured empirically using non-parametric techniques (i.e., techniques that do not assume any particular functional form). The expected scheduling cost can then be found analytically from properties of the estimated distribution, under certain mild assumptions.[13] This approach is in its infancy, with the Research Team aware of only two such empirical measurements: Fosgerau and Fukuda (2010) and Koster, Droes, and Verhoef (2011). Both of these empirical applications are for urban road travel, but the second one concerns the

[12] Even if travel time were certain, the traveler might not choose to arrive at the most preferred arrival time due to travel congestion or a mismatch with the schedules of transportation services. Indeed, this type of scheduling theory was first used to examine how travelers adjust their schedules in response to sharp rises and falls in highway congestion over the course of an urban rush hour (Small 1982).

[13] These assumptions basically guarantee that the general shape of the distribution will not vary over different times of day, although its mean and inter-quartile range (or other measure of dispersion) can vary. See Fosgerau and Fukuda (2011).

scheduling costs of airport access via road travel. Meanwhile, an approximation to this approach would be to assume a rather general parametric distribution, such as a gamma distribution, whose solution has been found analytically by Koster, Verhoef, and Kroes (2009).

Regardless of the particular distribution function assumed, reliability can be summarized using just one measure of dispersion if the shape of the distribution does not change as that measure of dispersion changes (Fosgerau and Karlström 2010). Unfortunately, it is not usually known whether the shape of the distribution will remain unchanged in the face of some investment that improves reliability, so this theoretical finding is of limited use in practice. Instead, it is more appropriate to choose a measure of dispersion that focuses on the most costly part of the travel-time distribution. One recommendation for such a measure, made by Small, Winston, and Yan (2005) and Brownstone and Small (2005), is the difference between the 80th percentile and the median, since this emphasizes those parts of the travel-time distribution most likely to result in costly missed connections or late arrivals. Such a measure can be calculated from an empirically estimated non-parametric probability distribution, as was done by Small, Winston, and Yan (2005).

Other Factors Affecting Measurements of Reliability

Other factors may affect the value of reliability, as well. Experiments in psychology have shown that people are relatively more comfortable in situations where they feel they have control. Thus, the value of reliability is likely to be smaller when the person undergoing a particular unanticipated delay can react to it constructively, even if only to learn information about it. For example, travel time uncertainty enroute to or from the airport in a private car may have a lower value than uncertainty about delays while on an aircraft awaiting a mechanic—especially, if the cause of the aircraft's problem is unknown. Similarly, uncertainty in the time waiting for an aircraft to arrive at a gate from a previous flight may be valued more highly than uncertainty in the walking distance to a gate, due to the passenger's ability to react to the latter by walking faster.

Thus, theory tells us several things about how the value of reliability depends on travel and traveler characteristics:

- *The reliability of travel is best measured as a property indicating dispersion of the distribution of uncertain travel times the traveler may encounter on a given trip.* This distribution represents the possibilities that might occur for the given trip; empirically it might be measured by historical data for travel time on different days for the same route, season, day of week, and time of day. Dispersion can be measured by a standard deviation, by the probability of exceeding some threshold, or by other properties of the distribution that reflect the relatively infrequent but disrupting occasions when travel is much longer than anticipated. Such measures of dispersion do not require assuming a particular form for the probability distribution, and, therefore, can make maximum use of the historical data without prior assumptions.

- *The value of reliability is likely to depend strongly on scheduling flexibility.* When people don't care much about the time they depart or arrive, travel time uncertainty is not very important to them. Conversely, when arriving late at some event (or departing early from an event in order to allow a buffer time) is very costly, they will place a high value on being able to accurately predict their travel time.
- *The value of reliability is likely to depend on how much information and control the passenger has over the situation where uncertain travel times are faced.*

While, as discussed above, there is a growing body of evidence on the measures of travel time variability that is most conceptually accurate, those measures are not necessarily appropriate for presentation to respondents in a survey. For example, the concepts of a standard deviation or the difference between the 80th percentile and the median will not be understood by most respondents. Using them in a survey would, therefore, have detrimental impacts on response quality. Even relatively simple concepts, such as the extent of variability presented as a range around the expected value, have been observed to lead to problems in identifying a meaningful estimate of the valuation of variability (see Hess et al., 2007). Furthermore, even where complex presentations of variability may work for studies that focus mainly on such variability (e.g., as in Bates et al., 2001), such presentations may not work in surveys with a larger number of attributes or a different topical focus. This is because any attributes that are difficult to understand are likely to be ignored or misunderstood by some respondents in favor of other attributes.

From this perspective, a more simple presentation of variability may be appropriate in the present context. For example, in the case of flight delays, this could use the measure calculated and widely reported by the U.S. Department of Transportation consisting of the percentage of flights that arrive at their destinations more than 15 minutes later than scheduled.

Distinguishing Between Reliability and Specific Time Components

Because travel time reliability is defined in terms of variations in the duration of travel time components, it is sometimes not obvious whether a particular kind of delay should be considered a separate time component or an aspect of reliability. In particular, how should the time spent experiencing a delay that may or may not cause a problem in achieving a planned objective at the destination be approached?

As an example, consider three kinds of time spent in the aircraft. First, there is time spent in normal operations that occur in the absence of delays: boarding and alighting, taxiing to and from the runway, takeoff and landing, and time actually in the air. Second, some time spent on aircraft is caused by congestion or other scheduling delays, but it is covered by the buffer times that airlines add to published schedules and so are not commonly perceived as a reliability problem. Airline schedules build in extra time for boarding passengers with late connecting flights, waiting for other aircraft to move out of the way, queueing on the taxiway, and delays encountered in the air enroute to the destination. (Formerly, there was often holding in the air for landing clearance, but this has become less common as air traffic control instead has attempted to shift those delays to the ground at the departure airport.) Third, there are delays beyond those built into schedules, caused by such factors as unusual runway congestion, bad weather, faulty aircraft, and late crew arrival.

There is value in reducing all three kinds of in-aircraft time, but the Research Team finds it most useful to treat the first two specifically as travel time components and the third as an aspect of reliability. The first component (routine operations) might be affected by certain investments (for example, changes in air traffic control that permit shorter air distances). The second (anticipated delays) is the result of expectations by airlines and passengers, which are affected by airport congestion but also the airlines' choices when trading-off extra built-in scheduled time (a negative for marketing) against better on-time performance (a positive for marketing).[14] The third (unanticipated delays) can be viewed as a particular realization of the uncertain travel times whose distribution forms the basis for the value of reliability, as just discussed. Thus, the first two kinds of in-aircraft time are treated as time components with value to be measured empirically, and the *distribution* of the third kind as a measure of unreliability, whose value is also to be measured empirically.[15]

Even this does not fully account for the variations in values of time that travelers may display. It is plausible that travelers place a higher value on saving those parts of in-aircraft time when they are not free to use electronics or move about the cabin. Some of this higher-valued time occurs during delays, but some occurs during routine operations, such as takeoff and landing. Ideally, one would like to measure their values separately, but doing so in a survey would be costly because one cannot ask too many stated preference questions or ask survey respondents to account for too many characteristics in such questions without creating respondent fatigue.

[14] Such supply-side responses to airport reliability and delays explicitly (e.g.., how much to buffer schedules to improve on-time performance, and how much connection time to allow in itineraries) are very important to airlines as they have implications for both their passenger market shares and for operating costs (e.g., high costs for missing scheduled connections vs. additional costs of increasing scheduled times).

[15] There is a further problem that the impacts of these different kinds of delays might not be additive. For example, a traveler who is especially sensitive to the third kind of delay (unanticipated delay) due to a tight scheduling constraint might find the other kinds of delay more onerous due to worry about meeting the schedule. The Research Team is not aware of any practical method to handle such spillovers from one type of travel time to another, and so the usual practice is adopted of assuming the spillovers are additive. The practice of distinguishing several types of delays makes this assumption less likely to pose a problem than in the case where they are aggregated into a single measure, because at least some parts of delay are able to be valued differently from others.

Travel Time Reliability in Air Travel

In considering how to apply the lessons of past research on travel time reliability discussed in the previous section, it is worth discussing in more detail how travel time uncertainty affects air travel in particular.

The airline traveler can suffer two different consequences of unexpected delays. One is the possibility of missing one's initial flight due to delays in ground access or in the time it takes to check-in for a flight and clear security. The other is the possibility of missing a connecting flight and/or some important event or connection at the final destination (for example, a meeting or the last train of the day home), as a result of a delay in the arrival of the flight on the previous leg of the trip. These two consequences differ in terms of the costs suffered, but also in terms of precautionary travel decisions made in response to the uncertainty. Both of these differences affect the value of reliability.

In the case of delays that might cause a traveler to miss an initial flight segment, the traveler can make allowances by leaving his or her ground origin earlier than otherwise would be necessary (that is, by allowing a buffer) or by taking a more expensive but more reliable travel mode (e.g., a taxi instead of public transit). This typically involves trading-off some additional inconvenience or expense against the perceived cost if the flight is missed. In the second case, that of missing a connecting flight or a planned event at the destination, the traveler can book an itinerary with more connection time or one that arrives at the destination earlier, or choose an itinerary with better on-time performance. Furthermore, the cost of missing a connection, as well as the ability to avoid it by choosing a less tightly scheduled itinerary, depends on the frequency of connecting flights, their load factors, and the policies of the airline (and the specific fare class) regarding shifting a traveler who has missed a connection to another carrier where that would reduce the delay involved. The load factor on potential alternate flights affects travelers with a connecting itinerary in two ways. First, it may affect the fare that is available if a traveler would like to book an alternative itinerary that allows more time for the connection. Second, if a traveler misses a connection, the ability to take a later flight may be constrained if those flights are full (although airlines may be able to make a seat available on a full flight by offering incentives to other passengers on that flight to volunteer to take a later flight). Unfortunately, public data on aircraft passenger load factors by flight segment do not allow any meaningful analysis of either of these effects. Finally, further delays can be caused on the egress journey, where the traveler has the option of using a more reliable egress mode from the destination airport.

In addition, the perceived costs of unexpected delays may differ for both objective and subjective reasons. Objectively, for a business traveler attending a meeting or a leisure traveler attending an event at a specific time, such as a wedding, the entire trip might be wasted if delay at the destination is too much. Subjectively, travelers may be more anxious when they cannot estimate the extent or the consequences of a delay. For example, a traveler encountering delays on the ground access trip may have no way to estimate its extent (although this is rapidly changing due to new technologies); whereas the length of delay can be somewhat estimated while waiting in a check-in or security screening line, reducing anxiety while allowing the traveler to more accurately judge the danger of missing a flight—factoring in the possibility that staff will invite people with close departures to move ahead in the queue.

A number of other strategies are also relevant, although difficult to analyze rigorously. Experienced travelers may make their own judgments as to likely check-in and security delays, while other travelers (or those returning home from an unfamiliar airport) may instead simply follow the standard advice offered by airlines about airport arrival time. For an early morning departure, uncertainty in ground access time (and the cost of allowing a large buffer) can be reduced by staying at a hotel near the airport the night before. (Some airport hotels encourage this and reduce its cost by offering free parking for the entire trip duration for those who stay at the hotel for one night.)

Trips arriving at the end of the day encounter a different set of issues. While travelers are less likely to have an event scheduled at a specific time, a late arrival at the destination may take time out from leisure, other planned activities, or sleep. If the destination is away from home, it could mean having difficulty getting a meal or having to pay for a taxi to reach their final destination if less expensive transportation options have stopped running. Travelers missing a connecting flight may have to stay overnight in a hotel at their connecting point, which could be extremely disruptive to their plans for the following day. In all cases, late arrival may require more expensive or inconvenient ground transportation, and planning for this contingency may affect the chosen egress mode at the destination airport—for example, booking a car rental ahead of time or, if it is the home airport, leaving a car parked at the airport instead of planning to use public transit or to be picked up by a family member.

Finally, one empirical result from a study of reliability in urban travel by Noland et al. (1998) found that no discernible additional costs could be attributed to planning efforts (such as additional mental effort required to organize one's schedule in light of travel time uncertainty) once scheduling costs were accounted for in the manner described in the previous section. However, based on the discussion above, one can postulate that, for some types of air travel, the additional effort required to account for contingencies of uncertain travel times might be substantial. An example would be trips requiring multi-modal connections on an unfamiliar local transit system with infrequent service.

Thus two additional conclusions are reached:

- *Once scheduling costs are accounted for, other planning costs have not been verified to be important in urban travel as a distinct source of value of reliability. But they might be important for air travel for complex trips with tight schedules.*
- *The detailed trade-offs involved in the choice of flights deserve further empirical research in order to fully understand how air travelers value reliability*. One important research need is to learn how travelers obtain and use information about the variability in travel times and flight schedule reliability. For example, travelers

can now obtain airline on-time statistics fairly easily, but how many travelers actually use this information and how do they extrapolate estimates of the schedule delay costs they may incur from the data?

2.3 Valuation of Individual Components of Time in Air Travel

A good way to advance understanding of the value of time and value of reliability in air travel is to note that such travel involves many distinct travel segments, each involving time that might be made shorter or longer by actions taken by air carriers or terminal operators. Given the theory developed above, some likely differences across these components in the values of time and reliability can be identified and—equally important—in the factors that affect those values. This initially led to the Research Team to divide the time spent in making an air trip into groups of components, which are listed below. The boundaries between the trip components were later modified as the stated preference survey for this project was finalized:

1. Ground-side access time
2. Time spent in flight check-in, security, and walking to gate
3. Time spent in gate area before boarding
4. In-aircraft time
5. Transfer connection time
6. Baggage pickup and terminal egress time
7. Ground-side egress time, including deplaning and walking to baggage claim or terminal exit (but not picking up baggage)

Component 1: Ground-side access time

This part of the trip is similar to an urban trip: indeed in many cases it *is* an urban trip. Thus, the extensive theoretical and empirical literature on the values of urban travel time and its reliability is relevant. This is especially true for the literature on journey to work and other work trips because they, like travel to an airport, potentially involve a target (preferred) arrival time and substantial perceived costs of missing this target. One difference, however, is that the penalty for lateness is likely to be even higher for air travel (due to a missed a plane) than for journey to work or other work trips (being late for work, a meeting or appointment).

Unreliability, as perceived by the traveler, may be especially high on a return air trip from an airport in an unfamiliar city. Lack of knowledge of the public transit system or of the typical patterns of highway congestion may add substantially to the perceived dispersion of ground-side access time. Survey evidence is needed to measure this perceived dispersion, which may differ from objectively measured dispersion.

Component 2: Time spent in flight check-in, security, and walking to gate

This portion of the trip potentially involves high stress due to uncertainty and unfamiliarity with the physical layout and with required procedures. For example, travelers cannot know ahead of time the length of various queues for check-in (particularly if they need to bypass ticket kiosks and check bags or otherwise interact with an airline representative) or to pass security screening. Furthermore, there is only limited opportunity to use this time productively, and the environment is often noisy and crowded. Thus, this component of time is likely to have a high value (i.e. travelers would pay a lot to reduce it); and this value depends strongly on a traveler's situation, experience with air travel, and reaction to stress. Furthermore, this part of the trip can contribute a lot to overall travel time uncertainty, making it a natural target for policies or investments designed to reduce uncertainty.

Component 3: Gate area time

Time spent at the gate, including patronizing nearby services, is probably the main use of any buffer time that was allowed and not lost through unexpected delays in the previous components of the trip. If this experience is relatively pleasant, it will reduce the overall cost of unreliability of the entire trip, by permitting a larger buffer. For example, people may reduce the chance of missing their flight by planning to arrive in time for a leisurely meal, then adjusting their plans to a more hurried or carry-on meal if they are delayed during ground-side access or flight check-in and security. Hence, investments in improving the environment for this part of the trip, or in making it more productive through mobile communications technology, may have an especially high payoff.

However, it is worth remembering, from our theoretical review, that the valuation of any component of time depends not just on an absolute measure of how pleasant it is, but on how pleasant it is *relative to* whatever is given up when this component of time is increased. For buffer time at an airport, the relevant comparison is most likely with time spent at home (for outbound trips) or with time on the purposes of the trip (for return trips). The enjoyment of these alternative time uses and, therefore, the valuation of time at the gate, may be quite different for single-day trips than multi-day trips.

Component 4: In-aircraft time

Time spent in the aircraft will be valued based on factors similar to those for urban trips—including dependence on trip purpose and income. The value will be less when conditions are more pleasant; those conditions depend on load factors, seat spacing, temperature, noise level, quality of staff service, in-flight entertainment, and the like. Many of these factors will be functions of the specific airline and type of aircraft used for the flight.

For purposes of how travelers perceive disutility , the most important parts of in-aircraft time are probably dwell time at the gate (after boarding) and delays on the taxiway system before reaching the runway, which may be extra onerous due to the stress of not being sure if the plane will take off on-time. To the best of the Research Team's knowledge, the issue of differences in the perceived value of time involved in delays while in the aircraft compared to those incurred waiting to board the aircraft or in-aircraft travel time generally has not been investigated.

Component 5: Transfer connection time

For connecting flights, time spent deplaning and walking to the departure gate (have similar characteristics to the same components at the departure airport (#2 above, in the sense that both activities require walking from place to place within the airport. The major difference being that component #5 only involves movement between gates and does not include processing as in checking bags or passing through security described in component #2. However, the penalty for lateness on the inbound flight may be even greater than in the case of a non-stop flight—missing a connection means not only delay at the connecting airport but also the potential of several hours additional delay or even an overnight stay in a location that was not planned as part of the intended itinerary. As was the case with a gate or taxiway delay prior to departure, any time spent waiting to deplane from the inbound aircraft has a very high value.

There is also a similarity between this component and component #3, as arriving at a connecting gate early then would entail waiting time.

Component #5 has been studied in detail for air travel (Theis et al., 2006). The theory in this work suggests that each traveler determines an optimal amount of connection time that considers the likelihood of missing a connection, the benefits of having adequate time to eat, use a phone, and deal with personal comfort—all being traded off against a general desire to reduce overall travel times. The empirical work finds that air passengers on average perceive additional benefits from up to 15 minutes above the minimum connection times allowed by airlines, but that these benefits gradually turn to disbenefits as connection times are lengthened beyond that amount. It is reasonable to expect that this additional time will vary as a function of overall flight time, with passengers on long-haul flights potentially having a greater desire for slightly longer connection times. As described by Theis et al., connection times are primarily an issue for airline operations planning and less so for airport design.

Component 6: Baggage pickup and terminal egress time

This component is similar to flight check-in—it involves waiting for an uncertain amount of time in an environment in which there are limited opportunities for other activities (except perhaps making phone calls (parts of #2). The importance of reliability is probably diminished, compared to making the original flight, but may not be entirely absent due to the desired schedule at the destination, particularly making connections to scheduled ground transportation. The commonly experienced lack of information on expected delivery times for baggage may increase the valuation for this component.

In the case of international trips, immigration and customs add another layer of unpleasantness and/or uncertainty, similar to check-in and security at the origin airport.

Component 7: Ground-side egress time, including deplaning and walking to baggage claim or terminal exit (but not picking up baggage)

The time spent getting from the destination airport to the actual trip destination has characteristics similar to ground access time at the origin (#1). The importance of reliability is likely to be smaller than at the origin because most of the trip has now been completed. But the actual extent of unreliability may be greater if the non-home destination city is unfamiliar: for example, the traveler may be unsure of ground transportation options, and may worry about getting lost if driving a rental car or the reliability of local transit.

Each of the foregoing travel time components may be further divided into sub-components that travelers may perceive as having different disutility. For example, waiting during the ground-side access trip may be perceived as having a greater disutility per minute (higher value of time saved) than in-vehicle time, while time spent walking to the gate within the terminal building may have a higher perceived disutility per minute than time spent riding a people mover or moving walkway. However, quantifying differences in the perceived disutility for these sub-components presents empirical challenges, both because of the large number of potential sub-components and the relatively small time differences involved in most practical situations.

The perceived value of travel time for each of the components and sub-components of an air trip are not of equal importance from the perspective of airport capital investment decisions, or may be relevant to some types of project but not others. Reduced air passenger in-aircraft delays forms one of the major benefits of airside capacity improvements. Similarly, a reduction in time spent moving within the airport terminal complex and, in particular, a reduction in the walking distance (and hence time spent walking), forms a significant part of the justification for construction of automated people-movers at airports.

It follows from these two observations that care is required in assessing the value of different travel time components where there may be significant differences in the perceived disutility of different sub-components. Failure to properly account for these differences could lead to the use of inappropriate value of travel time savings in the context of a particular project.

Adjustments for the Stated Preference Survey

In the course of designing the stated preference survey, to be described below in Chapter 3, the aforementioned time components were modified to better distinguish between those that were likely to have similar perceived values of time savings and to maintain a manageable stated preference survey. The resulting components used in the stated preference experiments were as follows:

1) Airport ground access time
2) Terminal access time from ground transportation
3) Check-in and security time
4) Time to reach the gate area from security
5) Time in the gate area until boarding the flight
6) Flight time, including making any flight connections

Since the stated preference experiments only addressed the choice of flights and the trip to and through the departure airport, the time components used in the experiments did not include the time spent at the destination airport or the ground egress trip.

2.4 Productive Use of Time Spent in Travel

In the previous section, it was noted that valuation of time may depend on how pleasantly the time is spent. Similarly, it can depend on how productive this time is for doing tasks such as making phone calls, reading, or working on a laptop. Productivity deserves special mention here because it particularly affects business travelers and so is likely to be highly valued and a prominent consideration by air travelers. Furthermore, it can be influenced by investments made by an airport authority or airline, for example, through the availability of power outlets or Wi-Fi service in a terminal or on an airplane.

In addition, the productivity of waiting time can affect the value of reliability throughout the trip because waiting at the gate is a likely use of any extra buffer time the traveler decides to build into his or her itinerary. If time spent waiting at the airport is nearly as enjoyable as time at home or as productive as time at the office, then travelers may be inclined to include more buffer time in their plans and, thereby, reduce the cost of unreliability.

However, there are some limitations to the possibilities of reducing values of time and reliability by productivity-enhancing technology. One is privacy. Travelers may avoid making phone calls on sensitive business matters where other people can overhear them, or using a laptop for company business in situations where people sitting next to them can see their computer screen. A second limitation is space and comfort. Many airline seats and even crowded departure lounges make it difficult to work on a laptop computer, while access to power in order to preserve battery charge can be a further limitation (witness travelers sitting on the floor to be within reach of a power outlet). A third consideration is the continuity of the activity in terms of location—productive work often involves some setup time which makes a block of uninterrupted time in one location more productive than several shorter blocks of time separated by movement from one place to another. Indeed, the fact that an air journey is inherently split into so many different components reduces the ability to use travel time productively and, thus, keeps values of time and reliability from being very low. This is in contrast with the conditions on high speed rail trips, where seating is generally more spacious, power outlets and Wi-Fi are commonly available, and the trip involves longer blocks of uninterrupted time, a fact that Eurostar actively uses in its marketing on the London to Paris and Brussels routes.

2.5 Other Considerations

Several additional factors are likely to affect values of time and reliability for air travel.

The effect of income on value of time is likely to be strong for any of these components of air travel, in part because higher-income people often are concerned to use their time productively and, as a result, are more willing to pay for amenities, such as a quiet and uncrowded environment. But, as noted earlier, there is no reason to assume that value of time is strictly proportional to income or, for that matter, that the relationship with income is similar across different travel time components.

Safety is an additional factor. Of course, safety is valued for its inherit importance, but it can also be related to the value of time. The level of perceived safety can affect the value of time spent in situations in which it produces feelings of anxiety or stress, but the extent of this is unknown. Further research could help clarify the precise role that perceived safety plays in air travel decisions.

The fact that air passengers often travel in parties of more than one has implications for assessing the value of time. For example, do children have the same value of time as their parents? The presence of young children drastically changes the way the adults traveling with them use their time during trips, with implications for the perceived values of time and reliability for the entire party. Also, because the costs of some ground access and egress modes do not vary proportionally with the size of the travel party, observed differences in ground access and egress mode use by large versus small travel groups may reflect these differences in cost, and this, in turn, affects the way empirical studies can infer values of time from people's choices.

