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ALTERNATIVE METHODS OF ELICITING INDIVIDUAL WILLINGNESS TO PAY
FOR TRAVEL TIME SAVINGS: A PILOT STUDY

by

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B.S. University of Central Florida, 2006

A thesis submitted in partial fulfillment of the requirements
for the degree of Masters of Science
in the Department of Economics
in the College of Business Administration
at the University of Central Florida
Orlando, Florida

Spring Term
2008

ABSTRACT

How does one estimate the value of an individual's time? One possible way is to estimate how much a person is willing to pay for time savings. The majority of transportation studies have used stated preference surveys to estimate an individual's willingness to pay (WTP) for travel time savings. However, stated preferences approaches are subject to hypothetical bias since they elicit WTP for hypothetical outcomes instead of real outcomes. One study used a revealed preference approach in a natural experiment to elicit WTP for travel time savings but the data was for a non-recurring event, which was not replicable. The purpose of this pilot study is to explore new methods, using procedures from a replicable field experiment, to elicit individual WTP for travel time savings. By using a revealed preference approach in an experimental setting, we address the legitimate concern over hypothetical bias while allowing the experimental methods and resulting data set to be replicated in other settings. The results show that the proposed field experiment is feasible, and that a sample of college students places a value of \$22.43 on an hour of time. This estimated value is significantly greater than zero. We also find that individual WTP for travel time savings is significantly larger than the average wage rate, and that this WTP varies significantly across certain demographics. We conclude by reviewing the simplifying assumptions made within the study and offer extensions of how our data set can be replicated in the future for more complete analysis.

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INTRODUCTION

How does one estimate the value of an individual's time? One possible way is to estimate how much a person is willing to pay for time savings. The majority of transportation studies have used stated preference surveys to measure individual willingness to pay (WTP) for travel time savings. However, stated preference approaches are subject to hypothetical bias since they elicit WTP for hypothetical outcomes instead of real outcomes (Cummings, Harrison and Rutström, 1995). Hypothetical bias occurs when an experimenter makes statistical inferences based on subject's responses to hypothetical survey questions, such as "*Would* you be willing to pay...", instead of using observations from subject's actual purchasing decisions in real scenarios. For this reason, using a revealed preference approach to observe individual choices over real outcomes