Although the primary focus of the current project is on the value of passenger travel time, benefit-cost analysis also has to consider the costs to airlines of flight delays. Apart from the direct costs of increased fuel use and additional crew time when aircraft are delayed, there are additional delays elsewhere in the network when one aircraft is delayed for whatever reason. To reduce some of these problems, airlines include some buffer time in their schedules, which, of course, is a cost to them and to travelers even if they succeed in eliminating unplanned delays.

A particular difficulty for airline scheduling arises in cases where there is a large difference between the airport capacity in good weather and bad weather. Competitive considerations cause the airlines to schedule their flights to take full advantage of the good weather capacity, particularly when those conditions occur for a large part of the time. However, this can result in situations where bad weather causes a huge increase in delays to levels that greatly exceed the buffer allowances in the schedule. Rather than have large delays ripple through the rest of their network, airlines often cancel flights in order to bring demand closer to the available capacity. In some cases, they are forced to cancel the flights anyway because the aircraft or crews scheduled to operate them are delayed somewhere else in the network. However, this imposes a different set of costs to recover from the disruption and to handle the passengers who would have flown on the cancelled flights.

2.6 Implications for Measurement

Time components

The discussion above suggests that some of the time components probably have similar characteristics with regard to value of time and reliability, and so can be grouped together to make analysis and discussion more tractable. A grouping into four broad components, while distinguishing three major types of trip purpose, can serve as a clear framework for measuring values of time and reliability. This leads to the matrix shown in Table 5. However, it should be noted that this breakdown does not cover all the major variables identified as being important, in particular trip length (especially single-day versus multi-day) and portion of the trip (outbound, intermediate, or return). Furthermore, certain types of situations may warrant singling out one particular component for a more intensive analysis.

Table 5: Major combinations of time components for measuring values of time and reliability.

Time component	Component numbers
Airport Access/Egress	1, 8
Security, check-in, & moving within airport	2, 5, 7
Waiting at gate	3, 6
In-aircraft time	4

Survey needs

As noted, the values of time and reliability are likely to depend strongly on technology, whether for productivity or entertainment. Furthermore, the relevant technologies are changing rapidly, creating the danger that any measured values will be soon outdated.

To cope with this problem, any stated preference (SP) survey of hypothetical choices in air travel situations would ideally specify the characteristics of the technology assumed to be available. By varying these characteristics across situations about which travelers are queried, one could, in principle, estimate models that enable measured values of time and reliability to be updated as new technologies become implemented. But, in practice, this could make the survey unduly complicated, and is perhaps less important than providing a more detailed categorization of travel time components. The SP survey performed in the current research project handled changing technology by asking the respondents about the actual technologies they used or encountered.

Surveys also need to pay careful attention to travelers' scheduling desires, constraints, and general degree of flexibility, because these strongly affect the value of reliability. This was done by asking questions about these matters with respect to a recent trip and then asking for hypothetical choices for a similar trip. Alternatively, they can be specified as characteristics of some hypothetical trip, although this runs the danger of the respondent considering the situation to be impractical or incomprehensible. The better the survey explains the scheduling constraints that are assumed to apply, the more likely the responses will provide valid information about preferences under those constraints.

This kind of strategy suggests designing surveys to describe scheduling constraints in a way that corresponds to what people actually worry about during their travel. For example, most travelers know what it means to miss a flight, to be late for a meeting, to feel rushed during a connection, to miss out on a planned meal, or to be forced onto an uncomfortable egress mode. To the extent the survey can describe conditions in these terms, respondents are more likely to understand the situation they are being asked to consider in their hypothetical choices.

Finally, our review suggests keeping an open mind about how income, or any other measure of financial well-being, is considered. It is clear that both overall household income and the respondent's own wage rate are likely to affect the values of time and reliability; thus, it is useful to ascertain both of these quantities in a survey, as well as the traveler's position within the household. Then the challenge to the analyst is to specify models that use this information in a parsimonious yet informative way so that the variation of values of time and reliability with financial well-being can be accurately measured without overly restrictive preconceptions.

2.7 Recent Empirical Studies of Air Traveler Values of Time

As described in Hess et al. (2007), there are significant challenges in using data that describe air travelers' chosen itineraries alone to estimate values of time. In particular, it is difficult to infer what fares and other itineraries are available to travelers when they make their choices; thus, determining their time/cost trade-off is correspondingly difficult. Work based on such data is traditionally marred by problems with identifying significant and meaningful parameters values, notably for the cost coefficient (e.g., Pels et al., 2001, 2003; Hess & Polak, 2005, 2006a, 2006b). In addition, it is difficult to determine the effects of travel time components other than flight time without having information about the details of those components. As a result, more recent work uses data from air passenger surveys, which include both information about past trips made by the travelers and stated preference (SP) data describing how they might make those trips under changed circumstances.

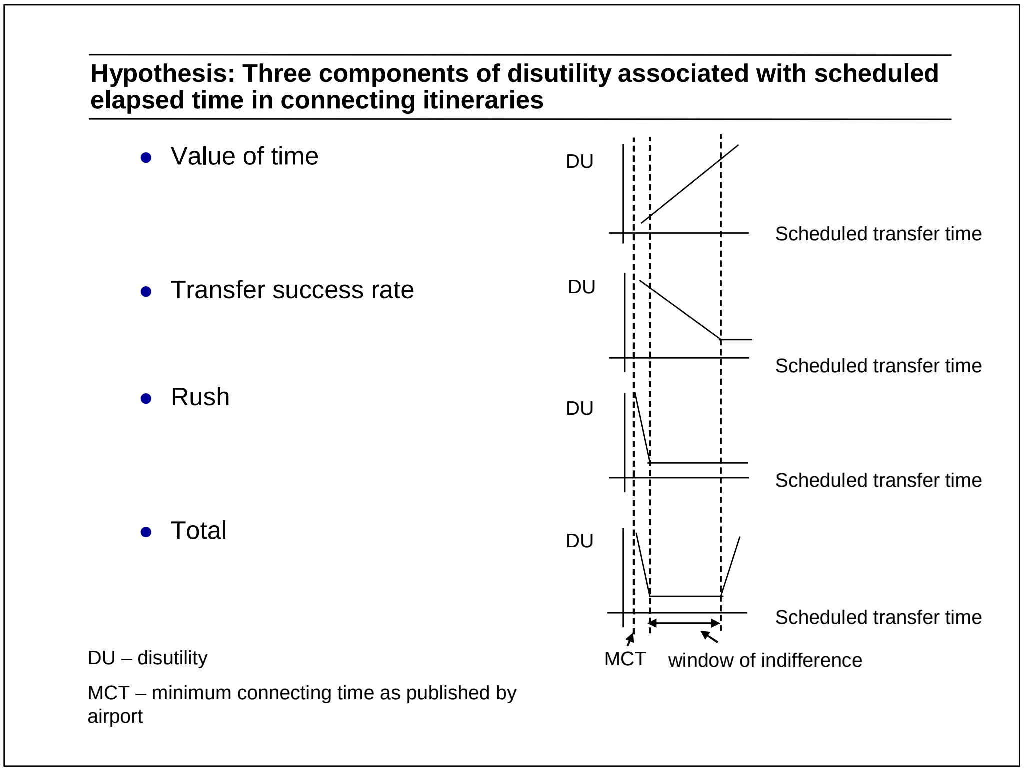
Evidence in the literature suggests that data from SP surveys can be used to produce reliable measures of monetary valuations for different service attributes (Louviere, et. al., 2000). In particular, regular air travelers are accustomed to making complex choices, reducing any detrimental impacts of the hypothetical setting of SP surveys. Further steps can be taken to mitigate presentational effects, as described in Collins et al. (2011), who used an SP survey mimicking a typical online booking system. This study is also of interest given its in-depth study of the valuations of in-flight amenities, which show very high valuations on long-haul flights for better entertainment systems and greater seat pitch, relating to earlier points in the report about productive use of travel time.

The studies conducted to date distinguish values for ground access/egress times, flight times, connection times and flight reliability, but not specifically for the times to check-in and clear security, nor for the initial wait time at the origin airport. Using data from a survey designed to collect information about actual trips made by air travelers combined with stated preference data, Adler et al. (2005) find that air travelers' values of access/egress and flight time, as well as flight reliability, exhibit considerable heterogeneity across the population of travelers. They represented flight reliability by using the U.S. Department of Transportation's on-time performance metric (percentage of flights arriving no more than 15 minutes late), which is convenient because it is readily available to air travelers for most flights at the time of booking. In the above cited Adler 2005 study, which accounts for random differences in preferences among travelers, the value of flight time is found to be approximately $70 per hour for business travelers and about half that for non-business travelers. The value of access/egress time is only about 10-15% less than flight time, for both business and non-business travelers. The value of reliability is found to be $38 per 10 percentage point change in on-time performance for business travelers, but only $7 per 10 percentage points for non-business travelers (with a high degree of heterogeneity for the latter). These results are broadly confirmed by Hess et al. (2007), with the additional finding that for holiday travelers, the sensitivity to on-time performance increases with flight distance.

A later study by Warburg et al. (2006), using the same survey data, identifies the key traveler characteristics, both demographic and trip-related, that cause systematic differences in values of time across the population. In addition to trip purpose (business vs. non-business), these factors include income, travel party composition, fare reimbursement, and duration at the destination, among others.

As noted earlier, Theis et al. (2006) use a survey instrument that collects and provides more detail about connection conditions to estimated values for connection times. This study finds that the estimated values vary depending on the duration of the connection, with very short times quite onerous to travelers and very long times about equally onerous as other travel time elements. Figure 3 illustrates these effects in terms of three components of "disutility": the general preference for shorter overall travel times, balanced by the desire to make a connecting flight and to have time at the connection to deal with personal comfort and communication. This figure is intended only to show the general shape of the effects. The work described in Theis et al. (2006) includes statistical estimation of the numerical values of these effects.

Figure 3. Disutilities Associated with Connecting Time



Source: Georg Theis, et al., Risk Averseness Regarding Short Connections in Airline Itinerary Choice, April 2006.

Finally, work by Hess and Adler (2011) shows how values of time compare across four surveys that were conducted over a 5-year period. This work suggests that values of air travel time have changed over this period, likely as a result of such factors as changes in the composition of air travelers and changes in airport and in-flight amenities, some of which can be forecast and some of which may be difficult to anticipate. An implication of this finding is that values of time need to be periodically updated.

3 DATA COLLECTION AND MODELING RESULTS

This chapter summarizes the Research Team's process of data collection through the development and administration of a stated preference (SP) survey of airline travelers who had made recent domestic air trips within the U.S. The primary purpose of the SP survey was to provide suitable data to estimate the value of travelers' willingness to pay for various individual time components that are part of air travel (as defined in Chapter 2). The components included airport ground access time, time to reach the terminal, time to reach and pass security, time to reach the gate from security, time spent waiting at the gate until boarding, in-flight time, and expected flight delay. It was expected that travelers place different values on the time associated with different aspects of the air trip. For example, time spent waiting in line to clear security may be more or less onerous than time spent getting to the airport, or time getting from security to the departure gate. Understanding the relationships between these different time components allows for better evaluations of potential airport infrastructure investment projects, instead of the current approach to project evaluation that uses the same values of time (VOT) regardless of the nature of the proposed capital investments.[16]

The SP survey questionnaire gathered information from airline travelers who were able to recall the details of their trip[17]. The questionnaire collected data on the recent air travel experience of survey respondents and used stated preference experiments to collect data that were used to estimate travelers' willingness to pay for travel time savings for various time components under a range of different hypothetical conditions.

The survey employed a computer-assisted self-interview (CASI) technique developed by Resource Systems Group, Inc. The stated preference survey instrument was customized for

[16] The current approach for performing benefit-cost analyses for projects funded by FAA Airport Improvement Program grants provides single values for business travel, personal travel and a hybrid of business and personal travel, when the divisions of the two classes are not known. These values are applicable to all investment types.

[17] The Research Team contracted with an online survey sample provider. This provider recruits and maintains a panel of 6.5 million potential survey respondents, cross referenced with demographic attributes that allowed for the selection of respondents that met criteria specified by the Research Team. This approach allowed the Research Team to specify a sample of recent air travelers, and assure adequate samples of business travelers and personal travelers. Because the survey provider begins the process with a panel willing to complete surveys, the traditional metric of response rate in a general population survey is not relevant.

each respondent by presenting questions and modifying wording based on respondents' previous answers. These dynamic survey features provide an accurate and efficient means of data collection and allow presentation of realistic alternative scenarios that correspond with the respondents' reported experiences. The customized, proprietary software was programmed for online administration to targeted audiences.

This chapter documents the development and administration of the survey questionnaire and presents the primary survey findings. The methodology and results of a discrete choice model estimation are reviewed to support these findings. This chapter then reports how the Research Team used the data from stated preference experiments to infer the implied values of time of the survey respondents. The resulting values of time are presented, and additional research is summarized to clarify and explore various issues that were identified in the course of analyzing the survey results or estimating the implied values of time. The following sections of this chapter review the:

- Final survey questionnaire (Section 3.1)
- Administration of the survey (Section 3.2)
- Survey results (Section 3.3)
- Model estimation to assign values of time to the survey results (Section 3.4)
- The resulting values of time implied by the survey results (Section 3.5)
- Additional research undertaken to clarify and explore various issues (Section 3.6)

Section 3.7 provides a summary and conclusions from the research described in this chapter. The complete set of survey questions and detailed response tabulations appear as Appendices B.1 and B.2 to this report, and documentation of the additional research summarized in Section 3.6 is found in Appendix B.3.

3.1 Survey Questionnaire

The survey questionnaire was designed to collect information about a recent air trip made by respondents within the U.S. and to estimate their sensitivities to paying for various trip attributes and air travel-related time components. The survey questions were grouped into four main sections:

1) Trip characteristics questions
2) Stated preference choice experiments (a statistical technique used to determine how people value different attributes that make up a single product or service)
3) Attitude and air travel background questions
4) Demographic questions

The complete set of survey questions as they appeared on-screen is included in Appendix B.1.

Trip Characteristics Questions

After being presented with basic instructions about how to navigate the computer-based survey questionnaire, respondents were asked a set of screening questions to ensure that they qualified for the survey. To qualify, respondents had to be 18 years of age or older, not employed by the aviation industry, and must have made a recent trip in the U.S. that used a purchased ticket. The respondents were told that a purchased airline ticket was one for which they or their employer paid for the airline fare and did not include any flights for which they received frequent flyer award tickets, airline vouchers and/or free flights. Respondents who indicated that their most recent air trip was more than six months prior to the survey were thanked for their time and terminated from completing the survey.

Qualifying respondents were asked to focus on their most recent trip in one direction that met all of the screening criteria as they continued through the survey. This most recent trip, referred to as the respondent's reference trip, formed the basis for the rest of the survey. Respondents were asked a series of questions regarding the specific details of their reference trip, including:

- Departure date of the trip
- Ticket acquisition and payment
- Airfare
- Trip origin and destination addresses
- Origin and destination airports
- Trip purpose
- Party size
- Number of nights away from home
- Airport access mode(s)
- Airport access time
- Airport access cost
- Parking lot type used (if any) and parking cost
- Time to reach the airport terminal from parking lot or where dropped off
- Anticipated total time that would be spent in the airport terminal
- Number of bags checked
- Baggage fee
- Time from entering the terminal to reach security screening
- Actual and anticipated security time

- Time from security screening to reach the gate area
- Time spent in gate area before boarding commenced
- Activities performed at the gate
- Delay (if any) in departure and arrival of the flight
- Scheduled local departure and arrival times
- Preferred arrival time
- Number of flight connections or stop-overs
- Connection airport(s)
- Airline(s) used
- Preferred airlines – most preferred, second-most preferred, and third-most preferred

Stated Preference Choice Experiments

After completing the trip characteristics section of the questionnaire, respondents moved on to answer a series of stated preference choice experiments to estimate respondents' travel preferences and behavior under hypothetical alternative trip scenarios.

Initial versions of the stated preference experiments included a single design that included both flight itinerary attributes and airport access/in-airport time components combined. However, it was determined that this design would be too complex for respondents to complete.

After working through several iterations of the design, the Research Team decided to create two separate sets of choice experiments– one covering attributes related to flight itinerary, and a second covering attributes related to airport ground access and in-airport time components up to the point of boarding the aircraft.

The details of each respondent's reference trip were used to build eight pair-wise choice experiments for each set, each experiment comprising two hypothetical but credible alternatives for making the trip that the respondent had described. Respondents chose which of each alternative scenario they would have preferred, had these been the only options available for their trip.

Flight Itinerary Choice Experiments

The flight itinerary choice experiments were designed to understand respondents' preferences for different flight-related factors, including:

- Flight time (airport-to-airport)
- Airfare
- Number of connections and connection time

- Air carrier
- Departure and arrival time
- Type of aircraft
- On-time performance of the flight(s)
- Average amount of delay for delayed flights

Factors related to airport access, time spent in the airport terminal, or other non-flight-related factors were intentionally excluded to focus the respondent on the attributes relevant to the choice between different flight itineraries, in particular airfares, flight time, the number of connections, and expected delay.

A series of eight trade-off scenarios described by these attributes were each presented to respondents as two hypothetical flight alternatives. The eight attribute values were varied independently across the two alternatives and respondents were asked to select the alternative they most preferred under the conditions that were presented.

The attribute values presented in each alternative varied around a set of base values. To ensure that the scenarios were realistic, the trip characteristics of each respondent's reference trip were used to calculate the base values for each attribute where applicable. The values for the attributes in each scenario were varied from the base value by multiplying or adding one of several factors to give the level required by the experimental design for that particular scenario.

Attributes and Levels

Airport-to-Airport Time. The flight time attribute represented the total airport-to-airport travel time, including time spent for taxi, takeoff and landing, in-flight time, and time spent at connecting airports, if applicable. The taxi, takeoff, landing, and in-flight times were combined to give the non-stop flight time that varied for this attribute, with connection times included as a separate component that varied independently from flight time. Non-stop flight time varied around a base value that was calculated as the distance between airports at 500 miles per hour plus a fixed value of 30 minutes to account for taxi, takeoff, and landing (Equation 1). The ground speed of 500 miles per hour was selected to represent an average of eastbound and westbound flights, and was used for both turboprop and jet aircraft. Each connection was assumed to add 30 minutes to the non-stop flight time to allow for the additional distance, landing, taxi, and takeoff.

Equation 1. Base Flight Time Calculation

Base flight time = 60[airport-to-airport distance]/500mph+30*

This base flight time value was varied according to the following levels:

1) [Base flight time * 0.9] + connection time + connections*30

2) [Base flight time * 1.0] + connection time + connections*30
3) [Base flight time * 1.1] + connection time + connections*30
4) [Base flight time * 1.2] + connection time + connections*30

The amount of variation was chosen to present differences in travel time between the alternatives that are large enough to get respondents to trade-off against the attribute, but not so large as to be seen as unbelievable or unrealistic.

Airfare. The airfare value was calculated from the respondent's reported airfare using the following levels:

1) Reported airfare * 0.70
2) Reported airfare * 0.85
3) Reported airfare * 1.00
4) Reported airfare * 1.15
5) Reported airfare * 1.30

As with the flight time attribute, these levels were chosen to present enough variation to encourage respondents to trade-off against the attribute, but not as large as to be unrealistic or to dominate the stated preference exercises.

Number of Connections. The number of connections presented varied depending on the respondent's reported trip length. To ensure that the number of connections presented was realistic, respondents were classified into one of two groups using the base flight time that was calculated as part of the airport-to-airport time and presented in Equation 1. For the purposes of this attribute, short flights were defined as having a base flight time of four hours or less, while long flights were defined as having a base flight time of more than four hours. The number of connections for short flights varied between zero connections and one connection, while the number of connections for long flights varied between zero connections and two connections.

Connection Time. The connection time attribute represented the total time spent at connecting airports, if applicable. This attribute was not presented for alternatives that presented non-stop flights. Connection time varied between 45 and 90 minutes per connection according to the following levels:

1) 45 minutes
2) 60 minutes
3) 75 minutes
4) 90 minutes

These levels were chosen to fall within the range of typical flight connection times, but also to present differences large enough to encourage respondents to trade-off against the attribute.

Air Carrier. The air carrier, or airline, attribute was customized for each respondent based on their ranking of airlines earlier in the questionnaire. The air carrier attribute was varied according to the following levels:

1) Most preferred airline
2) 2nd-most preferred airline
3) 3rd-most preferred airline
4) Airline reported for reference trip (if not one of the 3 most preferred)

Arrival Time. The arrival time attribute varied around each respondent's preferred arrival time for their reference trip according to the following levels:

1) 2 hours before preferred arrival time
2) 1 hour before preferred arrival time
3) At preferred arrival time
4) 1 hour after preferred arrival time
5) 2 hours after preferred arrival time

Because some respondents may report preferred arrival times very early or very late in the day, this attribute was validated to ensure that arrival times were not shown between the hours of midnight and 6:00 AM. While there are certainly commercial flights that operate during this time period, the Research Team felt that they are infrequent enough to not be a viable option for most respondents. If a flight were shown to arrive between midnight and 2:00 AM, the entire flight itinerary was shifted earlier such that the arrival time was shown to be before midnight. Similarly, if a flight were shown to arrive between 2:00 AM and 6:00 AM, the entire flight itinerary was shifted later such that the arrival time was shown to be after 6:00 AM.

Departure Time. Departure time was included as an attribute to make the flight itinerary presentation realistic. However, this attribute did not vary independently from the other attributes. Departure time was calculated as the flight time subtracted from the arrival time (accounting for any differences in time zone between the arrival and departure airports). Departure time was also validated to ensure that no flights were shown to depart between the hours of midnight and 6:00 AM.

Aircraft Type. Respondents were presented with different aircraft types depending on the length of their reference trip. To ensure that the types of aircraft presented were realistic, respondents were classified into one of three groups using the base flight time that was calculated as part of the airport-to-airport time and presented in Equation 1. The three groups were flights less than two and a half hours, flights between two and a half and four hours, and flights greater than four hours. Flights with a base flight time of less than two and a half hours were presented with the following aircraft types:

1) Propeller
2) Regional jet
3) Standard jet

Flights with a base flight time between two and a half and four hours were presented with the following aircraft types:

1) Regional jet
2) Standard jet

Flights with a base flight time greater than four hours were presented with the following aircraft types:

1) Standard jet
2) Widebody jet

On-time Performance. On-time performance was presented as the percent of flights that arrive on-time. On-time was defined as arriving at the gate earlier than 15 minutes after the scheduled arrival time, consistent with the definition of an on-time flight by the Federal Aviation Administration (FAA). On-time performance varied according to the following levels:

1) 90% of flights on-time
2) 80% of flights on-time
3) 70% of flights on-time
4) 60% of flights on-time
5) 50% of flights on-time

Average Delay for Delayed Flights. In addition to on-time performance, a second delay-related attribute was presented that represented the average duration of delay for delayed flights. Because flights are not considered delayed until they are at least 15 minutes late, this attribute started at a value of 20 minutes of delay and varied up to 50 minutes according to the following levels:

1) 20 minutes
2) 30 minutes
3) 40 minutes
4) 50 minutes

Table 6 summarizes the attributes and levels used to generate the alternatives in the flight itinerary choice experiments.

Table 6. Stated Preference Attribute Levels– Flight Itinerary Choice Experiments

Attribute	Level	Calculation		
Airport-to-airport time[a]	1	[Base flight time * 0.9] + connection time + connections*30		
	2	[Base flight time * 1.0] + connection time + connections*30		
	3	[Base flight time * 1.1] + connection time + connections*30		
	4	[Base flight time * 1.2] + connection time + connections*30		
Airfare	1	Reported airfare * 0.7		
	2	Reported airfare * 0.85		
	3	Reported airfare * 1.0		
	4	Reported airfare * 1.15		
	5	Reported airfare * 1.30		
Connections		**Flight <= 4 hours**	**Flight > 4 hours**	
	1	0 connections (non-stop)	0 connections (non-stop)	
	2	1 connection	1 connection	
	3	--	2 connections	
Connection Time	1	45 minutes		
	2	60 minutes		
	3	75 minutes		
	4	90 minutes		
Carrier	1	Most preferred airline		
	2	2nd-most preferred airline		
	3	3rd-most preferred airline		
	4	Airline used for reference trip (if not one of the 3 most preferred)		
Arrival Time[b]	1	2 hours before preferred arrival time		
	2	1 hour before preferred arrival time		
	3	At preferred arrival time		
	4	1 hour after preferred arrival time		
	5	2 hours after preferred arrival time		
Departure Time[b]	N/A	Arrival time - travel time		
Aircraft Type		**Flight < 2.5 hours**	**Flight 2.5 to 4 hours**	**Flight > 4 hours**
	1	Propeller	Regional Jet	Standard Jet
	2	Regional Jet	Standard Jet	Widebody Jet
	3	Standard Jet	--	--
On-time Performance	1	90% of flights on-time		
	2	80% of flights on-time		
	3	70% of flights on-time		
	4	60% of flights on-time		
	5	50% of flights on-time		
Average Delay for Delayed Flights	1	20 minutes		
	2	30 minutes		
	3	40 minutes		
	4	50 minutes		

[a] *Base flight time was calculated as: 60*[airport-to-airport distance]/500mph+30.*

[b] Arrival time and departure time were validated to ensure that flights were not shown to arrive or depart between the hours of 12:00 AM and 6:00 AM. If a calculated departure or arrival time did fall within this period, the flight itinerary was shifted earlier or later to avoid this period.

The specific levels used in each stated preference experiment were determined by using an orthogonal experimental design[18], which ensured that information was collected from respondents in a statistically efficient manner. The experimental design was created using Ngene, a software tool designed specifically for this type of application. Given the number of attributes and levels specified by the researcher, Ngene created an experimental design that minimized correlation in the variation of the attributes.

The final solution reached by Ngene, given the attributes and levels specified above, was an experimental design with 128 experiments divided into sixteen groups of eight. One of the sixteen groups was randomly chosen for each respondent and the eight experiments were shown to respondents in a randomized order.

The final design was evaluated by the Research Team, checked for correlation, and adjusted to eliminate stated preference experiments where one alternative would be clearly dominant over the other, which would result in little useful information obtained from that experiment.

Airport Time Components Choice Experiments

While the flight itinerary stated preference choice experiments were designed to understand how travelers value various attributes related to air travel, the airport time components choice experiments were designed to understand how travelers value time related to different segments of the on-ground portion of the trip. The on-ground portion of the air trip can be broken down into many different components. However, the Research Team necessarily had to balance the need to collect detailed information with the need to minimize respondent burden and the distinct possibility of presenting too many different time components for respondents to reasonably evaluate. After much discussion, the Research Team grouped the on-ground times into the following components:

- **Airport Ground Access Time:** The travel time from the respondent's origin location to their parking location, drop-off location, or transit stop/station at the airport.
- **Terminal Access Time:** The time to reach the airport terminal from the parking location, drop-off location, or transit stop/station.
- **Check-in and Security Time:** The time to check-in and check baggage (if applicable), reach security, wait in line, and clear security. Although check-in and security are two separate lines, many respondents do not check-in or check bags at the airport. In addition, the Research Team has no reason to believe that the disutility associated

[18] Orthogonal design is an experimental design used to measure the comparative importance of various attributes.

with waiting to check-in would be different from the disutility for waiting for security screening.

- **Time to Reach the Gate Area:** The time spent traveling to the gate area after clearing security.
- **Gate Time:** The time after reaching the gate area until boarding commences.

Respondents were presented with a series of trade-off scenarios, each of which comprised two alternatives describing the on-ground portion of the trip. The alternatives were described by the attributes listed above, as well as by airport access mode and airport access cost. By varying mode, cost, and the different time components independently, the experiments allowed respondents to demonstrate their sensitivities to each of the attributes by making trade-offs between them over the set of eight experiments.

The attribute values presented in each question varied around a set of base values. To ensure that the scenarios were realistic, the trip characteristics of each respondent's reference trip were used to calculate the base values for each attribute where applicable. The values for the attributes in each scenario were varied from the base value by multiplying or adding one of several factors to give the level required by the experimental design for that particular scenario.

Attributes and Levels

Airport Ground Access Mode. Respondents were presented with the following four modes to get to the airport:

1) Drive and park at the airport
2) Drive and get dropped-off
3) Taxi
4) Transit

Access mode and associated costs can be very important to travelers. Indeed, some travelers will not consider certain modes for their trip at all. Because of this possibility, the mode attribute was constrained such that the same mode (which was the mode that the respondent reported for their trip) was presented in each alternative for a minimum of four of the eight stated preference experiments. This helped to prevent the mode and cost attributes from dominating the other travel time attributes and forced respondents to trade-off against these other attributes.

Airport Ground Access Cost. Access costs presented in the airport time components choice experiments included parking costs, taxi fares, and transit fares. If the presented mode was drive and park at the airport, parking costs were presented at the following levels:

1) $10/day
2) $15/day

3) $20/day
4) $25/day

If the presented mode was taxi, the fare was calculated as a $3.00 initial charge (flag drop) plus a per-mile fee that was varied to give the following levels:

1) $3.00 + $1.50/mile
2) $3.00 + $2.00/mile
3) $3.00 + $2.50/mile
4) $3.00 + $3.00/mile

If the presented mode was transit, the fare was calculated at 13.5 cents per mile plus a base fare that was varied to give the following levels:

1) $2.00 + $0.135/mile
2) $4.00 + $0.135/mile
3) $6.00 + $0.135/mile
4) $8.00 + $0.135/mile

No cost was shown for driving and getting dropped-off at the airport. While vehicle operating and maintenance costs are associated with this mode, the Research Team has found in past studies that travelers do not perceive these costs on a per-trip basis (RSG, 2008).

Airport Ground Access Time. Airport ground access time varied around the respondent's reported access time. Reported times were varied using the same levels for similar modes. For example, if the respondent reported an auto trip (drive and park, drive and drop-off, or taxi) and an automobile alternative was presented, or if the respondent reported a transit trip and a transit alternative was presented, access times varied according to the following levels:

1) Reported access time * 0.80
2) Reported access time * 0.90
3) Reported access time * 1.10
4) Reported access time * 1.20

If a respondent reported an auto trip and a transit alternative was presented, the travel times were increased to account for transit access, egress, wait time, and potentially slower travel times in minutes:

1) 15 + reported access time * 1.2
2) 15 + reported access time * 1.3
3) 15 + reported access time * 1.4

4) 15 + reported access time * 1.5

The inverse of these levels was used if a respondent reported a transit trip and an automobile alternative was presented:

1) [Reported access time – 15] * 0.833
2) [Reported access time – 15] * 0.769
3) [Reported access time – 15] * 0.714
4) [Reported access time – 15] * 0.667

Terminal Access Time, Check-in and Security Time, Time to Reach the Gate Area, and Gate Time. After arriving at the airport, travel times were split into four categories:

1) Time to reach the airport terminal from the parking lot, drop-off location, or transit stop
2) Time to check-in and check baggage (if applicable), reach security, wait in line, and clear security
3) Time to reach the gate area after clearing security
4) Time waiting at the gate area until boarding commences

These times were all varied around the respondent's reported values according to the following levels:

1) Reported time - 40%
2) Reported time - 20%
3) Reported time + 20%
4) Reported time + 40%

Minimum and maximum amounts of variation for the travel time attributes were set to ensure that all time attributes varied within the same general range. This helped prevent a single time attribute from dominating the others if the base time used in the attribute calculation was very large. The minimum variation for any given attribute was 4 minutes, while the maximum was set at 16 minutes.

Table 7 summarizes the attributes and levels used to generate the alternatives in the airport time components choice experiments.

As with the flight itinerary choice experiments, the experimental design was created using Ngene, a software tool designed specifically for this type of application. The final solution reached by Ngene also resulted in an experimental design with 128 experiments which were divided into sixteen groups of eight. One of the sixteen groups was randomly chosen for each respondent and the eight experiments were shown to respondents in randomized order.

The final design was evaluated by the Research Team, checked for correlation, and adjusted to eliminate stated preference experiments where one alternative would be clearly dominant over the other, which would result in little useful information obtained from that experiment.

Table 7. Stated Preference Attribute Levels – Airport Time Components Choice Experiments

Attribute	Level	Calculation			
Access Mode[a]	1	Drive and Park			
	2	Drive and Dropped-off			
	3	Taxi			
	4	Transit			
Access Cost		**Drive and Park**	**Dropped-Off**	**Taxi**	**Transit**
	1	$10/day	0	$3 + $1.50/mi	$2 + $0.135/mi
	2	$15/day	0	$3 + $2.00/mi	$4 + $0.135/mi
	3	$20/day	0	$3 + $2.50/mi	$6 + $0.135/mi
	4	$25/day	0	$3 + $3.00/mi	$8 + $0.135/mi
Access Time		**If Reported Mode = Auto or Taxi**		**If Reported Mode = Transit**	
		Drive/Taxi	**Transit**	**Drive/Taxi**	**Transit**
	1	Reported time * 0.8	15 + Reported time * 1.2	[Reported time – 15] * 0.833	Reported time * 0.8
	2	Reported time * 0.9	15 + Reported time * 1.3	[Reported time – 15] * 0.769	Reported time * 0.9
	3	Reported time * 1.1	15 + Reported time * 1.4	[Reported time – 15] * 0.714	Reported time * 1.1
	4	Reported time * 1.2	15 + Reported time * 1.5	[Reported time – 15] * 0.667	Reported time * 1.2
Terminal Time[b]	1	Reported time - 40%			
	2	Reported time - 20%			
	3	Reported time + 20%			
	4	Reported time + 40%			
Security Time[b]	1	Reported time - 40%			
	2	Reported time - 20%			
	3	Reported time + 20%			
	4	Reported time + 40%			
Security to Gate Time[b]	1	Reported time - 40%			
	2	Reported time - 20%			
	3	Reported time + 20%			
	4	Reported time + 40%			
Gate Time[b]	1	Reported time - 40%			
	2	Reported time - 20%			
	3	Reported time + 20%			
	4	Reported time + 40%			

[a] *Respondents were presented with the same access mode in both alternatives in at least 4 of the 8 experiments.*

[b] *A minimum variation of 4 minutes and a maximum variation of 16 minutes were used for these calculations.*

Attitude and Air Travel Background Questions

After completing the two sets of stated preference choice experiments, respondents answered a series of attitude questions that asked the level to which they agree or disagree with five statements related to how they buy air tickets and their general air travel attitudes. Next, they were asked about the number of round trips they have made by air within the U.S. in the past year for business or work and other purposes. They were also asked about their membership status in frequent flyer programs for their preferred airlines. To end this section, respondents reported whether they had missed a flight connection within the past two years.

These questions were intended to provide additional context to help understand respondents' choices in the choice experiments. These were also asked to enable the Research Team to explore factors that could explain differences in willingness to pay for travel time savings among the survey respondents.

Demographic Questions

In the final section of the survey, demographic information was collected in order to classify respondents, identify differences in responses or values of time among traveler segments, and confirm that the sample contained a diverse cross section of the traveling population. Both individual and household incomes were collected to identify if values of time are related to income and, if so, whether that relationship is better captured by individual wage rates or average household wage rates. All respondents answered demographic questions relating to the following areas:

- Gender
- Household size
- Annual individual income before taxes
- Annual household income before taxes
- Employment status

Before finishing the survey, respondents were given the opportunity to leave open-ended comments about the survey or air travel in general.

3.2 Survey Administration

Quotes were solicited from three market research panel firms in October of 2012 to support the survey effort. Based on the understanding of sample request, overall price, and history of providing a dependable sample in similar efforts, the Research Team selected Research Now to produce a generally representative sample of air travelers nationwide in an efficient and timely way. The sampling plan was designed to include a sufficient range of travelers and trip types to support the statistical estimation of the coefficients of a choice model.

These differences can then be reflected in the structure and coefficients (value of time estimates) of the resulting choice models.

Soft Launch Survey Administration

The Research Team initiated a "soft launch" on February 20, 2013 and concluded it on February 22, 2013. A total of 105 respondents completed the survey during that time. As a result of the soft launch, the Research Team implemented two changes to the time components conjoint exercise:

1) The same airport access mode was presented for each alternative in a minimum of four of the eight experiments. This helped to prevent the mode and cost attributes from dominating the other travel time attributes and forced respondents to trade-off against these other attributes.
2) Minimum and maximum amounts of variation for the travel time attributes were set to ensure that all time attributes varied within the same general rage. This helped prevent a single time attribute from dominating the others if the base time used in the attribute calculation was very large.

After completing the pretest and subsequent adjustments, the revised survey questionnaire was re-launched to collect the remaining data.

Full Survey Administration

The full survey commenced on April 1, 2013 and concluded on April 20, 2013. Respondents were recruited at random from the general panel population of all 50 states who met the following criteria (as described in Section 3.1, above):

- Must be at least 18 years old
- Must have made a domestic flight (within the contiguous U.S., Alaska and Hawaii) in the last 6 months
- Must not be employed by the airline industry

An additional 1,155 responses were collected during this time. Table 8 summarizes the data collection effort.

Table 8. Data Collection Summary

	Purpose of Recent Trip		
	Business	**Non-business**	**Total**
Soft Launch	32	73	105
Full Launch	291	864	1,155
Total	**323**	**937**	**1,260**

3.3 Survey Results

A total of 1,260 respondents completed the online survey, including 105 responses from the soft-launch in February and 1,155 from the full launch in April. The number of records was reduced to 1,171 after completing data checks and outlier analysis during the model estimation work, which is described in more detail in Section 3.4 (*Model Estimation*) of this report. The descriptive analysis of the data presented here is based on the 1,171 respondents who were included in the model estimation work.

For the purposes of statistical modeling and most other analysis in this report, respondents were grouped into two traveler market segments. The segments are described in Table 9 along with the respective number of respondents contained within each segment.

Table 9. Traveler Market Segments

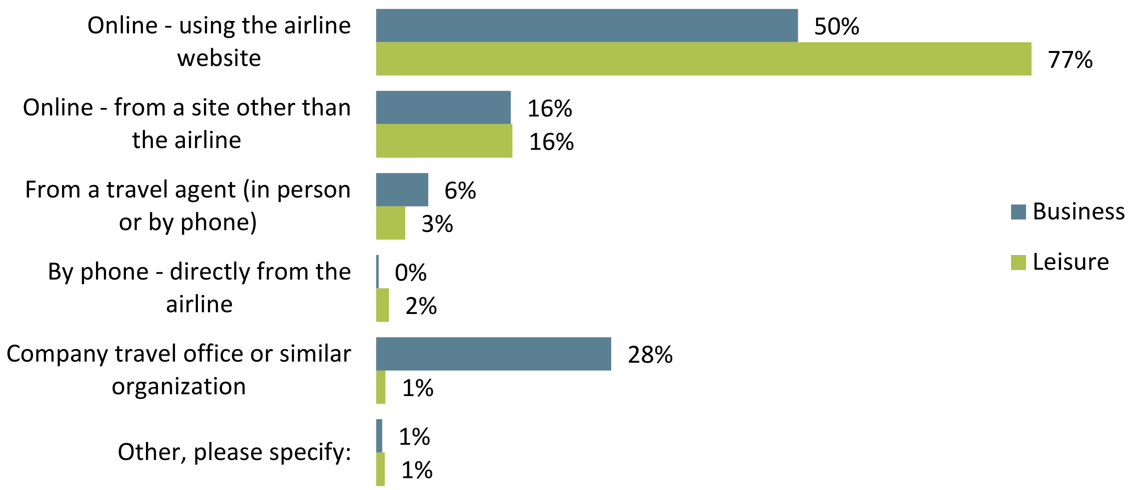
Market Segment	Respondents	Trip Purpose
Business Travelers	297 (25%)	1. Business
		2. Attend conference
Leisure Travelers	874 (75%)	1. Vacation
		2. Visit friends or relatives
		3. Attend school/college
		4. Other

Many of the tabulations presented in the remainder of this report and in Appendix B.2 are segmented by these categories. A complete set of tabulations of survey questions by market segment is shown in Appendix B.2.

Trip Characteristics Questions

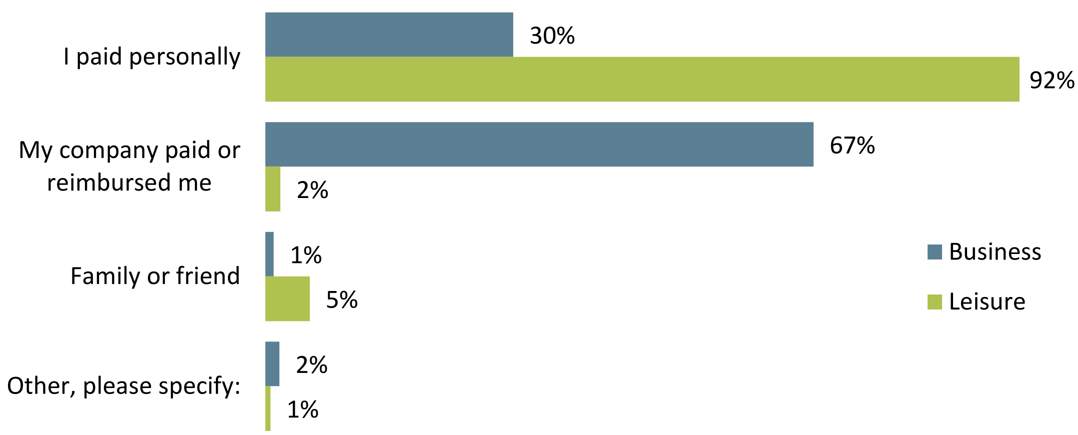
At the beginning of the trip characteristics section, respondents were asked about where they purchased their air ticket. A large majority of respondents purchased their tickets online, with 70% of overall respondents reporting that they purchased their tickets online using the airline's website, and 16% reporting that they purchased their tickets online from a web address other than an airline's website. Figure 4 shows reported airline ticket acquisition method segmented by business and leisure travelers.

Figure 4. Ticket Acquisition Method by Market Segment



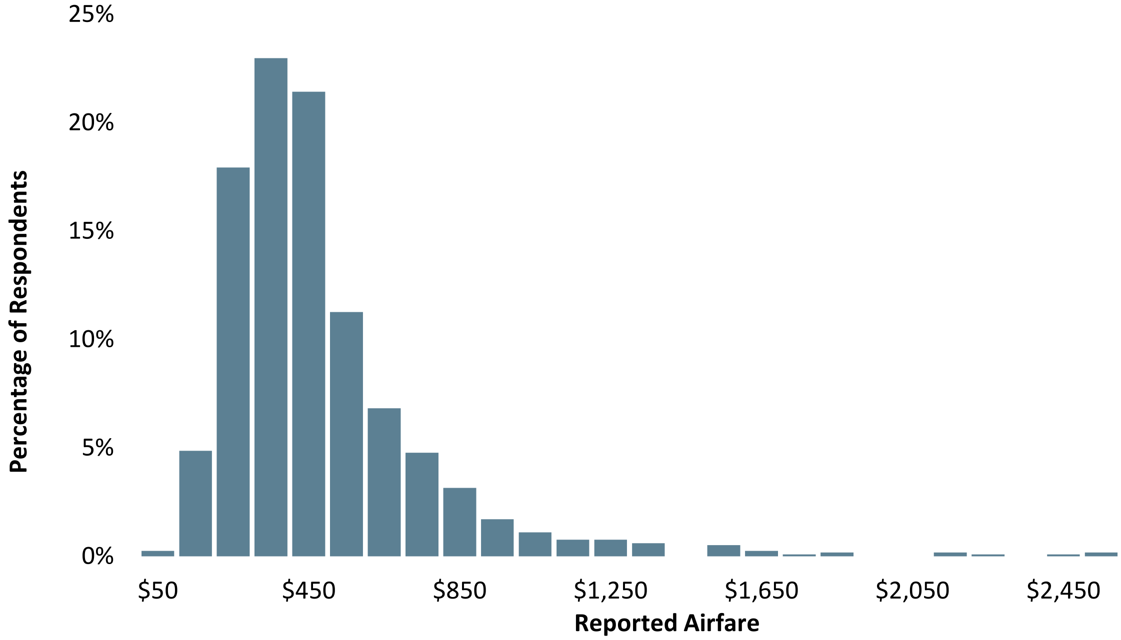
Overall, the majority of respondents reported that they personally paid for the air ticket (77%). However, only about 30% of business travelers paid for their tickets themselves, while 67% of them were reimbursed by their employers. On the other hand, 92% of leisure travelers paid for their own airfare. Figure 5 shows these differences by trip purpose.

Figure 5. Payment Source by Market Segment



Next, respondents were asked to enter their airfare. The median airfare for all respondents was $370 and the mean airfare was $438. Figure 6 shows the distribution of the reported airfare for all respondents.

Figure 6. Distribution of Reported Airfare



Overall, respondents reported 172 distinct origin airports and 148 distinct destination airports throughout the country. The origin and destination airports, stratified by number of respondents, are displayed in Figure 7 and Figure 8, respectively. The top five origin airports reported by the sample respondents were Chicago O'Hare International Airport (ORD), Denver International Airport (DEN), Newark Liberty International Airport (EWR), Boston Logan International Airport (BOS), and Phoenix Sky Harbor International Airport (PHX). The top destination airports reported were Orlando International Airport (MCO), McCarran International Airport (LAS), Fort Lauderdale–Hollywood International Airport (FLL), Phoenix Sky Harbor International Airport (PHX), and Los Angeles International Airport (LAX). Table 10 and Table 11 compare the top five origin and destination airports with data from the Bureau of Transportation Statistics' Airline Origin and Destination Survey (also known as DB1B) from 2008.[19] The tables show that the survey sample matches the DB1B sample reasonably well, although warm weather destinations are slightly overrepresented in the survey sample. This is most likely due to the fact that the survey was fielded during the February to April timeframe, a popular season for visiting warm-weather destinations such as Florida, Arizona, and California.

[19] The Research Team had the 2008 dataset processed, cleaned, and in formatted tables spinning on an SQL server from another study. Given that these data were being used as one point of comparison for the survey sample, the marginal benefit of using new data did not outweigh the investment of time in spending several days repeating the data processing tasks.

Figure 7. Location of Origin Airports by Number of Reported Trips

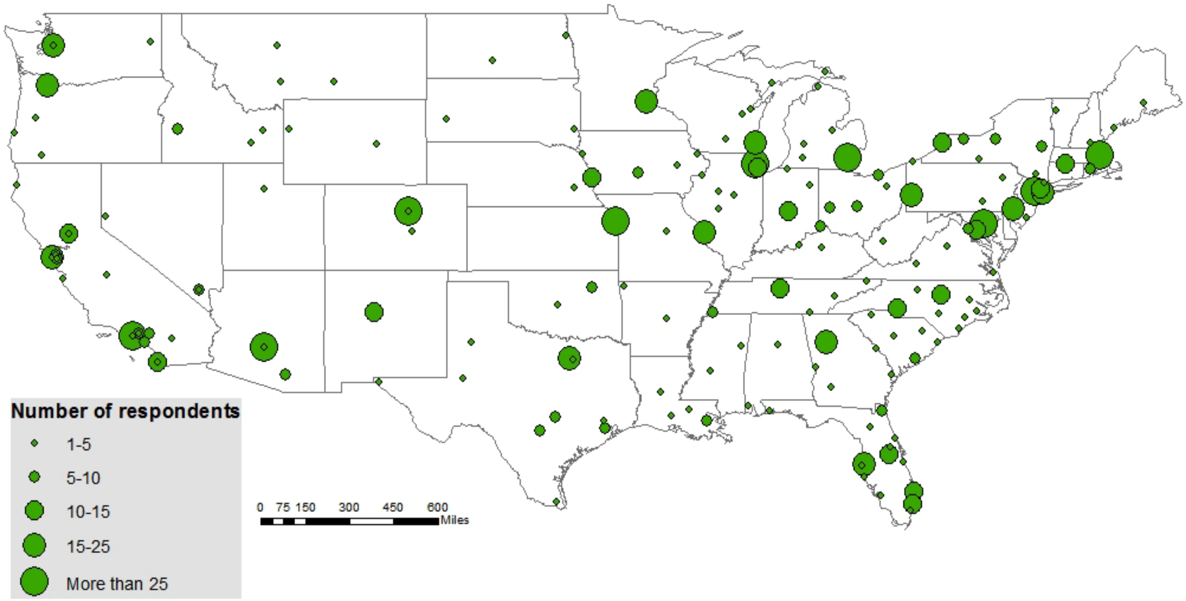


Figure 8. Location of Destination Airports by Number of Reported Trips

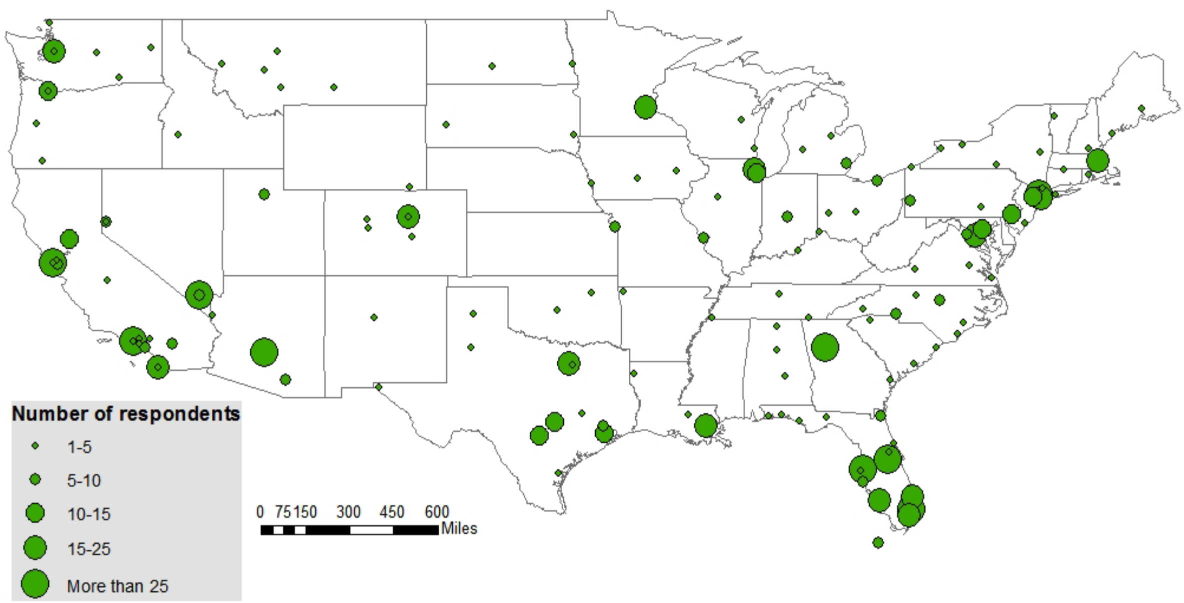


Table 10. Comparison of Top 5 Origin Airports with DB1B Data

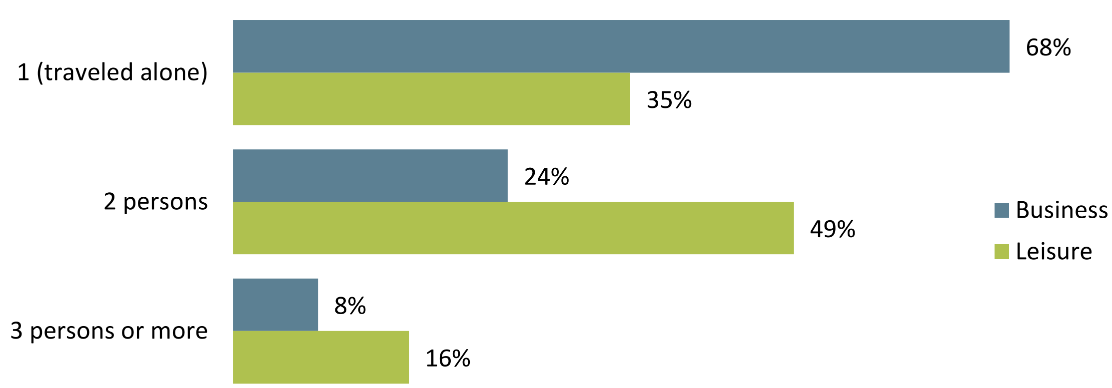
Airport	Sample Originating Passengers	Sample %	DB1B Originating Passengers	DB1B %
Chicago O'Hare International (ORD)	42	3.6%	898,921	3.6%
Denver International (DEN)	41	3.5%	667,916	2.7%
Newark Liberty International (EWR)	37	3.2%	713,308	2.9%
Boston Logan International (BOS)	32	2.7%	641,235	2.6%
Phoenix Sky Harbor (PHX)	29	2.5%	541,358	2.2%

Table 11. Comparison of Top 5 Destination Airports with DB1B Data

Airport	Sample Originating Passengers	Sample %	DB1B Originating Passengers	DB1B %
Orlando International (MCO)	72	6.1%	1,172,747	4.9%
McCarran International (LAS)	66	5.6%	1,416,725	5.9%
Fort Lauderdale–Hollywood International (FLL)	55	4.7%	595,001	2.5%
Phoenix Sky Harbor International (PHX)	47	4.0%	646,174	2.7%
Los Angeles International (LAX)	39	3.3%	848,285	3.5%

About 44% of all respondents traveled alone; however, 68% of business travelers traveled alone, compared to 35% of leisure travelers (Figure 9). Nearly half of the leisure travelers reported a party size of two. The average party size for business travelers was calculated as 1.47, whereas the average party size for leisure travelers came out to be 1.93.

Figure 9. Party Size by Market Segment



Leisure travelers reported longer visits, with over one-third (34%) reporting a stay of more than seven days compared to 6% of business travelers. As shown in Figure 10, a majority of business travelers (65%) stayed for 2-4 nights.

Figure 10. Length of Stay by Market Segment

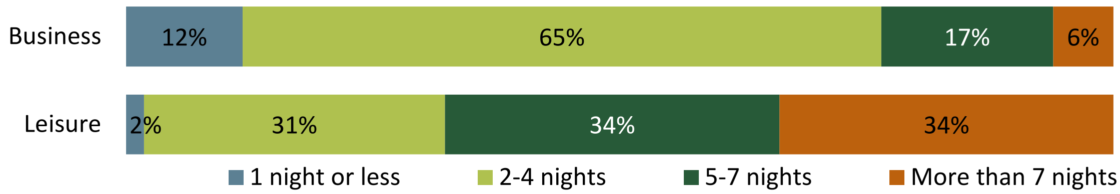


Table 12 shows respondents' access modes to the airport. About 60% of business travelers and 41% of leisure travelers arrived at the airport by private vehicle and parked at or near the airport for the entire trip. Being driven and dropped-off was cited as the next most commonly used access mode by both groups, with taxi, door-to-door van, and limousine being used less often. A few respondents (24 in total) reported their access modes in their own words by selecting 'other' option. Where possible, these responses were re-coded to the correct pre-defined categories based on the respondents' stated access modes.

Table 12. Reported Access Mode by Market Segment (Multiple Responses were Allowed)

Access Mode	Business		Leisure	
	Count	Percent	Count	Percent
Private vehicle and parked at/near airport for entire trip	178	60%	358	41%
Private vehicle and was dropped off at the airport (did not park)	68	23%	311	35%
Taxi	15	5%	40	5%
Shuttle bus or door-to-door van	12	4%	45	5%
Limo/Town car	7	2%	33	4%
Private vehicle parked at/near the airport for a short time and driven away by others	4	1%	32	4%
Rental car	9	3%	18	2%
Local city or regional bus	1	0%	11	1%
Train (commuter rail, Amtrak, etc.)	1	0%	11	1%
Rail transit, subway or streetcar	3	1%	20	2%
Other	1	0%	3	0%

There was very little reported use of public transit or rail by survey respondents for their access trips, particularly in the case of respondents making business trips. While this is consistent with airport access mode use at many airports, it has some important implications for the time component stated preference choice experiments, as discussed further below. The low use of rental cars reported by survey respondents reflects the fact that the airport access trips in question were for the outbound segment of a roundtrip and thus typically starting from the respondent's home or place of work.

Respondents provided their trip origin location either by directly entering the address or locating the origin on a map, either of which allowed the latitude and longitude for the trip origin to be determined. The latitude and longitude coordinates for each respondent's trip origin and origin airport were used to calculate the airport ground access distance using a Google Maps driving directions algorithm. Respondents also reported their ground access time to the airport. Reported access times for business travelers ranged from about five minutes to four hours, with a mean reported access time of 50 minutes for this group. A similar trend was observed for leisure travelers. Table 13 shows the mean and median reported access time and Google-calculated access distance.

Table 13. Ground Access Time and Ground Access Distance by Market Segment

	Access Time (minutes)		Access Distance (miles)	
Region	Mean	Median	Mean	Median
Business	50	40	32	22
Leisure	50	45	34	23

Figure 11 shows the distribution of reported terminal access time among all respondents, where the value shown on the horizontal axis is the upper bound of each time range. The terminal access time is defined as travel time from the location where the respondent parked, was dropped-off, or alighted from public transportation to the airport terminal entrance. The majority (56%) of respondents reported a terminal access time of 5 minutes or less. The mean and median terminal times reported were 8 minutes and 5 minutes, respectively.

Figure 11. Distribution of Reported Terminal Access Time

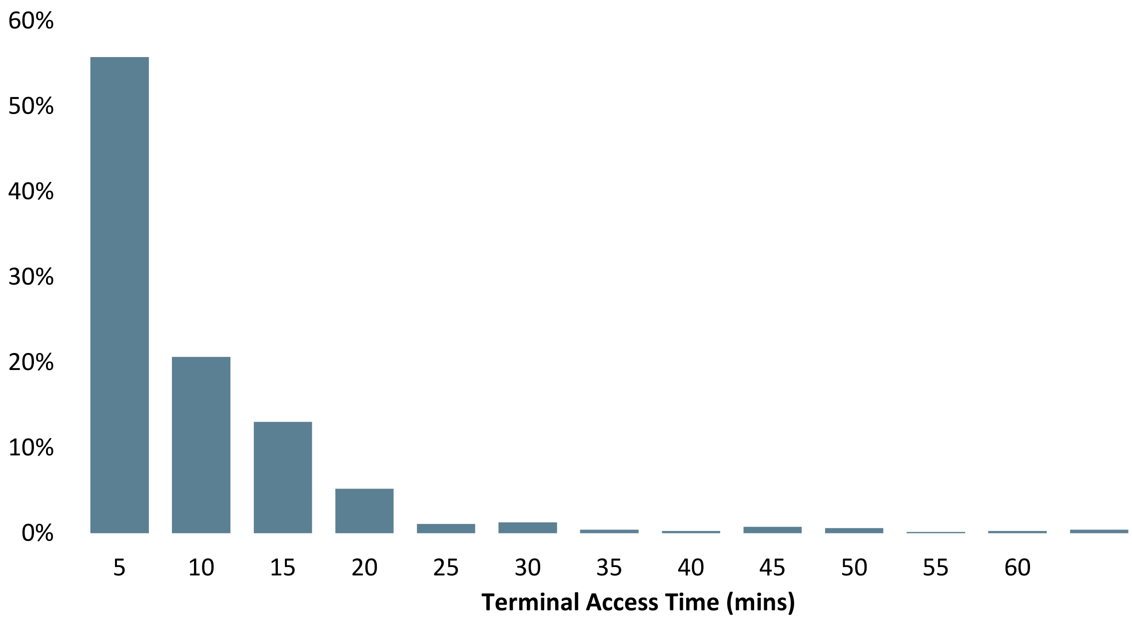


Figure 12 shows the distribution of the reported time from entering the terminal to reaching the security screening area or line at the airport, including any time spent checking in or dropping off checked baggage. The mean and median reported times to reach security were 14 minutes and 10 minutes, respectively.

Figure 12. Distribution of Reported Time to Security Screening from Entering the Terminal

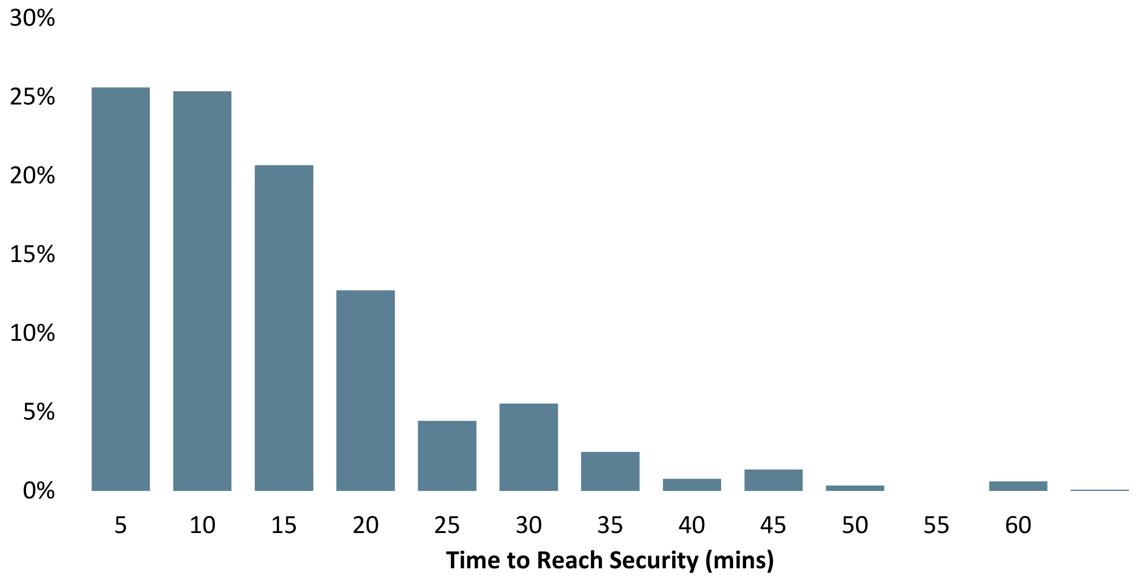


Figure 13 shows the distribution of the time it took respondents to clear security, including time spent waiting in line, placing hand baggage and other items on conveyer belts, and progressing through any mechanical and/or personal screening systems. As can be seen in the figure, there is more variability in reported security times. The mean and median reported times to clear security were 17 minutes and 15 minutes, respectively.

Figure 13. Distribution of Reported Time to Clear Security

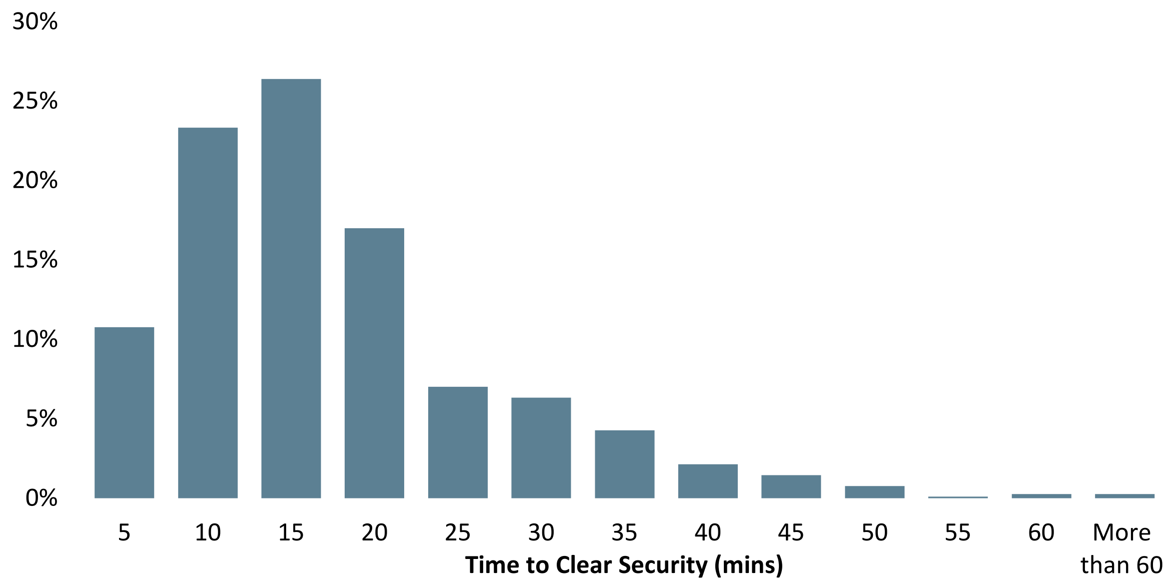
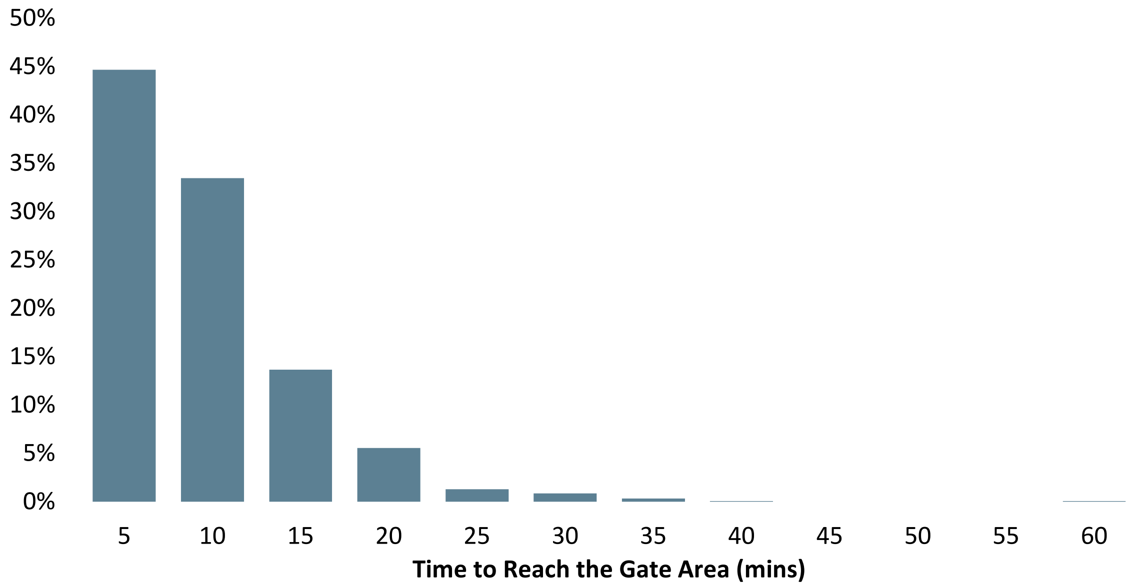


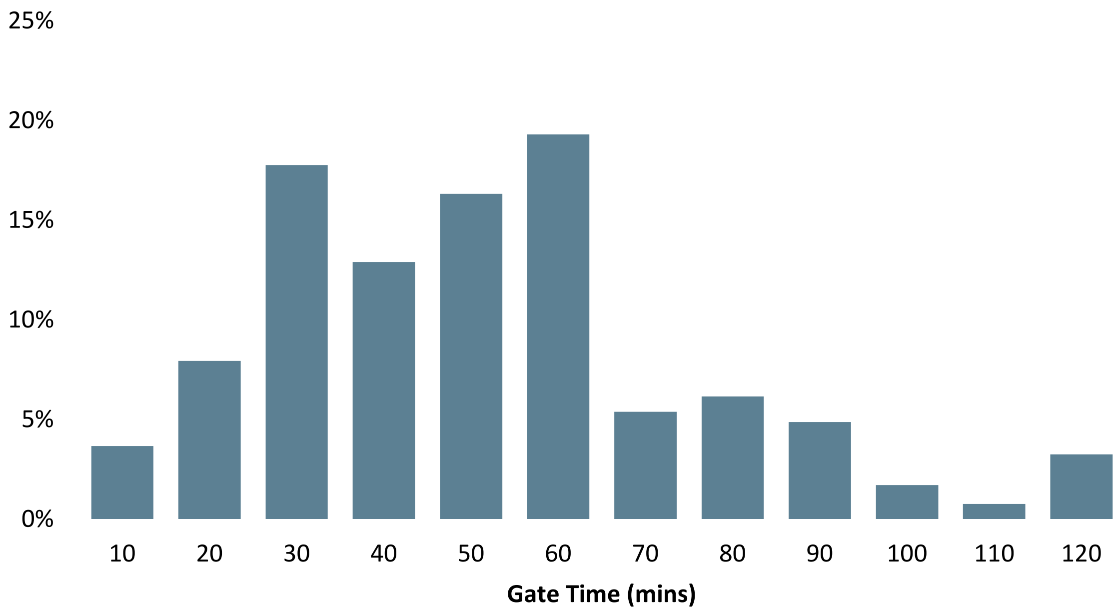
Figure 14 shows the distribution of the time reported by respondents to reach the gate area after clearing security.

Figure 14. Distribution of Reported Time to Reach the Gate Area from Security



Finally, Figure 15 shows the distribution of the time that respondents reported spending after reaching the gate area until flight boarding commenced, termed the gate time.

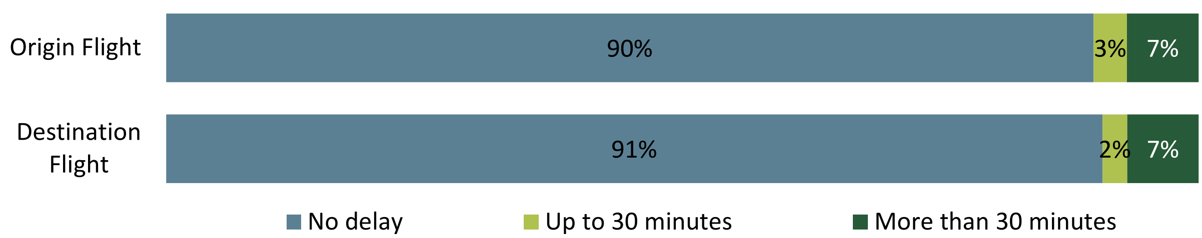
Figure 15. Distribution of Reported Gate Time



The mean and median times are highest for this time component at 49 minutes and 45 minutes, respectively. This is expected since this part of the airport journey is the least onerous and travelers can spend this time patronizing airport services and using mobile technology, such as cell phones or laptop computers. Also, this time represents the difference between the time that travelers allowed to reach the gate in case they encountered delays and the actual time that it took them to reach the gate, which is generally less. Airlines commonly advise passengers to arrive at the airport at least an hour before their flight, although it often takes much less than that to reach the gate area. The most common activities cited by respondents while waiting in the gate area include purchasing food and drinks, reading a book, magazine, newspaper or business documents, using a mobile device and checking e-mails.

A large number of respondents reported on-time flight departure and flight arrival. In accordance with the Federal Aviation Administration (FAA) definition, the flights were considered on-time if they departed earlier than 15 minutes after the originally scheduled time or if they arrived earlier than 15 minutes after the originally scheduled time. Ninety percent of flight departures and 91% of flight arrivals at the destination were reported on-time (Figure 16).

Figure 16. Flight Delay at Origin and Destination



Respondents were more likely to travel on flights departing earlier in the day. Approximately 64% of respondents traveled on flights departing before noon, with a similar proportion for both trip purpose segments (Figure 17). This high percentage of flight departures before noon can likely be attributed to the fact that the respondents were reporting the outward leg of their trip.

Figure 17. Flight Departure Time by Market Segment

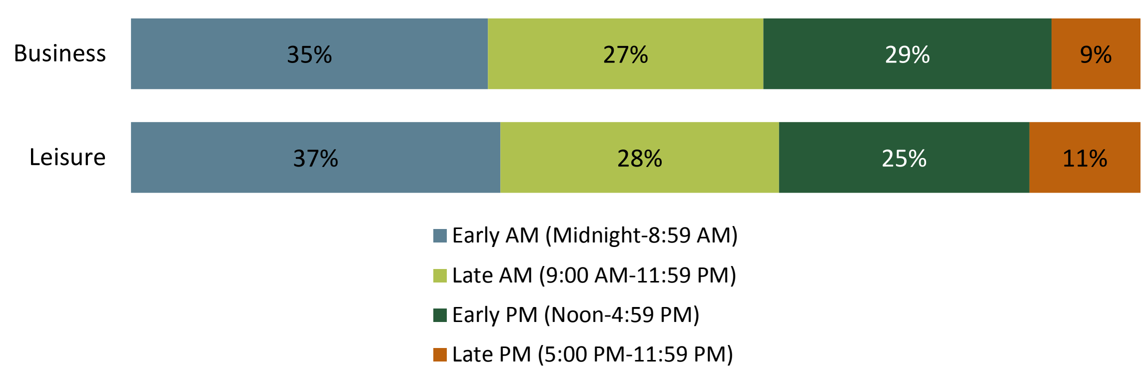
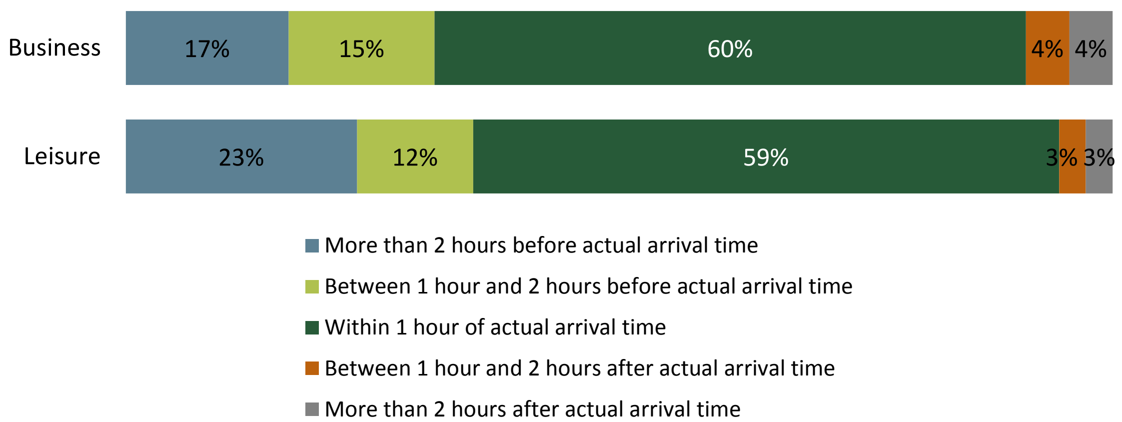


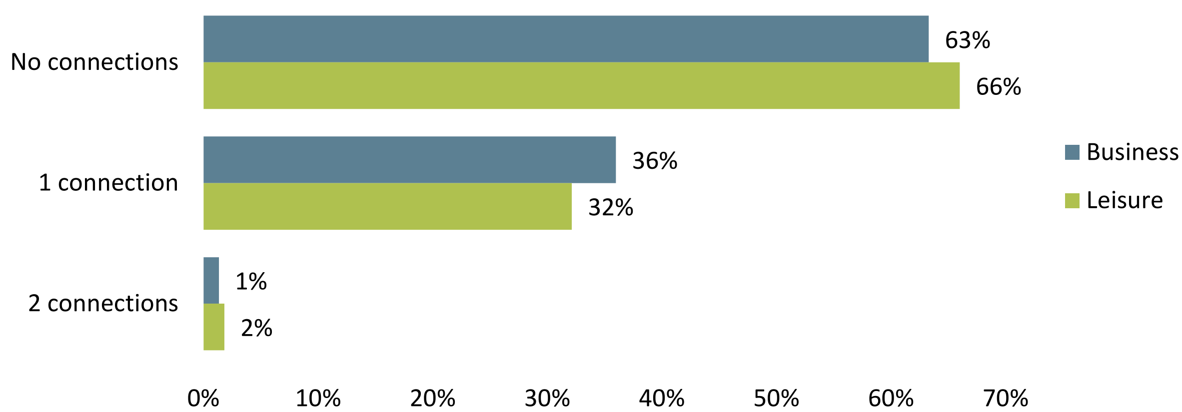
Figure 18 shows the distribution of preferred arrival time of travelers with respect to actual arrival time. The majority of the sample (60%) would have preferred an arrival time within one hour of their actual arrival time. About one-third of respondents would have preferred to arrive more than an hour earlier than their actual arrival time, whereas only 6% would have preferred to have arrived more than an hour later than the actual arrival time. The distribution is somewhat similar for both business and leisure travelers.

Figure 18. Distribution of Preferred Arrival Time with Respect to Actual Arrival Time



Overall, about two-third of respondents reported a non-stop flight (Figure 19). The mean connection time for travelers who reported at least one connection was calculated as 85 minutes and the median connection time was calculated as 70 minutes.

Figure 19. Number of Connections by Market Segment



Because airline choice can be an important factor in flight itinerary selection, respondents were also asked to report their three most preferred airlines. Table 14 presents each airline's frequency of being ranked as one of the top three choices. The top three most frequently preferred airlines were Southwest Airlines, Delta Airlines, and United Airlines. Responses to this question were used to construct levels for the air carrier variable shown in the flight itinerary stated preference choice experiments later in the survey.

Table 14. Respondents' Airline Preference

Airline	Survey Respondents Including Airline in Set of Preferred Airlines
Southwest Airlines	602
Delta Airlines	597
United Airlines	464
American Airlines	381
JetBlue Airways	244
US Airways	233
Alaska Airlines	139
Continental Airlines	139
AirTran Airways	135
Frontier Airlines	107
Virgin America	101
Hawaiian Airlines	84
United Express	54
Delta Connection	50
Allegiant Air	35
Air Canada	34
US Airways Express	20
Sun Country Airlines	19
America West Airlines	17
Horizon Air	17
American Eagle	16
Spirit Airlines	13
Express Jet	4
SkyWest Airlines	3
WestJet	3
Atlantic Southeast Airlines	1
Cape Air	1

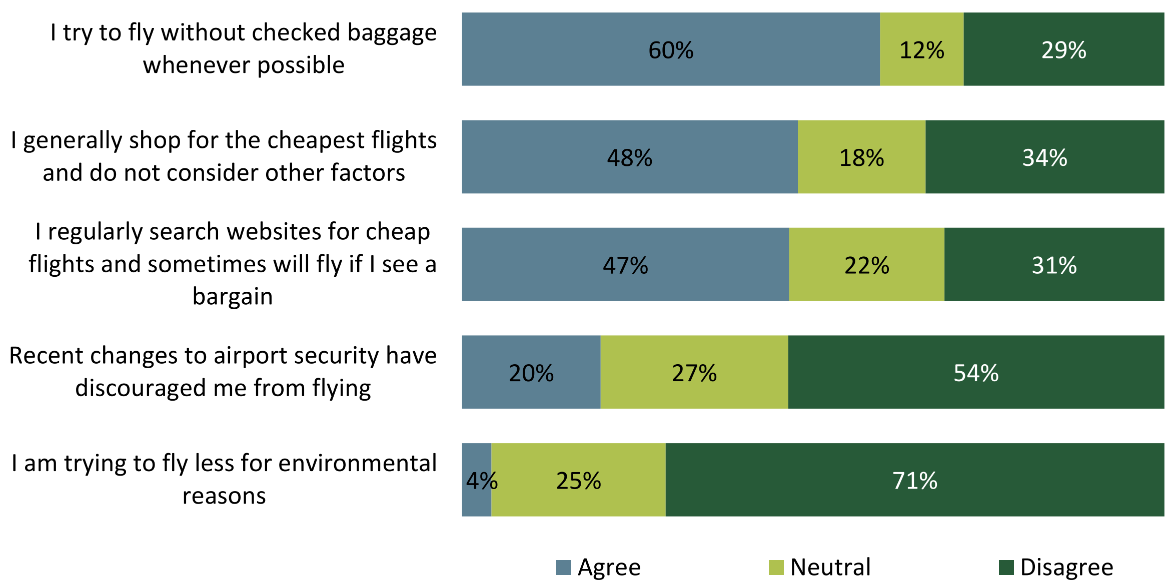
Questions on Attitudes to Air Travel and Recent Experience

Upon completing the stated preference experiments, respondents were asked to answer a series of questions related to their attitudes about flight itinerary selection and their general level of experience with air travel.

As noted in Section 3.1 above, these questions were asked to enable the Research Team to conduct additional analyses of factors that could explain differences in willingness to pay for travel time savings among the survey respondents.

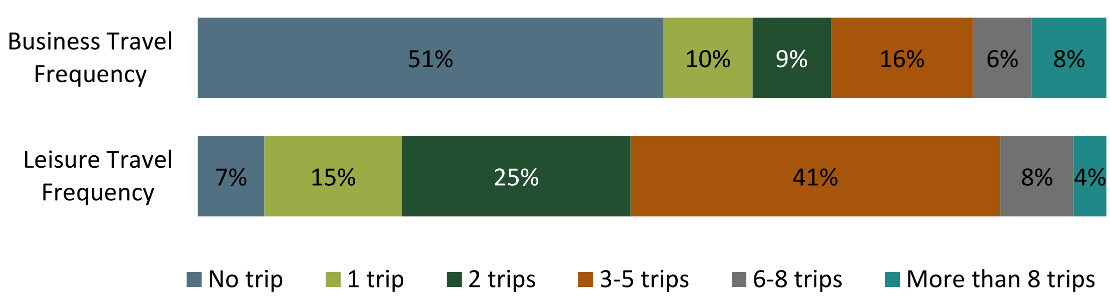
When presented with a series of questions regarding their attitudes about how they buy air tickets and other air travel behavior, respondents were most likely to agree that they try to fly without checked baggage whenever possible (60%). Conversely, respondents were less likely to fly less for environmental reasons, as shown in Figure 20. Respondents also indicated they generally shop for the cheapest flights and do not consider other factors (48%). Nearly, 47% agreed that they regularly search websites for cheap flights and sometimes will fly if they see a bargain. A majority of travelers (54%) disagreed with the statement that the recent changes to airport security have discouraged them from flying (20% agreed with the statement).

Figure 20. Air Journey Attitudes Statements



When they were asked about the number of round trips they have made by air within the U.S. in the past year for business or work purposes, more than 50% cited they had not made a business/work related trip in the past year. On the other hand, about 81% of respondents had made between one and five leisure or non-work related trips in the past year (Figure 21).

Figure 21. Number of Round Trips in the Past Year by Trip Purpose



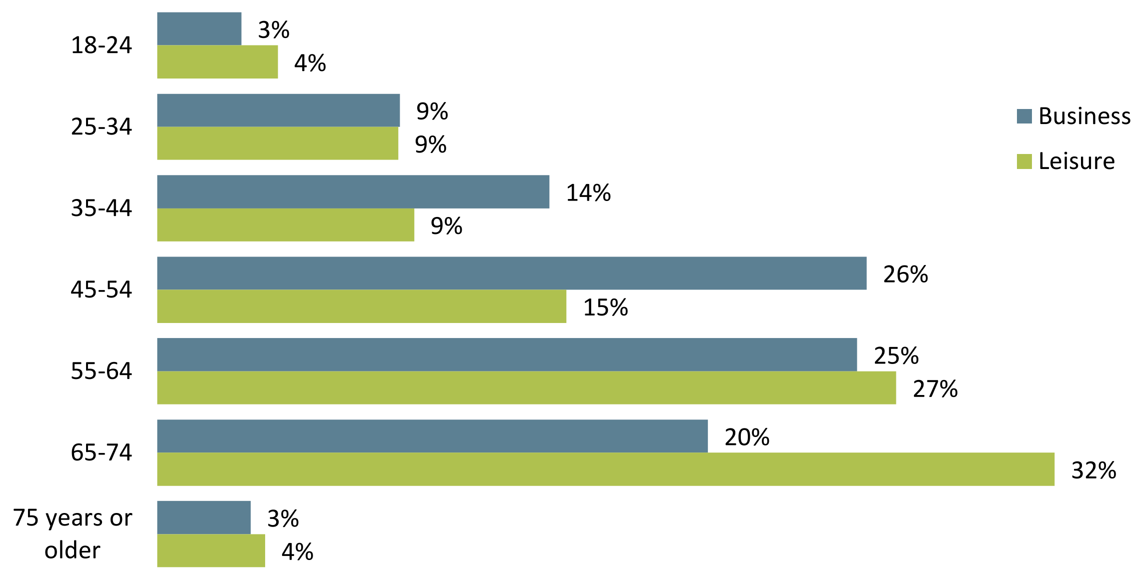
Respondents were also asked about their membership status in frequent flyer programs for their preferred airlines. A majority of the respondents reported that they were enrolled in standard memberships for their preferred airlines. For the respondents' most preferred airline, approximately 85% of business travelers and 80% of leisure travelers were members of a frequent flier program.

Finally, 16% of respondents reported that they had missed a flight connection in the last two years.

Demographic Questions

Of the 1,171 total respondents, slightly over half were female (55%). The median age of business respondents fell in the category of 45-54 years old and the median age category for leisure travelers was 55-64 years. About 44% of respondents reported being employed full-time, while 32% reported that they were retired.

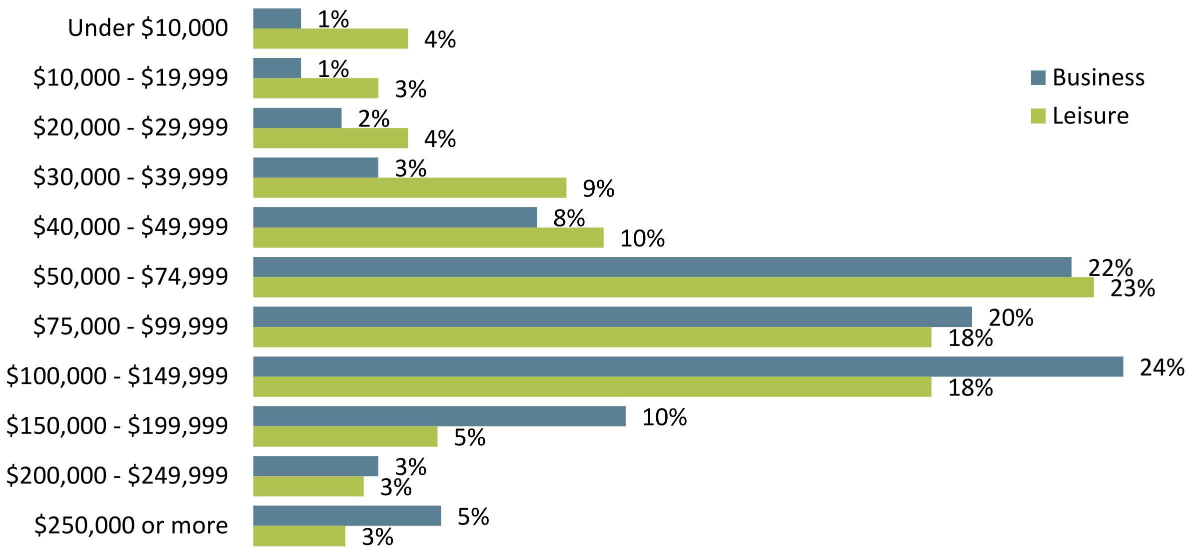
Figure 22. Age by Market Segment



The distribution of annual individual income reported by the respondents is shown in Figure 23. The median individual income of business respondents was in the $75,000 to $99,999 income category and the median individual income for leisure travelers fell in the $50,000 to $74,999 category.

It should be noted that the sample demographics are not proportional to the U.S. population as a whole. The sample has a slightly higher proportion of female respondents, is older on average, and has higher incomes on average. This is not surprising as the segment of the U.S. population that travels by air can be expected to be significantly different than the general population. In past airline research conducted by the Research Team, we have found that air travel samples are consistently older and have higher incomes than the general population. Unfortunately, there are no publicly available data that give reliable, nationwide, current demographic distributions for air passengers making domestic air trips to use as a point of comparison. There are also pronounced longitudinal trends in the air travel passenger mix that will not be apparent from current demographic data.

Figure 23. Annual Individual Income by Market Segment



3.4 Model Estimation

Statistical analysis and discrete choice model estimation were carried out using the stated preference survey data. Responses from the stated preference scenarios were expanded into a dataset containing 16 observations for each respondent (eight observations from the flight itinerary stated preference survey and eight from the time components stated preference survey). Each observation included the values of the attributes presented in each alternative, the respondent's chosen alternative, and additional background information about the respondent's reported trip and demographic characteristics. This dataset formed the basis for the discrete choice model estimation described in this section of the report.

The statistical estimation and specification testing were completed using a conventional maximum likelihood procedure that estimated a set of coefficients for a multinomial logit

(MNL) model[20] for the two traveler market segments of those making business and those making personal trips. The model coefficients provide information about the respondents' sensitivities to the attributes that were tested in the trade-off scenarios. The sensitivities were used to calculate the implied values of various time components discussed in Section 3.5.

Identification of Outliers

The choice data were screened to ensure that all observations included in the model estimation represented realistic trips and reasonable trade-offs in the stated preference exercises. In particular, inputs that were used to build the stated preference experiments were reviewed, including (the categories are not mutually exclusive):

- Comparing reported ground access time to ground access distance (24 cases)
- Comparing reported flight time to the distance between airports and the number of connections (18 cases)
- Comparing reported access costs to access mode and distance (11 cases)
- Identifying invalid origins and destinations (same origin and destination airport, international origin or destination airport, etc.) (34 cases)
- Evaluating reported values for airport time components (combined terminal access time, time to reach and clear security, and time to reach the gate area greater than 2 hours) (10 cases)
- Screening for inappropriate comments provided by respondents at the end of the survey that indicated the respondents were not paying attention or not taking the survey seriously (2 cases)

Significant changes were made in the airport time components stated preference choice experiments after the soft launch. Therefore, stated preference data from the soft launch was not used for estimating choice models for the time components choice experiments. Additionally, some choice experiments were removed from the time components choice data used for model estimation where responses from the soft launch showed inconsistent choice behavior or respondents selected options with very high access costs.

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[20] The multinomial logit model has the general form $p(i) = \dfrac{e^{U_i}}{\sum_{AllModes} e^{U_j}}$, where p(i) is the probability that mode i will be chosen and Ui is the "utility" of mode i, a function of service and other variables. See, for example, M. E. Ben-Akiva and S. R. Lerman, Discrete Choice Analysis, MIT Press, 1985 for details on the model structure and statistical estimation procedures.

After completing the data cleaning and outlier analysis, a total of 1,171 survey responses were used to conduct the discrete choice model estimation and specification testing for the flight itinerary choice experiments and 1,072 survey responses were used to conduct the discrete choice model estimation and specification testing for the airport time components choice experiments.[21]

Multinomial Logit Model Estimation and Specification

Using the cleaned dataset, several discrete choice model specifications were tested to explain the respondent choices in both the flight itinerary and the airport time components choice experiments. The statistical estimation and specification testing were completed using a conventional maximum likelihood procedure that estimated a set of coefficients for a multinomial logit (MNL) model. The MNL model estimates a choice probability for each alternative presented in the stated preference choice experiments. The alternatives are represented in the model by observed utility equations of the formula:

$$U_1 = \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$$

Where each X represents a variable included in the information presented to the respondents in the choice experiments and each β is a coefficient estimated by the model that represents the sensitivity of the respondents in the sample to the corresponding variable.

Several utility equation structures were tested using the variables included in the stated preference scenarios. Other background variables were tested as potential covariates to identify systematic differences in behavior, such as:

- Trip purpose (business or leisure)
- Party size
- Flight distance
- Income (individual and household)
- Reimbursement for travel expenses

As could be expected, many of these interacting variables did explain behavioral differences in the sample. On average, business travelers had higher willingness-to-pay (WTP) values than non-business travelers, those who were being reimbursed for their travel expenses had higher WTP values than those who were not, high income respondents had higher WTP values than low-income respondents, and multiple-person parties had higher WTP values than those traveling alone.

[21] Note that in the descriptive analysis presented in the previous section, data from both the soft launch and the full launch were used with a total of 1,171 respondents.

It is not immediately obvious why someone in a multiple-person party would have a higher WTP than someone traveling alone, other factors being equal. However, it is possible that some respondents making an air trip with others were paying the airfare for the other members of the travel party as well as their own and took this into account in making trade-offs between airfare and travel time.

Including all of these interactions in the MNL model specification becomes difficult as the sample gets divided among several dimensions. As a result, only the most significant interactions that were identified, including trip purpose and individual income, are included in the model results presented in this section of the report. Further discussion of several of these issues is included in Section 3.6 below.

The final flight itinerary choice model included the following variables:

1) **Flight Time:** Origin to destination travel time included in-flight time and any connection time(s).
2) **Airfare**: The airfare was shown either as the one-way or roundtrip fare depending on the respondent's reference trip.
3) **Number of Connections:** This variable was entered as a categorical variable with no connections as the reference category and one connection or two connections as other discrete categories.
4) **Type of Aircraft:** This was also entered as a categorical variable with four categories: propeller (reference), regional, standard, and widebody aircraft.
5) **Expected Delay:** This measure was calculated as the product of percentage of delayed flights from the on-time performance and the average amount of delay for delayed flights. For example, if the percentage of flights that were shown as on-time in a given alternative scenario was 60% (i.e. 40% of flights were delayed) and the corresponding delay shown was 30 minutes, the expected delay was calculated as 0.4 x 30 = 12 minutes.
6) **Arrival Time:** The difference between the arrival time shown in the stated preference experiment scenarios and the respondent's preferred arrival time was assigned to one of five categories. The reference category was when the arrival time in the stated preference experiment scenario fell within one hour before or after the preferred arrival time. The other four categories were defined as:
    - More than 2 hours before the preferred arrival time
    - Between 1 hour and 2 hours before the preferred arrival time
    - Between 1 hour and 2 hours after the preferred arrival time
    - More than 2 hours after the preferred arrival time
7) **Airline:** The airlines shown in the stated preference experiment scenarios were selected from the most-preferred airline, the second-most-preferred airline, and the third-most-preferred airline or the airline used in the actual trip (termed the current

carrier) if this was not either of the three most preferred airlines. This was coded as a three-level categorical variable. Although the Research Team initially estimated the current carrier separately, the coefficient estimate for the current carrier was not statistically different from the coefficient for the third-most-preferred airline.

The final airport time components choice model included the following variables:

1) **Ground Access Time:** This was defined as the travel time from respondent's trip origin location to where he/she parked, or got dropped off.
2) **Ground Access Cost:** This was defined as the one-way "out-of-pocket" access cost for the access trip. If the drive and park option was shown, the ground access cost included the parking cost as well.
3) **Ground Access Mode:** The ground access modes shown in the stated preference experiment scenarios were selected from four options: drive and park, drive and dropped off, transit, and taxi. This was coded as a four-level categorical variable.
4) **Terminal Access Time:** This was defined as the time to reach the airport terminal from the location where parked, dropped off, or alighted from public transportation.
5) **Check-in and Security Time:** This time component was defined as the time to check-in and check baggage (if applicable), reach security, wait in line, and pass security.
6) **Time to Reach the Gate Area:** This was defined as the time to reach the gate area after passing security.
7) **Gate Time:** The gate time was defined as the time after reaching the gate area until boarding commenced.

Model Coefficients

The MNL model results and resulting values of time are presented below for business and leisure travelers. Table 15 and Table 16 present the results for the flight itinerary choice models, while Table 17 and Table 18 include the results for the airport time components choice models.

In the second set of models, the cost variable was interacted with individual income to identify the relationship between the willingness to pay for travel time savings and traveler income. Separate specifications were tested using household income and individual income in the development of the analysis, and individual income was found to provide the best explanation of the respondent choice behavior. Table 19 and Table 20 present the results with income effects for the flight itinerary choice models, while Table 21 and Table 22 include the results for the airport time components choice models. The coefficient values, robust standard errors, robust t-statistics, and general model statistics are also presented (and defined below).

The coefficient values are the values estimated by the choice model that represent the relative importance of each of the variables. It should be noted that these values are unitspecific and the units must be accounted for when comparing coefficients (units are specified in Tables 15-22, below).

The tables below identify key diagnostics for each model, starting with the standard error. The standard error is a measure of error around the mean coefficient estimate. The t-statistic is the estimated value of the coefficient divided by the standard error, which can be used to evaluate statistical significance. A t-statistic numerically greater than 1.96 (positive or negative) indicates that the estimated value of the coefficient is statistically different from 0 (unless otherwise reported) at the 95% significance level.

The model fit statistics that are presented include the number of observations, the number of estimated parameters, the initial log-likelihood, the log-likelihood at convergence, rho-squared, and adjusted rho-squared. The log-likelihood is a model fit measure that indicates how well the model predicts the choices observed in the data. The null log-likelihood is the measure of the model fit with coefficient values of zero (which implies that each option is equally likely to be chosen). The final log-likelihood is the measure of model fit with the final coefficient values at model convergence. A value closer to zero indicates better model fit. The log-likelihood cannot be evaluated independently, as it is a function of the number of observations, the number of alternatives, and the number of parameters in the choice model.

The rho-square model fit measure accounts for this to some degree by evaluating the difference between the null log-likelihood and the final log-likelihood at convergence. The adjusted rho-square value takes into account the number of parameters estimated in the model. It should be noted that there are significant differences between an R^2 value commonly used to evaluate linear regression models and the adjusted rho-square value used in MNL models. R^2 in a linear regression model gives the proportion of the variance in the dependent variable which is explained by the model. However, the adjusted rho-square depends on the ratio of the beginning and ending log-likelihood functions and thus measures the improvement from the null model to the fitted model. Therefore, the adjusted rho-square value in MNL models is expected to be much smaller than the expected R^2 value in linear regression models. A value of 0.12 or higher for the adjusted rho-square is considered good for MNL models with panel data (data with multiple responses by each respondent).

Table 15. MNL Model Results – Flight Itinerary SP Experiments (Business Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
B_{Flight_time}	Min	Flight time	-0.00522	0.00126	-4.15
B_{Fare}	$	Airfare	-0.00614	0.000545	-11.27
$B_{Connection\_0}$	(0,1)	Number of connections – 0 (reference)	--Fixed--		
$B_{Connection\_1}$	(0,1)	Number of connections – 1	-0.59	0.172	-3.43
$B_{Connection\_2}$	(0,1)	Number of connections – 2	-1.73	0.377	-4.58
$B_{Aircraft\_propeller}$	(0,1)	Type of aircraft – propeller (reference)	--Fixed--		
$B_{Aircraft\_regional}$	(0,1)	Type of aircraft – regional jet	0.611	0.127	4.82
$B_{Aircraft\_standard}$	(0,1)	Type of aircraft – standard jet	0.763	0.122	6.25
$B_{Aircraft\_widebody}$	(0,1)	Type of aircraft – widebody jet	0.722	0.159	4.55
$B_{Expected\_delay}$	Min	Expected value of delay (probability of delay x average amount of delay for delayed flights)	-0.0293	0.00473	-6.19
$B_{Arrival\_preferred}$	(0,1)	Within +/- 1 hour of preferred arrival time (reference)	--Fixed--		
$B_{Arrival\_early1}$	(0,1)	More than 2 hours before preferred arrival time	0.25*	0.385	0.65
$B_{Arrival\_early2}$	(0,1)	Between 1 hour and 2 hours before preferred arrival time	-0.176*	0.121	-1.45
$B_{Arrival\_late1}$	(0,1)	More than 2 hours after preferred arrival time	-0.334*	0.747	-0.45
$B_{Arrival\_late2}$	(0,1)	Between 1 hour and 2 hours after preferred arrival time	-0.127*	0.119	-1.07
$B_{Carrier\_1}$		Most preferred carrier	0.379	0.0887	4.27
$B_{Carrier\_2}$		2^{nd} most preferred carrier	0.13*	0.0741	1.75
$B_{Carrier\_3}$		3^{rd} most preferred/current carrier (reference)	--Fixed--		
** Not significant at 95% confidence level*					

Fit Statistics	
Number of parameters:	14
Number of observations:	2,376
Number of individuals:	297
Null log-likelihood:	-1646.918
Final log-likelihood:	-1299.118
Rho-square:	0.211
Adjusted rho-square:	0.203

Table 16. MNL Model Results – Flight Itinerary SP Experiments (Leisure Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
B_{Flight_time}	Min	Flight time	-0.00572	0.00073	-7.83
B_{Fare}	$	Airfare	-0.00983	0.000642	-15.31
$B_{Connection\_0}$	(0,1)	Number of connections – 0 (reference)	--Fixed--		
$B_{Connection\_1}$	(0,1)	Number of connections – 1	-0.772	0.0908	-8.50
$B_{Connection\_2}$	(0,1)	Number of connections – 2	-2.3	0.25	-9.19
$B_{Aircraft\_propeller}$	(0,1)	Type of aircraft – propeller (reference)	--Fixed--		
$B_{Aircraft\_regional}$	(0,1)	Type of aircraft – regional jet	0.663	0.0943	7.04
$B_{Aircraft\_standard}$	(0,1)	Type of aircraft – standard jet	0.725	0.0901	8.05
$B_{Aircraft\_widebody}$	(0,1)	Type of aircraft – widebody jet	0.674	0.106	6.35
$B_{Expected\_delay}$	(0,1)	Expected value of delay (probability of delay x average amount of delay for delayed flights)	-0.0202	0.00288	-7.01
$B_{Arrival\_preferred}$	(0,1)	Within +/- 1 hour of preferred arrival time (reference)	--Fixed--		
$B_{Arrival\_early1}$	(0,1)	More than 2 hours before preferred arrival time	-0.286*	0.233	-1.23
$B_{Arrival\_early2}$	(0,1)	Between 1 hour and 2 hours before preferred arrival time	-0.138	0.0646	-2.13
$B_{Arrival\_late1}$	(0,1)	More than 2 hours after preferred arrival time	-0.98	0.289	-3.39
$B_{Arrival\_late2}$	(0,1)	Between 1 hour and 2 hours after preferred arrival time	-0.118*	0.068	-1.74
$B_{Carrier\_1}$		Most preferred carrier	0.372	0.0536	6.94
$B_{Carrier\_2}$		2nd most preferred carrier	0.0816*	0.0455	1.79
$B_{Carrier\_3}$		3rd most preferred/current carrier (reference)	--Fixed--		

** Not significant at 95% confidence level*

Fit Statistics		
Number of parameters:	14	
Number of observations:	6,992	
Number of individuals:	874	
Null log-likelihood:	-4846.485	
Final log-likelihood:	-3517.118	
Rho-square:	0.274	
Adjusted rho-square:	0.271	

Table 17. MNL Model Results – Airport Time Components SP Experiments (Business Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
B_{Time_access}	Min	Ground access time	-0.0128	0.00422	-3.02
B_{Cost_access}	$	Ground access cost (including parking)	-0.0413	0.00473	-8.74
$B_{Mode\_transit}$	(0,1)	Ground access mode – transit (reference)	--Fixed--		
$B_{Mode\_drop\text{-}off}$	(0,1)	Ground access mode – drive and dropped-off	1.14	0.21	5.44
B_{Mode_drive}	(0,1)	Ground access mode – drive and park	1.27	0.25	5.10
B_{Mode_taxi}	(0,1)	Ground access mode – taxi	0.301*	0.224	1.34
$B_{Time\_terminal}$	Min	Terminal access time	-0.0233	0.00735	-3.17
$B_{Time\_security}$	Min	Check-in and security time	-0.0256	0.00431	-5.95
$B_{Time\_security\_gate}$	Min	Time to reach gate area	-0.0222	0.00688	-3.23
B_{Time_gate}	Min	Gate time	-0.0141	0.00358	-3.93

** Not significant at 95% confidence level*

Fit Statistics		
Number of parameters:	9	
Number of observations:	2,144	
Number of individuals:	268	
Null log-likelihood:	-1486.108	
Final log-likelihood:	-1183.802	
Rho-square:	0.203	
Adjusted rho-square:	0.197	

Table 18. MNL Model Results – Airport Time Components SP Experiments (Leisure Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
$\mathbf{B}_{Time\_access}$	Min	Ground access time	-0.0202	0.00251	-8.05
$\mathbf{B}_{Cost\_access}$	$	Ground access cost (including parking)	-0.0715	0.00476	-15.01
$\mathbf{B}_{Mode\_transit}$	(0,1)	Ground access mode – transit (reference)	--Fixed--		
$\mathbf{B}_{Mode\_drop\text{-}off}$	(0,1)	Ground access mode – drive and dropped-off	1.13	0.145	7.79
$\mathbf{B}_{Mode\_drive}$	(0,1)	Ground access mode – drive and park	1.23	0.186	6.62
$\mathbf{B}_{Mode\_taxi}$	(0,1)	Ground access mode – taxi	-0.359	0.15	-2.39
$\mathbf{B}_{Time\_terminal}$	Min	Terminal access time	-0.031	0.00449	-6.90
$\mathbf{B}_{Time\_security}$	Min	Check-in and security time	-0.0339	0.00284	-11.93
$\mathbf{B}_{Time\_security\_gate}$	Min	Time to reach gate area	-0.0272	0.00411	-6.62
$\mathbf{B}_{Time\_gate}$	Min	Gate time	-0.021	0.00218	-9.66

Fit Statistics		
Number of parameters:	9	
Number of observations:	6,385	
Number of individuals:	804	
Null log-likelihood:	-4425.745	
Final log-likelihood:	-3035.381	
Rho-square:	0.314	
Adjusted rho-square:	0.312	

Table 19. MNL Model Results with Individual Income – Flight Itinerary SP Experiments (Business Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
$\mathbf{B}_{\text{Flight\_time}}$	Min	Flight time	-0.00542	0.00124	-4.36
$\mathbf{B}_{\text{Fare\_inc\_level1}}$	$	Airfare if Income less than $75,000, else 0	-0.00966	0.00108	-8.91
$\mathbf{B}_{\text{Fare\_inc\_level2}}$	$	Airfare if Income between $75,000 and $199,999, else 0	-0.00552	0.000628	-8.79
$\mathbf{B}_{\text{Fare\_inc\_level3}}$	$	Airfare if Income $200,000 or more, else 0	-0.00322	0.000886	-3.64
$\mathbf{B}_{\text{Connection\_0}}$	(0,1)	Number of connections – 0 (reference)	--Fixed--		
$\mathbf{B}_{\text{Connection\_1}}$	(0,1)	Number of connections – 1	-0.62	0.17	-3.64
$\mathbf{B}_{\text{Connection\_2}}$	(0,1)	Number of connections – 2	-1.76	0.383	-4.60
$\mathbf{B}_{\text{Aircraft\_propeller}}$	(0,1)	Type of aircraft – propeller (reference)	--Fixed--		
$\mathbf{B}_{\text{Aircraft\_regional}}$	(0,1)	Type of aircraft – regional jet	0.636	0.13	4.90
$\mathbf{B}_{\text{Aircraft\_standard}}$	(0,1)	Type of aircraft – standard jet	0.781	0.124	6.30
$\mathbf{B}_{\text{Aircraft\_widebody}}$	(0,1)	Type of aircraft – widebody jet	0.747	0.162	4.60
$\mathbf{B}_{\text{Expected\_delay}}$	Min	Expected value of delay (probability of delay x average amount of delay for delayed flights)	-0.03	0.00481	-6.24
$\mathbf{B}_{\text{Arrival\_preferred}}$	(0,1)	Within +/- 1 hour of preferred arrival time (reference)	--Fixed--		
$\mathbf{B}_{\text{Arrival\_early1}}$	(0,1)	More than 2 hours before preferred arrival time	0.148*	0.424	0.35
$\mathbf{B}_{\text{Arrival\_early2}}$	(0,1)	Between 1 hour and 2 hours before preferred arrival time	-0.193*	0.125	-1.54
$\mathbf{B}_{\text{Arrival\_late1}}$	(0,1)	More than 2 hours after preferred arrival time	-0.245*	0.699	-0.35
$\mathbf{B}_{\text{Arrival\_late2}}$	(0,1)	Between 1 hour and 2 hours after preferred arrival time	-0.13*	0.121	-1.07
$\mathbf{B}_{\text{Carrier\_1}}$		Most preferred carrier	0.408	0.0918	4.45
$\mathbf{B}_{\text{Carrier\_2}}$		2^{nd} most preferred carrier	0.136*	0.0759	1.80
$\mathbf{B}_{\text{Carrier\_3}}$		3^{rd} most preferred/current carrier (reference)	--Fixed--		

** Not significant at 95% confidence level*

Fit Statistics		
Number of parameters:	16	
Number of observations:	2,376	
Number of individuals:	297	
Null log-likelihood:	-1646.918	
Final log-likelihood:	-1269.127	
Rho-square:	0.229	
Adjusted rho-square:	0.220	

Table 20. MNL Model Results with Individual Income – Flight Itinerary SP Experiments (Leisure Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
$\mathbf{B}_{\text{Flight\_time}}$	Min	Flight time	-0.00606	0.00073	-8.31
$\mathbf{B}_{\text{Fare\_inc\_level1}}$	$	Airfare if Income less than $75,000, else 0	-0.0121	0.00076	-15.86
$\mathbf{B}_{\text{Fare\_inc\_level2}}$	$	Airfare if Income between $75,000 and $199,999, else 0	-0.00883	0.000868	-10.17
$\mathbf{B}_{\text{Fare\_inc\_level3}}$	$	Airfare if Income $200,000 or more, else 0	-0.00381	0.00135	-2.82
$\mathbf{B}_{\text{Connection\_0}}$	(0,1)	Number of connections – 0 (reference)	--Fixed--		
$\mathbf{B}_{\text{Connection\_1}}$	(0,1)	Number of connections – 1	-0.789	0.0931	-8.48
$\mathbf{B}_{\text{Connection\_2}}$	(0,1)	Number of connections – 2	-2.32	0.254	-9.12
$\mathbf{B}_{\text{Aircraft\_propeller}}$	(0,1)	Type of aircraft – propeller (reference)	--Fixed--		
$\mathbf{B}_{\text{Aircraft\_regional}}$	(0,1)	Type of aircraft – regional jet	0.682	0.095	7.17
$\mathbf{B}_{\text{Aircraft\_standard}}$	(0,1)	Type of aircraft – standard jet	0.743	0.0905	8.21
$\mathbf{B}_{\text{Aircraft\_widebody}}$	(0,1)	Type of aircraft – widebody jet	0.698	0.107	6.54
$\mathbf{B}_{\text{Expected\_delay}}$	(0,1)	Expected value of delay (probability of delay x average amount of delay for delayed flights)	-0.0216	0.0029	-7.44
$\mathbf{B}_{\text{Arrival\_preferred}}$	(0,1)	Within +/- 1 hour of preferred arrival time (reference)	--Fixed--		
$\mathbf{B}_{\text{Arrival\_early1}}$	(0,1)	More than 2 hours before preferred arrival time	-0.292*	0.236	-1.24
$\mathbf{B}_{\text{Arrival\_early2}}$	(0,1)	Between 1 hour and 2 hours before preferred arrival time	-0.148	0.0657	-2.26
$\mathbf{B}_{\text{Arrival\_late1}}$	(0,1)	More than 2 hours after preferred arrival time	-0.984	0.286	-3.44
$\mathbf{B}_{\text{Arrival\_late2}}$	(0,1)	Between 1 hour and 2 hours after preferred arrival time	-0.13*	0.0688	-1.89
$\mathbf{B}_{\text{Carrier\_1}}$		Most preferred carrier	0.378	0.054	7.00
$\mathbf{B}_{\text{Carrier\_2}}$		2nd most preferred carrier	0.0879*	0.0462	1.90
$\mathbf{B}_{\text{Carrier\_3}}$		3rd most preferred/current carrier (reference)	--Fixed--		

** Not significant at 95% confidence level*

Fit Statistics	
Number of parameters:	16
Number of observations:	6,992
Number of individuals:	874
Null log-likelihood:	-4846.485
Final log-likelihood:	-3448.519
Rho-square:	0.288
Adjusted rho-square:	0.285

Table 21. MNL Model Results with Individual Income – Airport Time Components SP Experiments (Business Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
$\mathbf{B}_{Time\_access}$	Min	Ground access time	-0.0136	0.00436	-3.13
$\mathbf{B}_{Cost\_access\_inc\_level1}$	$	Ground access cost (including parking) if Income less than $75,000, else 0	-0.0586	0.0103	-5.68
$\mathbf{B}_{Cost\_access\_inc\_level2}$	$	Ground access cost (including parking) if Income between $75,000 and $199,999, else 0	-0.0383	0.00491	-7.80
$\mathbf{B}_{Cost\_access\_inc\_level3}$	$	Ground access cost (including parking) if Income $200,000 or more, else 0	-0.0212	0.00939	-2.26
$\mathbf{B}_{Mode\_transit}$	(0,1)	Ground access mode – transit (reference)	--Fixed--		
$\mathbf{B}_{Mode\_drop-off}$	(0,1)	Ground access mode – drive and dropped-off	1.13	0.211	5.36
$\mathbf{B}_{Mode\_drive}$	(0,1)	Ground access mode – drive and park	1.32	0.254	5.19
$\mathbf{B}_{Mode\_taxi}$	(0,1)	Ground access mode – taxi	0.30*	0.22	1.37
$\mathbf{B}_{Time\_terminal}$	Min	Terminal access time	-0.0232	0.00735	-3.16
$\mathbf{B}_{Time\_security}$	Min	Check-in and security time	-0.0271	0.00444	-6.11
$\mathbf{B}_{Time\_security\_gate}$	Min	Time to reach gate area	-0.0221	0.0068	-3.25
$\mathbf{B}_{Time\_gate}$	Min	Gate time	-0.0139	0.00358	-3.88
** Not significant at 95% confidence level*					

Fit Statistics		
Number of parameters:	11	
Number of observations:	2,144	
Number of individuals:	268	
Null log-likelihood:	-1486.108	
Final log-likelihood:	-1167.710	
Rho-square:	0.214	
Adjusted rho-square:	0.207	

Table 22. MNL Model Results with Individual Income – Airport Time Components SP Experiments (Leisure Trips)

Parameters	Units	Description	Value	Robust Std. Error	Robust t-stat
$\mathbf{B}_{Time\_access}$	Min	Ground access time	-0.0207	0.00257	-8.06
$\mathbf{B}_{Cost\_access\_inc\_level1}$	$	Ground access cost (including parking) if Income less than $75,000, else 0	-0.0853	0.00718	-11.88
$\mathbf{B}_{Cost\_access\_inc\_level2}$	$	Ground access cost (including parking) if Income between $75,000 and $199,999, else 0	-0.0747	0.00655	-11.39
$\mathbf{B}_{Cost\_access\_inc\_level3}$	$	Ground access cost (including parking) if Income $200,000 or more, else 0	-0.0561	0.00618	-9.08
$\mathbf{B}_{Mode\_transit}$	(0,1)	Ground access mode – transit (reference)	--Fixed--		
$\mathbf{B}_{Mode\_drop\text{-}off}$	(0,1)	Ground access mode – drive and dropped-off	1.12	0.146	7.67
$\mathbf{B}_{Mode\_drive}$	(0,1)	Ground access mode – drive and park	1.28	0.184	6.97
$\mathbf{B}_{Mode\_taxi}$	(0,1)	Ground access mode – taxi	-0.338	0.151	-2.24
$\mathbf{B}_{Time\_terminal}$	Min	Terminal access time	-0.0314	0.00451	-6.95
$\mathbf{B}_{Time\_security}$	Min	Check-in and security time	-0.0345	0.00286	-12.04
$\mathbf{B}_{Time\_security\_gate}$	Min	Time to reach gate area	-0.0274	0.00411	-6.68
$\mathbf{B}_{Time\_gate}$	Min	Gate time	-0.0212	0.00219	-9.69

Fit Statistics		
Number of parameters:	11	
Number of observations:	6,385	
Number of individuals:	804	
Null log-likelihood:	-4425.745	
Final log-likelihood:	-3017.497	
Rho-square:	0.318	
Adjusted rho-square:	0.316	

3.5 Values of Time

The willingness to pay for travel time savings, or value of time, is defined as the marginal rate of substitution between time and money–namely, the amount of money that a person would be willing to exchange for a reduction in travel time (or some specific component of travel time), while maintaining the same level of utility, or satisfaction. These rates of substitution are given by the ratios of the time and cost coefficients that are estimated in the MNL models, since these show the change in utility for any given change in the time or cost variables. Thus, the marginal rate of substitution between the various time component and cost variables given by the ratio of their coefficients provides the implied value that travelers would be willing to pay for a given time savings.

Table 23 shows the willingness-to-pay (WTP) values for business and leisure travelers without considering income. As can be seen in the table, the values for business travelers are consistently higher for each time component as compared to the corresponding values for leisure travelers. Additionally, there are considerable differences in WTP values for various time components. It should be noted that the WTP values for flight time and the expected value of flight delay were estimated from a different set of stated preference choice experiments than the on-ground time components. The flight times and airfares presented in the flight itinerary choice experiments were generally larger in magnitude than the airport access times and costs presented in the on-ground time components choice experiments. Because of potential scale effects (e.g., $5 on a $20 taxi fare could be perceived as much more onerous than $5 on a $600 airfare), this difference in the magnitude of the travel time and cost variables could have an impact on the WTP values.

The WTP value for reductions in expected delay (which is calculated by multiplying the probability of being delayed and average amount of delay for delayed flights) appears to be perceived as 5.6 times the WTP value for flight time savings for business travelers and 3.5 times the WTP value for flight time savings for leisure travelers.

Table 23. Willingness-to-pay Values (in $/hour) – Business and Leisure Travelers

Component	WTP - Business	WTP - Leisure
Airport Time Components Choice Experiments		
Ground access time	$18.60	$16.95
Terminal access time	$33.85	$26.01
Check-in and security time	$37.19	$28.45
Time to reach the gate area	$32.25	$22.83
Gate time	$20.48	$17.62
Flight Itinerary Choice Experiments		
Flight time	$51.01	$34.91
Expected value of flight delay	$286.32	$123.30

Finally, the values of various time components segmented by income are shown in Table 24 and Table 25 for business and leisure travelers, respectively. The income is the respondents' annual individual income from the previous year (2012) as reported by respondents in the survey. As expected, the willingness-to-pay values follow an upward trend as the income levels increase.

Table 24. Willingness-to-pay Values (in $/hour) by Income – Business Travelers

Component	Individual Income (2012 $ before taxes)		
	Less than $75,000	$75,000 - $199,999	$200,000 or more
Airport Time Components Choice Experiments			
Ground access time	$13.92	$21.31	$38.49
Terminal access time	$23.75	$36.34	$65.66
Check-in and security time	$27.75	$42.45	$76.70
Time to reach the gate area	$22.63	$34.62	$62.55
Gate time	$14.23	$21.78	$39.34
Flight Itinerary Choice Experiments			
Flight time	$33.66	$58.91	$100.99
Expected value of flight delay	$186.34	$326.09	$559.01

Table 25. Willingness-to-pay Values (in $/hour) by Income – Leisure Travelers

Component	Individual Income (2012 $ before taxes)		
	Less than $75,000	$75,000 - $199,999	$200,000 or more
Airport Time Components Choice Experiments			
Ground access time	$14.56	$16.63	$22.14
Terminal access time	$22.09	$25.22	$33.58
Check-in and security time	$24.27	$27.71	$36.90
Time to reach the gate area	$19.27	$22.01	$29.30
Gate time	$14.91	$17.03	$22.67
Flight Itinerary Choice Experiments			
Flight time	$30.05	$41.18	$95.43
Expected value of flight delay	$107.11	$146.77	$340.16

3.6 Additional Research

The previous sections of this chapter identified the following aspects of the survey findings and model results that appeared to deserve further analysis during the remainder of the project:

1) Comparison of the demographics and other air party characteristics of the survey respondents with corresponding data obtained from recent air passenger surveys, in order to determine how representative the survey respondents were to the air passenger population in general.
2) Higher WTP values found for multi-person travel parties compared to one-person parties.

3) Higher WTP values found for savings of time spent in the airport terminal compared to time spent in ground access.
4) Significant differences in the WTP values found for flight time compared to ground access time and time spent in the airport terminal.
5) Further study of the differences in WTP values for the different on-ground time components.
6) Possible non-linearity in traveler sensitivity to time differences.

The remainder of this section summarizes the findings of the additional analyses of the stated preference survey data undertaken by the Research Team to further explore the various issues suggested by the findings of the model estimation. One important aspect of further analysis of potential non-linearity in traveler disutility of different travel time components is traveler sensitivity to flight delay. It would seem reasonable that travelers would have a relatively low WTP for delay savings where the delays are fairly small, since they may already have made some allowance for some amount of delay in their travel plans and the consequences of a small amount of delay may not be particularly serious. However, as the length of the delay increases, the potential consequences become more serious, including the possibility of missed flight connections or ground transportation services at the destination, arriving at the destination at a very inconvenient hour, or being late for, or missing entirely, the event that is the primary (or only) purpose of the trip. On the other hand, beyond a certain point the length of the delay may cease to matter, since there are no more connecting flights that day or the event that motivated the trip is over.

Other potential additional analyses, not explicitly identified in the above sections of Chapter 3 but suggested by the findings of the model estimation, include the following:

1) Compare the distribution of the airport-pair markets of the flights taken by the survey respondents to the distribution of itineraries in the DB1B data for the second quarter of 2013 (the comparison of the survey markets discussed in Section 3.3 only considered the distribution of trip origins and destinations, not the airport-pair markets, and used older data).
2) Compare the values of the ground access WTP and modal constants found in the model estimation with corresponding values found in past studies that developed airport ground access models using revealed preference (RP) data.
3) Explore differences in the effect on WTP of basing this on individual income, household income, or household income adjusted for household size and composition.
4) Explore the use of continuous variables for income, rather than simply dividing income into three categories.
5) Determine whether WTP values for travelers on business trips are different if they pay for the trip themselves versus being reimbursed by their employer or client.

The following sections of this chapter summarize the findings of the additional analysis undertaken to address the foregoing issues:

- Comparison of survey respondent reported flights to national data
- Comparison of survey respondent air party characteristics to airport survey data
- Further analysis of survey results and model estimation
- Comparison of ground access coefficients estimated from survey data with ground access mode choice model coefficients in prior studies

A more detailed discussion of the analysis undertaken to address each of these topics is included as Appendix B.3 to this report.

Comparison of Reported Flights by Survey Respondents to National Data

Since the objective of the SP survey was to obtain a representative sample of air travelers who had made a recent domestic air trip, the extent to which the reported air trips in the survey correspond to the distribution of domestic air travel across different markets has important implications for how representative the survey results are for domestic air travel in general. Therefore a more detailed analysis was undertaken to compare the distribution of the reported trip origins, trip destinations, and airport-pair markets flown between the reported trips by the SP survey respondents and the corresponding distributions for all domestic air travel obtained from the U.S. DOT 10% Origin & Destination Survey (also termed Database 1B, or DB1B, data). The results of this comparison can be summarized as follows:

1) The distribution of trips across origin and destination airports between the SP survey responses and the DB1B data corresponds fairly closely. Origin airports with 10 or more air trips in the SP data accounted for 66% of the reported trips in the survey and 68% of the passengers in the DB1B data, while destinations with 10 or more trips in the SP data accounted for 72% of the reported trips in the survey and 69% of the passengers in the DB1B data. The difference between the SP data and the DB1B data becomes even less when considering origin and destination airports with five or more air trips in the SP data.

2) At the airport-pair market level, the distribution of the recent trips reported by SP survey respondents by market size (based on the DB1B data) is generally close to the distribution of reported passengers in the DB1B data, with the larger markets (those with more than 500 DB1B reported passengers) somewhat under-represented (about 8% fewer trips than would be expected if the distribution corresponded to the DB1B data) and smaller markets correspondingly overrepresented. Necessarily some airports or markets in the DB1B data would not appear in the SP survey data due to the survey sample size, but the under- or over-representation of markets in the survey is generally equivalent to one survey response or less. For the 146 largest directional markets, 32% did not appear in the survey trips, but the majority of these would have only been expected to have one reported trip, based on the survey sample size, and the remainder would only have been expected to have two

reported trips. Only 10% of the markets that were included in the survey trips were over-sampled by more than one reported trip and the largest over-representation was only four survey responses.

Therefore, on balance, the distribution of reported trips by market appears to be generally representative of the distribution of air passenger trips across the full range of markets of varying size and geographic location in the U.S.

Comparison of Air Party Characteristics by Survey Respondents to Airport Survey Data

In order to explore how representative the recent air trips reported by the SP survey respondents were to air travel in general, aside from the distribution of the airport-pair markets in which those trips took place, the air party characteristics for the reported trips were compared to data for domestic air passengers collected in an air passenger survey performed at Los Angeles International Airport (LAX) in 2011.

The LAX survey was used because it has a large sample size of 8,984 respondents making directional domestic trips that began at LAX (i.e., excluding passengers making flight connections at LAX). This survey contains one of the largest sample sizes of a recently completed air passenger survey and included respondents making air trips to destinations throughout the U.S. The comparison addressed the following air party characteristics:

- Air party size
- Trip purpose
- Household income
- Gender and age

However, some caution should be exercised in comparing the profiles of respondents to the LAX and SP surveys because it is not known how closely air travelers using LAX compare to a national profile of air travelers using the full national network of commercial airports that vary widely by size. Moreover, the median household income of residents of the Los Angeles metropolitan area is somewhat higher than the national median household income,[22] as reflected in differences between LAX survey respondents who were residents of Southern California and those who were visiting the region.

In comparing the findings of the SP survey with those from the LAX survey, it should be borne in mind that the SP survey was a survey of individual ***air travelers***, while the LAX survey (like all intercept surveys) was a survey of ***air trips***. The distribution of respondent

[22] According to the U.S. Census Bureau, the 2012 Los Angeles metropolitan area median household income is about 12.5% above the national level ($57,745 in the LA region compared to $51,324 nationally).

characteristics in an intercept survey will therefore reflect a higher presence in the survey sample of travelers who make more frequent air trips, since they have a higher likelihood of being surveyed. This will affect the observed distribution of those characteristics (such as household income) that influence the propensity for air travel (measured by the number of air trips made per year) or differ across travelers making different numbers of air trips per year.

The findings of this comparison are summarized as follows:

1) The most recent SP survey trips were found to have a significantly smaller proportion of single-person parties and a correspondingly higher proportion of two-person parties than observed in the LAX survey. The proportion of air parties of three or more was approximately the same between the most recent SP survey trips and the LAX survey. When adjusted to reflect differences in the number of air trips made per year for different trip purposes, the proportions of single-person and two-person parties in the SP survey results were closer to those in the LAX survey, but still understated the proportion of single-person parties and overstated the number of two-person parties.

2) The most recent SP survey trips had a smaller proportion of trips reported for a business purpose (excluding attending a conference or convention), although a significantly higher proportion of trips to attend a conference.[23] The proportion of SP survey trips for a vacation was only slightly higher than in the LAX survey. However, the proportion of trips to visit friends or relatives was significantly higher in the SP survey. The proportion of SP survey trips to attend school or college was significantly lower than in the LAX survey, although this could be a reflection of the age profile of the SP survey respondents discussed below. It might also be partly influenced by the timing of the two surveys, since the first wave of the LAX survey took place in late August when many students would be returning to school, and by the Los Angeles metropolitan area having the second highest concentration of college students in the U.S. (Florida, 2012).

   When considering the number of air trips in the previous year reported by the SP survey respondents, the proportion of business trips (including attending a conference or convention) was somewhat higher than given by the LAX survey for Southern California visitors and significantly higher than given by the LAX survey for Southern California residents. The proportion of air trips in the previous year reported by SP survey respondents for leisure was correspondingly lower than the proportion of non-business air trips given by the LAX survey. The SP survey asked respondents for the number of business and non-business trips taken in the previous

[23] In the model estimation using the data from the SP survey choice experiments the Research Team combined business trips with attending conferences and conventions to form a broader "business" trip purpose category.

year without any further breakdown by purpose, so it is unclear how the lower proportion of non-business trips reported by the SP survey respondents relates to the various trip purpose categories in the LAX survey. The lower proportion of business trips in the LAX survey may also reflect the timing of the survey, which was conducted in two waves with the first wave in late August, as well as the importance of Southern California as a vacation destination.

3) It was found that overall a higher proportion of the SP survey respondents were reasonably well-off (household incomes between $50,000 and $150,000) compared to the LAX survey respondents, but the SP survey respondents whose recent trip was for business purposes included a smaller proportion of higher-income households ($250,000 or more). When adjusted for the number of air trips in the previous year reported by the SP survey respondents, the proportion of business trips made by SP survey respondents with a household income of $250,000 or more was somewhat higher than found in the LAX survey.

4) The SP survey respondents were found to have a higher proportion of female respondents than the LAX survey respondents, although the difference is not significant in the case of those whose recent trip was for business purposes.[24] When adjusted for the number of reported air trips in the previous year, the proportion of both business and leisure trips reported by male respondents was slightly higher than found in the LAX survey.

5) The SP survey respondents were found to be substantially older than the air passenger population in the LAX survey, particularly for male respondents. Some 44% of male respondents in the SP survey were over 64, compared to only about 8% for Southern California visitors in the LAX survey, while 24% of female respondents to the SP survey were over 64, compared to about 9% for Southern California visitors.

In summary, the air party size on the reported recent air trips by SP survey respondents had fewer single-person parties than found in the LAX survey, which is consistent with the smaller proportion of business trips, although the difference was less when adjusted for the number of reported air trips in the previous year. The SP survey respondents appear to have generally higher household incomes than air travelers using LAX. Perhaps the most significant difference between the SP survey respondents and air travelers using LAX is the age distribution, with both male and female respondents to the SP survey being significantly older than the LAX survey respondents, particularly male respondents.

[24] However, it should be noted that in the case of an intercept survey, such as the LAX air passenger survey, there may be a tendency for a male member of an air party with both genders to respond on behalf of the party, whereas in the SP survey the respondent, male or female, will report the recent trip irrespective of the composition of that air party.

Further Analysis of Survey Results and Model Estimation

The Research Team undertook additional analysis of the survey results and model estimation. Some of the issues were resolved while others will require further research beyond the current project to fully address. The findings of this analysis are summarized as follows:

1) Air passengers' estimated value of willingness-to-pay (WTP) for savings in airport ground access time, and hence for the various on-airport time components that depend on the WTP value for ground access time, was found to vary with the respondents' age, although it is unclear how much of this variation is due to differences in respondents' income levels with age. The estimated WTP values for savings in flight time did not show a similar variation with age, with the values being generally similar across the age groups, with one unexplained exception for business travelers in the age group 55-64. The Research Team was unable to determine why the WTP values for ground access time savings appeared to vary by age group while those for flight time savings did not. The consistency of the WTP values for flight time savings across the age groups means that the age imbalance in the survey sample did not significantly affect the estimated WTP values for flight time. Further research is needed to understand whether the variation in WTP values for ground access time by age were simply a reflection of differences in respondents' income in each age group or there is an effect of age on WTP after controlling for income, and if so, how the age imbalance in the survey sample may have affected the estimated WTP values for ground access time.

2) Multi-person travel parties were found to have lower per-person WTP values. However, the drop in per-person WTP values follows more or less a linear trend as party size increases. This implies that respondents were actually making trade-offs in the choice experiments as if they were bearing the access cost themselves, not sharing the costs among the other party members, as was assumed in the model estimation described in Section 3.4. While it was intended that the airport ground access and airport time component SP choice experiments were for the travel party in the most recent trip described by the survey respondents, this may not have been fully understood by the survey respondents, who may have assumed that the choice experiment trade-offs applied to a single-person air trip. The implications of this for the estimated WTP values of ground access travel time should be explored in future research.

3) The Research Team undertook further analysis to try to explain the lower WTP values for access time savings compared to the WTP values found for savings of time spent in the airport and flight time, but was unable to come up with a clear explanation. It was felt that these differences might potentially be due to the scale differences in the travel times shown in the choice experiments and the effect of perceived access mode preferences.

4) In order to explore possible non-linearity in traveler sensitivity to time differences, choice models were estimated with non-linear functions of time and cost. However, the Research Team was unable to find any significant and conclusive results from

this analysis. An attempt to estimate WTP values for flight delay using a non-linear function of expected delay also gave inconclusive results, suggesting that further research with a larger survey sample size may be needed in order to capture any such effects.

5) After testing several continuous income transformations for the cost/fare variable, the research team used a regression-based approach to estimate the relationship between WTP values and income. It was found that using a respondent's individual income generally provided a better model fit of the relationship between WTP and income than using household income with no adjustment for household size and composition. This is not particularly surprising, since household income does not take account of household size and households with two or more adults will have a higher household income than a single-person household with the same per-person income. Using per-person household income, where each child was counted as 0.5, generally gave similar model fit as individual income. Individual income generally gave a slightly better model fit for business trips, while per-person household income gave a slightly better model fit for non-business trips. This seems reasonable since travelers on business trips are likely to base their value of time on their salary or wage rate, while those making personal trips are likely to base their value of time on their household income and composition.

6) The values of time shown in the Guidebook are expressed in terms of individual income. However, air passenger surveys that ask respondents to indicate their income typically request household income, as it may be perceived to be a less intrusive question than personal income and takes account of the incomes of other household members. The Research Team has included a table in the Guidebook that allows the user to estimate the corresponding individual income for any given household income, based on the responses to the SP survey, so that an airport may use either in determining the values of time for use in analysis.

7) The estimated relationships between WTP values and income obtained from the regression models gave progressively increasing, non-linear relationships between the WTP values for flight time and ground access time and income, with the resulting WTP values expressed as a percentage of the respondent's hourly income (assuming 2,000 hours worked per year), or the equivalent household income on a per person basis, declining with increasing income levels. Thus although lower income respondents had significantly lower estimated WTP values than higher income respondents, as would be expected, their WTP values as a percentage of their hourly income were found to be much higher. This may partly reflect the fact that higher income households generally pay a higher proportion of their income in taxes, so when expressed as percentage of their after-tax hourly income, the decline in WTP values would not be so great. However, it is unclear how much of the apparent relationship this would account for and the finding is deserving of future research to better understand this relationship.

8) Pending the results of future research to clarify and extend these findings, the estimated relationships provide a basis for incorporating a continuous function of income into air traveler choice models in order to account for differences in income when exploring the effect of other variables, as well as adjusting WTP values in airport BCA studies to account for changes in income distribution.

9) Not surprisingly, it was found that SP survey respondents making both business and leisure trips who paid for their trip themselves had a significantly lower value of WTP for savings of flight time and expected delay than those for whom someone else paid for the trip. This suggests that future research to confirm and extend the findings of the current study should take into account whether travelers are paying for their trip themselves in estimating WTP for travel time savings so that the estimates of WTP values can take account of any changes in the proportions of travelers paying for their trip themselves, since these are likely to vary by trip purpose and destination.

Survey Ground Access Coefficient Comparison with Prior Airport Ground Access Models

The estimates of WTP for ground access time savings obtained from the analysis of the SP survey results is critically important to the estimated WTP for time savings in each of the other time components between arriving and the airport and boarding the flight, since those values are estimated as a ratio of the WTP for ground access time savings. Because there is typically no cost charged for the other airport time components, the stated preference experiments only gave times for those components. Therefore, the disutility of time spent in each component was estimated relative to the disutility of time spent in ground access, where a cost is typically incurred, and the implied WTP for time savings in each component depends on the WTP for ground access time savings.

Since the cost and time differences for the ground access component in the SP experiments resulted in many cases from differences in the ground access mode assumed for each option in the experiments, in order to estimate the WTP for ground access time savings, it was necessary to control for differences in the perceived utility of the different ground access modes arising from attributes other than travel time and cost. This was done by estimating a constant term for each mode, expressed in equivalent minutes of travel time. Hence the estimated values of these terms influenced the estimated WTP for ground access time savings.

In order to determine how consistent the estimated WTP for ground access time savings and the modal constants obtained from the SP survey experiments are with the corresponding values given by airport ground access model choice models developed in prior studies, an analysis was undertaken to compare the values estimated from the SP survey experiments with the corresponding values given by a sample of five prior airport ground access mode choice models.

Since these models were estimated on data collected at different points in time, adjustments were made so that the resulting estimates of WTP were expressed in consistent dollars to the values estimated from the SP survey data, allowing for both inflation and changes in real household income over time using the national consumer price index published by the Bureau of Labor Statistics.

In comparing the WTP values given by the SP survey experiments with those given by the prior studies, it should be borne in mind that the five metropolitan regions covered by the prior studies had an average income in 2012 (weighted by population) that was 12% higher than the U.S. overall, and account for only 10% of the national population (U.S. Bureau of Economic Analysis, Table CA30). The higher average income of residents of the five metropolitan regions compared to the country as a whole may partly account for differences between WTP values estimated on data from those regions and from the SP survey which included respondents from a broader range of communities that may better reflect the nation as a whole.

The results of this comparison are summarized as follows:

1) The range of WTP values implied by the models estimated in the five prior studies is very large. The values implied by the coefficients, estimated using the SP data in the current study without taking respondent income into account, correspond to the lowest values in the range established by the five studies.
2) The WTP values for low- and high-income survey respondents from the three prior studies that considered respondent income span a narrower range, since they exclude the two studies that had the lowest and highest values (and did not consider the income of the respondents), although this is still quite wide. The definition of low-income households in the prior studies covers the lowest of the three income ranges used in the SP model, while the definition of high-income households in prior studies covers the two higher-income ranges in the SP model. The WTP values from the SP models for the three individual income ranges lie below the lower end of the range of WTP values given by the three prior studies for the corresponding household income range.
3) Although the difference varies by mode, it appears that the modal constants given by the SP model show a greater disutility relative to drop-off trips for all three modes compared to the values found in prior studies, although the difference is much greater for taxi than for the other two modes (drive and park, and transit).

It is unclear to what extent these differences may have arisen from the ground access travel time and cost values used in the choice experiments, and if any distortions in the choice process that this may have generated could have affected the implied WTP for ground access time savings. It is also not clear to what extent these differences are due to the different methodologies of the prior studies, or how much the higher-income levels in the five regions covered by the prior studies compared to the national income distribution may have influenced the implied WTP values given by the prior studies relative to those obtained from the SP survey experiments. Lastly, it must be recognized that air passenger surveys and mode choice modeling primarily concerned with airport ground access can address a wider range of factors, including ground access modes not considered in the SP survey experiments, than a survey that spans the range of travel time components associated with an air travel trip. This last point is a primary reason why the Research Team recommends that considerations for future research building on the current project include a larger survey effort, with segments of the surveys concentrated on different aspects of the air trip, including ground access (see Chapter 4 of this report).

Survey Ground Access WTP Values Comparison with Current U.S. DOT Guidance

In addition to other surveys, the WTP values for airport ground access obtained from the SP survey experiments can be compared to the recent guidance on the value of travel time savings for use in economic analysis issued by the U.S. DOT, which includes both air and surface modes (U.S.DOT, 2014). The U.S. DOT recommended values for surface modes are broadly consistent with the WTP values for airport ground access estimated from the SP survey choice experiments conducted for this research project. Table 26 compares the SP ground access WTP values to the value of travel time savings (VTTS) from the U.S. DOT guidance for local and intercity surface trips. In this comparison, we assume that while "local travel" reflects the typical distances and modes of ground access trips made by air travelers to airports, the "intercity" values may be closer to the perceived VTTS for these trips, which, after all, form part of an intercity journey**.**

Table 26. Comparison of Ground Access WTP Values from SP Survey Experiments to U.S. DOT Surface Transportation Value of Time Guidance

Trip Purpose	SP Survey (2013 $/hour)	U.S. DOT Local (2012 $/hour)	U.S. DOT Intercity (2012 $/hour)
Business	$18.60	$24.10	$24.10
Leisure	$16.95	$12.30	$17.20

Note: The SP survey uses the term leisure travel, while the U.S. DOT guidance uses the term personal travel. It is assumed that these are equivalent.

The values in the U.S. DOT guidance for business travel are higher than those estimated in the current study, while those for personal local travel are lower than the WTP values estimated from the SP survey for leisure trips and the values for intercity personal travel are similar. Adjusting the U.S. DOT values to 2013 dollars using the approach specified in the U.S. DOT guidance will increase the 2012 values slightly. Comparing 2013 values for personal or leisure travel, the value for local surface travel would remain below the WTP estimates for airport ground access trips from the SP survey experiments, while the value of intercity surface travel would be about 3% above the WTP values from the SP survey.

The following points should be noted in the above comparison:

- The U.S. DOT values for local travel by surface modes covers all local travel, including commuting, shopping, recreation, etc., by all travelers. To the extent that air travelers have a higher average income than travelers in general, it could be expected that the VTTS for airport ground access trips would be higher than for local travel in general.

- The values for business travel in the U.S. DOT guidance are based on a percentage of the hourly median gross compensation, including fringe benefits, rather than any behavioral response of travelers making a business trip (as in the current study). While it may be argued that this is the value to the employer of any travel time savings, as the U.S. DOT guidance suggests, this is a different thing from the perceived VTTS to the traveler, as measured in the current study.

Therefore, while it is useful to compare the values in the U.S. DOT guidance to those estimated in the current study to see how consistent they are, it is important to bear in mind the differences in methodology used in the deriving the two different sets of values. In particular, the U.S. DOT guidance does not explicitly provide different values for travelers with different income levels, as was done in the current study, although the difference between the VTTS values for intercity travel by surface modes and those by air travel in the U.S. DOT guidance is largely justified on the grounds that air travelers have a higher median household income than households in general.

3.7 Summary and Conclusions

The stated preference survey gathered information from 1,171 air travelers who recently made an air trip within the U.S. The questionnaire collected data on current air travel behaviors and engaged the travelers in a series of conjoint choice experiments.

Multinomial logit (MNL) choice models were developed using the survey data to produce estimates of value of time (VOT) of air travelers for two market segments: business and leisure travelers. The magnitude and signs of the sensitivity estimates appear reasonable and intuitively correct.

The model coefficients were used to estimate values for the willingness to pay for travel time savings, or values of time, for different components of an air trip, including:

- Ground access time
- Terminal access time
- Check-in and security time
- Time to reach the gate area
- Gate time

The values of willingness to pay (WTP) for ground access time savings estimated from the results of the survey can be compared to the WTP values found in the literature on prior studies that estimated the value of airport ground access time using stated preference (SP) or revealed preference (RP) methods. The values of time for airport ground access estimated here, at about $19 per hour for business travelers and $17 per hour for leisure travelers, are at the lower end of the range of studies that use SP methods, and less than most studies that use RP methods. However, they are comparable to WTP values found in several prior airport access studies conducted by Resource Systems Group, Inc. (RSG), including a recent airport ground access mode choice study conducted in the greater New York region, which found ground access WTP values of approximately $17 per hour by those making automobile trips (RSG, 2009, RSG 2007 and Wilbur Smith Associates 2008).

The WTP values for the time to reach the airport terminal from the location where parked, dropped off, or alighting from public transportation are somewhat higher than those for the access trip itself, at $34 per hour for business travelers and $26 per hour for leisure travelers. This result could be partly due to non-linearity in traveler sensitivities to time savings. Airport ground access journeys are, on average, much longer than the terminal access component of the trip, and the per-minute sensitivity to time savings may, therefore, be lower.

The WTP values for the time to reach and pass security are higher still at $37 per hour and $28 per hour for business and leisure travelers, respectively. This makes sense intuitively, as the portion of the trip between arriving at the airport terminal and clearing security may be more stressful due to uncertainty in the wait times to check-in and clear security, as well as unfamiliarity with the physical layout of the terminals. This time is also not likely to be "productive" time, with travelers generally having little or no ability to work, relax, or even make phone calls while walking through the terminal, checking in, or navigating the security line.

The WTP values for the time to reach the gate from security ($32 per hour and $23 per hour for business and leisure travelers, respectively) and time spent in the gate area ($20 per hour and $18 per hour for business and leisure travelers, respectively) are somewhat lower than those for the other two airport time components discussed above. This can be attributed to the fact that travelers can spend this time patronizing airport services (such as shopping, eating, etc.), and can be more productive by using mobile communications technology. This is also the time component that travelers have some control over by changing their departure time to the airport from their starting locations. It should be noted that these WTP values are still higher than the ground access WTP (although marginally so, in the case of gate time). This is somewhat unexpected because the ground access trip generally does not provide the same opportunity for the activities that can be accomplished at the gate and can be associated with a high level of anxiety over unexpected delays in reaching the airport. However, as noted above for the time to reach the airport terminal from the location where parked, dropped off, or alighting from transit, these differences could possibly be explained by non-linearity in traveler sensitivity to time differences, with a lower per-minute sensitivity for the longer times typically experienced in ground access travel. This aspect could benefit from further investigation in future research.

The value for flight time (which includes in-aircraft time and time spent making any flight connections) is estimated to be the highest among all the time components ($51 per hour for business travelers and $35 per hour for leisure travelers). While these values are broadly consistent with the most recent guidance from the U.S. Department of Transportation on the values of travel time to be used in economic analysis (U.S. DOT, 2014), the higher values for flight time relative to the time spent in the airport terminal are somewhat unexpected. However, it should be noted that the values for flight time are based on trade-offs between flight time and airfare, while the values for the airport access and terminal time components are based on trade-offs between these times and airport access cost. The extent to which these differences in the WTP values are due to the different cost basis could benefit from further investigation in future research.

Overall, while the magnitudes of the WTP values seem broadly consistent with values found in other studies, some of the relationships between the different values were unexpected. These include the differences noted above between the values for flight time and those for airport ground access time, as well as between the values for ground access time and gate time. Because there are no existing studies that have estimated values of time for all of the on-ground time components identified here, there are no opportunities for a direct comparison of the relationships between the values of airport ground access time and those of other in-airport time components with those found in prior studies. Therefore, these relationships appeared to deserve more study in the additional analysis undertaken during the remainder of the project described below and in Section 3.6, including an examination of non-linear effects in travelers' time and cost sensitivities.

Additional Research Undertaken

The comparison of the distribution of airport-pair markets flown by the stated preference (SP) survey respondents in their reported recent trips with the distribution of domestic air passenger travel given by the U.S. DOT 10% Origin & Destination Survey (DB1B data) indicates that the reported trips in the SP survey data provide a representative sample of domestic air passenger travel. However, the composition of those trips in terms of trip purpose may understate the amount of business travel and overstate the proportion of personal trips, although the proportion of business trips in the total reported air trips made by SP survey respondents over the previous year is much closer to the proportion observed for domestic air travelers in an air passenger survey performed in 2011 at Los Angeles International Airport (LAX). To the extent that separate estimates of willingness to pay (WTP) for travel time savings have been made for business and leisure travel, any under-representation of business travel in the recent trips by SP survey respondents does not appear likely to have introduced a significant bias in the resulting WTP values.

Compared to air travelers in domestic markets from LAX, the SP survey respondents are older, particularly the male respondents, and tend to have higher household incomes. To the extent that separate WTP values have been estimated for survey respondents in respondents' different income ranges, any over-sampling of air travelers with household incomes above $50,000 per year in 2012 (assuming that survey respondents reported their income in the prior year to the survey) may not have significantly affected the resulting WTP values. However, although the extent of any bias is somewhat unclear due to differences in the way that income was measured and respondents grouped by income. In contrast to most air passenger surveys, which ask respondents to indicate their household income, the WTP values estimated from the SP survey data, and included in the Guidebook, were based on individual income, although the SP survey respondents also reported their household income.

Further analysis of the SP survey results and additional model estimation found that the effect of the age of the survey respondent did not have a significant effect on the estimated WTP values, after controlling for other factors. However, multi-person travel parties were found to have a lower per-person WTP for travel time savings compared to those traveling alone, as if the full cost of the air party trip was being paid by the survey respondent. It is unclear whether this truly reflects how air travelers regard the cost of travel or is due to of the way the SP choice experiments were presented to the survey respondents, and, therefore, represents an aspect that is deserving of future research to better understand (see Chapter 4).

The additional analysis was not able to quantify any non-linearity in the SP survey respondents' sensitivities to differences in flight time or airport ground access time, or WTP for reductions in flight delay. However, the additional analysis was able to develop a continuous relationship between WTP and individual or per-person household income to supplement the WTP values estimated for the three individual income groups in the analysis results included in the Guidebook. These aspects appear worthy of future research to confirm or modify the WTP values recommended in the Guidebook, as well as facilitating the process of updating WTP values to reflect changes in real household (or individual) incomes.

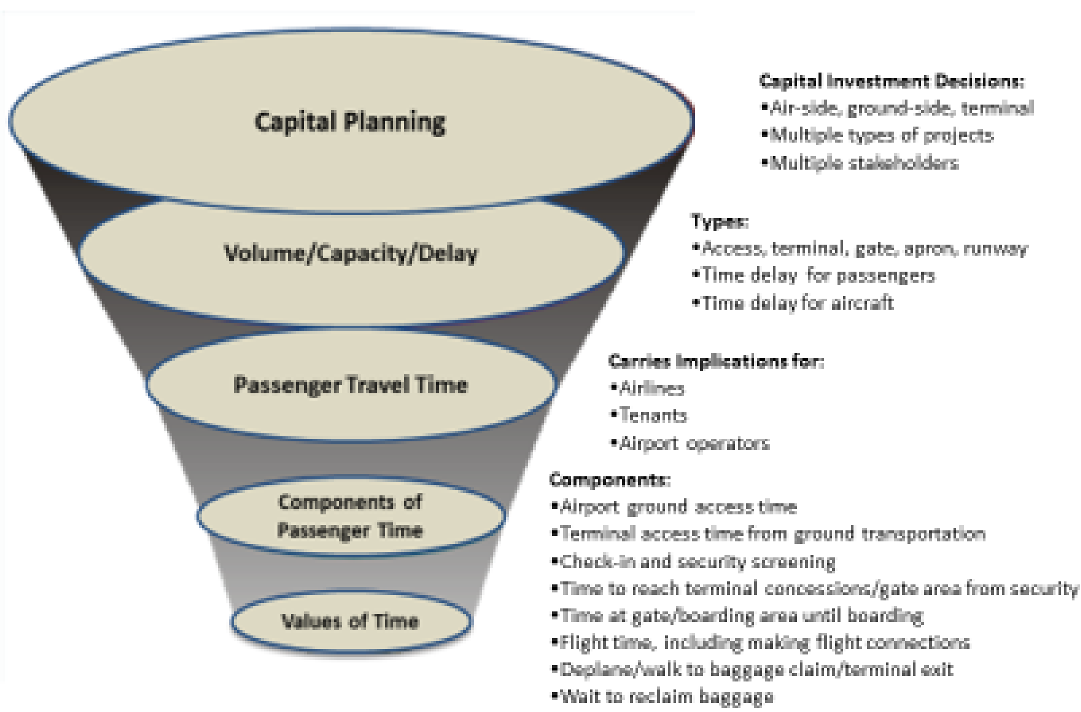
Finally, a comparison of the estimated model coefficients for the ground access trip component from the SP survey data with the corresponding coefficients from airport ground access mode choice models developed in prior studies for five metropolitan regions suggests that the SP survey model may have yielded a low estimate of the value of ground access time. However, the differences may partly reflect the higher average incomes in the five regions compared to the national average, which make it probable that the value of ground access time of airport travelers would be higher among the five regions than the nation as a whole. While the values of time given by the models developed from the SP survey are comparable to recent U.S. DOT guidance and previous studies conducted by RSG, they are at the low end of the range given by the airport ground access mode choice models developed in prior studies for the five regions, suggesting that this is a subject that should be revisited in future research.

4 FUTURE RESEARCH DIRECTIONS

ACRP 03-19 is designed to span both broad and narrow topics relating to airport capital investment. In the broad sense, it is intended to improve the application of benefit-cost analysis for airport investment decision-making through research into the value of air passenger travel time savings and preparation of a guidebook on integrating the value of air passenger travel time into benefit-cost analysis. In the narrow sense, it is a first step in a longer research process focusing on improving "value of time" measures which are used to help monetize benefits of capacity improvements. In practice, some (but not all) airport capital investments are made specifically to increase capacity and reduce delays occurring at some point in the course of making an air trip, in the air or on the ground, that reduces the time that air passengers need to spend getting to and through the airport. The given value of air passenger time delay is actually a mean ascribed value—the value of air passenger time is an array of a broader set of delay-related costs, and even those delay costs differ depending on when, where and how they occur. However, by improving the techniques for the valuation of passenger time delay, this research enables a much broader set of improvements to be made in the entire practice of capital planning assessment, which is to be addressed by the guidebook.

The logical relationship between the broad topic of airport capital investment planning and the narrower subject of the value of air passenger travel time is illustrated in Figure 24.

Figure 24. Relationship of Passenger Time Value to Broader Capital Planning Assessment



4.1 Research Conducted

Research for the current project initially drew on literature and case studies to review tools and analytical techniques used by airport managers and airport sponsors to evaluate: (1) how capital investment decisions are made; and (2) how the value of passenger time has been incorporated into these decisions. These parts of the research were followed by a summary of the most prominent current theories explaining how value of time and value of reliability are determined. Then the Research Team considered attributes of air travel that are relevant in light of these concepts, and decomposed air trips into distinct travel time components. The components include the process of getting to and from the airport, the different steps in getting through the airport, and elements of the flight itself. This approach was motivated by the recognition that air traveler willingness to pay (WTP) for time savings may differ for the time savings in each of these components, as well as by other attributes of the air trip, such as the trip purpose. Finally the Research Team developed and implemented a web-based stated preference survey that gathered information from air travelers who had recently made a domestic air trip within the U.S. and were able to recall the details of their trip.

Using these products, the Research Team has:

1) Collected data on the sample of recent air trips by survey respondents and used stated preference experiments to collect data that were used to estimate survey respondents' WTP for travel time savings in various travel time components under a range of different hypothetical conditions; and
2) Built a discrete choice model to explain the choices made by the survey respondents in the stated preference experiments and applied the estimated model coefficients to estimate the values of the willingness to pay for time savings in the various travel time components that are part of an air trip. These include airport ground access time, time to reach the terminal, time to reach and pass through security screening, time to reach the gate area from security screening, time spent waiting at the gate or in the gate area until boarding, in-flight time, and expected flight delay.

As research was conducted and reviewed for the project, it became obvious to the Research Team that practical considerations of scope and budget would limit the aspects that could be addressed in the current project and that a number of issues identified in the research would require more intensive data collection and modeling than was possible under this project. Future research to explore lines of inquiry, in addition to those addressed in the current project, would increase the understanding of how the values assigned by air passengers to savings of travel time and reduced delay vary across the different components of the trip. These time savings and delay reductions would also vary with the characteristics of the traveler and circumstances of the trip and would add depth to tools for capital investment decision making at airports. Just as the resources of this project were maximized by leveraging previous research, research following this project should be expected to leverage data collection techniques and findings from this project and subsequent or ongoing research.

4.2 Recommendations for Future Research

Refine and extend the findings of this project

The following research activities will add depth to the “willingness-to-pay” analysis that was reported in Chapter 3:

1) Increase the number of respondents to follow-on stated preference surveys to allow more in-depth analysis;
2) Maintain timeliness of estimated values of travel time savings by performing future stated preference surveys; and
3) Design any future stated preference surveys to achieve a balance between the stated preference survey’s length (not to overburden respondents) and comprehensiveness.

A stated preference survey with a significantly larger sample size will need to be performed and analyzed in order to enable future research to explore how WTP values vary across subsets of the air traveler population, such as different income strata, household composition, age, and gender, as well as for different trip purposes. In particular, a larger sample of air travelers on business trips is needed to improve the statistical significance of the WTP values for business travel. Furthermore, it would be helpful to collect data on the position of the respondents in their firm or organization, as well as the type of firm or organization they work for and more details on the purpose of the business trip being made, in order to provide more resolution on different types of business travel.

The stated preference survey and analysis of results needs to be repeated periodically (e.g., every five years) in order to track the changes in WTP over time. This is particularly important to account for changes in technology available to travelers and airport security processes adopted due to new laws or regulations. For example, cell phones, smart phones and the almost universal access to Wi-Fi in airports affect how air travelers are able to spend their time in airport terminals while waiting for flights. Similarly, the availability and use of Wi-Fi during flight may affect the value of time while in the air. While changing technology may in turn affect the values of travel time and reliability, this would only become apparent over time and would be dependent on the nature of the technological changes.

The widespread use of personal electronic devices facilitates and enhances professional and personal productivity while onboard flights, and thus these changes in onboard connectivity may reduce the perceived disutility of flight time and delays. Therefore, it could be expected that the value of time saved in flight would be reduced over time in real terms relative to incomes.

This project had to balance the conflicting requirements of the need for an in-depth survey, but also one that was not unduly complex, or had an overly burdensome length that would discourage responses. To accomplish this, trade-offs were made that limited the number of questions in order to shorten the survey length. While necessary, these trade-offs limited the issues that the survey was able to address.

For example, the survey did not address airport egress (moving through the airport to baggage claim or terminal exit, waiting at baggage claim, waiting for ground transportation, getting to car rental or parking, and the ground trip to the final destination). Values in the guidebook for egress are based on the corresponding aspects of airport access and terminal circulation.

Also, the choice experiments did not distinguish between time spent checking in or checking any bags and time spent walking from the terminal entrance to security screening. While the Research Team had initially intended to separate the two aspects, these were consolidated to reduce the complexity of the choice experiments. Since many travelers check-in online before arriving at the airport and do not check bags, it would have been necessary to tailor the choice experiments to the circumstances of each respondent in order to generate appropriate times in the choice experiments. Questions to this effect would have added one more step to those who checked in or checked bags.

More importantly, the survey presented respondents with separate stated preference choice experiments for the decisions involving flight attributes and the decisions involving airport ground access and airport terminal attributes. Initially, it had been intended to develop choice experiments that varied both the flight attributes and ground access and airport terminal attributes in the same choice alternatives presented to the respondents, but it became clear that this presented respondents with too much information at once. In addition, it had initially been intended to include different airports in the choice experiments, but this would not only add a further level of complexity to the choice process, but would present difficulties generating appropriate values for the airports other than the one actually used by the respondent for their reported recent trip (for which they had provided details of the times and costs involved).

These decisions to reduce the survey length in the interest of the time it would take to complete the survey imposed three significant constraints on the choice experiments that deserve closer examination in future research. The first is that the values of time for ground access and terminal components of the trip are based on differences in ground access costs, while the values of time for the flight components of the trip are based on differences in airfare. In principle, the resulting WTP values should be consistent, although, of course, travelers may have a different willingness to pay for savings in ground access time from savings in flight time, as was found in the analysis. However, unlike the flight choice experiments, where differences in airfare are largely independent of the differences in flight time, convenience of the schedule, and number and duration of connections, differences in ground access costs are primarily due to differences in modal characteristics. Therefore, it is possible that the WTP values for ground access time savings are partly reflecting modal preferences rather than the true WTP for time savings for a given mode.

In an attempt to address this concern, some of the choice experiments presented different times and costs for the same ground access mode, although this presented the respondents with a counter-intuitive situation in which one alternative had a different ground access time and/or cost from the other alternative, when both alternatives used the same ground access mode (which, of course, in the real world would have the same travel time and cost in each alternative). While situations can arise in the real world in which there are differences in travel time and cost for the same mode (e.g., parking in a lower cost but more distant parking lot), in practice those choices are independent of any differences in the time spent in the airport terminal and travelers can make those trade-offs irrespective of the situation faced in the airport terminal. The extent to which this very artificial choice scenario influenced the choices made, and hence the implied WTP value, is unclear and deserving of further research.

The second constraint is that by eliminating airport choice from the experiments, the differences in the airport terminal time components between the two alternatives in each choice experiment were presenting respondents with two different situations at the same airport. Of course, in the real world, while there are differences in the time required to complete some steps in getting through the terminal (e.g., security screening) at the same airport, these are due to differences in congestion, which is not something that a traveler can choose between for a given flight.[25]

The survey respondents were instructed to take the times shown for each alternative in the choice experiments at face value. However, whether they in fact did so is unknown and how this may have influenced the relative weight they gave to time savings in the different components of their trip to and through the airport is also unclear and deserving of further research.

The third constraint is that separating the flight choice experiments from the airport ground access and terminal time choice experiments implicitly assumed that the different flight options presented to respondents were independent of any differences in ground access time or terminal time. However, in reality, differences in flight departure time can influence ground access times by different access modes. Where different airlines with similar flights available use different terminals, there may be differences in the time that travelers expect to spend in the airport terminal, as noted above. The extent to which air travelers consider airport ground access factors and the anticipated time required in the airport terminal in choosing between flights is unclear and deserving of future research.

In all, the survey had 1,260 respondents. A potential future project may take advantage of and build on the research reported in Chapter 2 and in Appendix A, including components

[25] Although by choosing between airlines, an experienced traveler can avoid a particularly congested terminal if another airline using a different terminal offers flights to the same destination at approximately the same time.

of an air trip, the literature review, and analysis of tools and techniques. The future project could consist of a much larger sample size, perhaps one with 5,000 or more responses, but divided into (perhaps) four surveys of 1,200 to 1,500 responses, that go into greater depth among fewer topics. One survey, for example, could concentrate on ground access and egress, while a second could address on-airport circulation issues. A third survey could cover the time spent between clearing security screening and boarding the aircraft, while a fourth could concentrate on flight times and delays. The surveys could then be joined for analysis, giving more depth to the topics addressed in the survey undertaken in this research.

Further Considerations that May Affect Value of Time but Go Beyond the Scope of this Research

Assessing the effect of airline strategies and business plans on the reliability of air travel goes beyond the scope of the current study. Airline interests lie in maintaining and increasing their market shares in a competitive market while offering air transport services at a high enough price to make a profit. This results in scheduling strategies at hubs and across airlines' route networks that contribute to the reliability of air travel. Flight time reliability affects airline costs, so airlines do have an interest in improved reliability aside from the benefit to their passengers. It is not clear whether airlines can translate improved reliability into higher fares, but this may be a suitable topic for future research.

The different airport time components have a relationship to a traveler's overall trip experience. This is an important consideration that could be featured in expanded research into how air travelers value the total air travel experience, including the travel time required in each component of the trip. Given the difference in values of time for the various trip components, it is not clear how the calculation of the total value of the end-to-end trip would proceed. However, as the focus of the current project is on passenger value of time considerations in airport capital investment decisions, the critical question is how a given capital investment affects the time spent in each component of the trip through the airport. Thus, the key issue is how to value the total travel experience at the airport, and whether aspects other than the time involved need to be considered. While this is a valid question, there is clearly more to how travelers value their travel experience than simply the time they spend traveling. In fact, one might expect that the more attractive the experience is, the more time the travelers would choose to spend at the airport. So, in this case, the value of time (using the conventional metrics) would be lower. While we may be able to make some inferences about this from the differences in the value of time of the different time components, the design of the stated preference experiments did not address non-time aspects of the airport experience and many of these issues are beyond the scope of the current project.

Research is also needed for improving an understanding about the extent to which travelers consider airport ground access and the time required to get through the airport terminal in making flight choices for a given trip, particularly when choosing between flights at the same airport. Presumably, these factors assume greater importance when choosing between flights at different airports. While it is clear that air travelers choose between flights based on cost differences, departure and arrival time considerations, and such factors as the airline, and the number and location of any flight connections, it is much less clear how the time spent in the airport terminal is perceived, and whether congestion or other in-terminal considerations are factors affecting the choice of flights. A related question is the amount of time that travelers allow for unanticipated delays getting to and from the airport or through check-in and security screening. Allowing more time to get to and through the airport reduces the likelihood of missing a flight, but results in spending more time waiting at the gate or in airport concessions if the delays are less than allowed for. A better understanding of these issues is needed to develop appropriate measures of the overall value of reducing end-to-end travel time for a given trip.

Assessing the wider social benefits of airport capital investments, such as benefits from investments that reduce emissions, is beyond the scope of the current study. These benefits are commonly referred to by economists as “externalities,” since they typically do not contribute directly to the costs or revenues of airports or their users. Such benefits are recognized throughout the benefit-cost literature as an important topic that should be considered in performing benefit-cost analysis. In future research, the value of social benefits can be integrated with the values of time and direct costs savings in a handbook for evaluation of airport capital investment decisions.

5 CONCLUSIONS

Recent changes in airport configurations and operational policies, and technology available to passengers have changed the way travelers value the time involved in air travel. These changes include security measures put in place since September 11, 2001, the proliferation of airside passenger amenities, and the widespread adoption of such technologies as wireless internet access, mobile phones, tablets and laptop computers. Moreover, these changes are continuing to evolve.

These changes mean that what was once “wasted time” can now be used as productive time, and that entertainment, dining and shopping can replace what was a monotonous wait time. On the other hand, security procedures have introduced new sources of uncertainty in the time required to get through the airport terminal to the gates. Therefore, it is sensible to approach the analysis of the value of time of air passengers by considering the values assigned to the time spent in different segments of a single airport trip, including ground access, terminal access, flight check-in and movement through security, time to reach the gate from security, time at the gate (or in the terminal in proximity to the gate), flight time and flight delay.

Travel time is often a significant consideration in benefit-cost analysis (BCA) for transportation projects and policies. Current guidance from the Federal Aviation Administration and other U.S. Department of Transportation agencies identify single values of time for business travelers and personal travelers, and a hybrid value of time for use when trip purposes of travelers are not known. The research presented in this report analyzed the value of travel time from the perspective that the various segments of an air trip each have a unique value of time that differs between business and personal travelers. For example, this research finds that passengers are willing to pay more for a reduction in the time spent in security lines than in waiting at the gate for a flight. Simply put, the value of time to air passengers is higher in a security line than at a departure gate.

It stands to reason that a proposed capital investment that will affect one or several trip segments will have a different value of travel time to passengers than an investment that will affect a different trip segment or set of segments. This insight, that one value of time should not be uniformly applied across a variety of capital investments, represents a major advance in how benefit-cost analyses can be approached and capital investment decisions can be considered.

The economic values that emerge from this research are the basis of the guidebook prepared by the Research Team for airport managers and sponsors, and their consultants, on how to: (1) apply these values to different types of capital investments; and (2) merge the results into benefit-cost analyses. As noted in the Introduction (Chapter 1), the guidebook can be downloaded at www.trb.org/Main/Blurbs/172472.aspx.

5.1 Follow-on Research

Although this project has resulted in a significant advance in how to approach BCA for airport capital projects, follow-on research is needed to improve the segmentation of air passengers' value of time. Such additional research can build off the insights and modeling developed in this project. Moreover, follow-on projects will also have access to the literature review, analysis of tools and techniques, case studies and the analysis of research gaps that are provided in the appendices to this report. They are available at www.trb.org/Main/Blurbs/172474.aspx.

As noted above in Chapter 4, perhaps the most important new task is to undertake additional stated preference surveys with greatly increased sample sizes. A significant limitation of the survey undertaken in this project was that budget considerations restricted the sample size to about 1,200 respondents. As a consequence, the number of survey questions and the complexity of the stated preference experiments needed to be limited in order to keep the required time to complete the survey manageable for respondents. A survey with a significantly larger sample size (say 5,000 – 6,000 respondents) would allow for tailored stated preference experiments around different aspects of the trip (for example, access, security, intra-airport circulation, gate, and flight times), which could then be combined together for analysis. Such topically-divided survey instruments would not be overwhelming to a respondent, and the richness of the derived data would be greatly expanded over a single survey that addresses all trip segments at the same level of detail.

Expanding the Concept of Measuring Value of Time by Trip Segment to Other Modes

Although this research is limited to air passengers, the segmentation of willingness to pay by different trip segments could also be applicable to other modes. Passenger rail, intercity bus and water transport have similar characteristics to air travel, in that their stations and terminals involve access and egress travel, wait times, and scheduled departures and arrivals, while the time spent in travel on each mode is influenced by the vehicle speed, the number of any transfers required, and the potential for delays. In fact, wait times are currently incorporated in value of time assessments for transit when proposed improvements are considered that will affect transfers between routes or lines. Highway travel is different due to the preponderance of individual car ownership and the decentralization of travel, as well as the ability to make an origin to destination trip in the same vehicle at any desired time and, therefore, the usefulness of trip segmentation may be limited, although it may be worth considering whether the value of travel time differs by the type of road or highway being used.

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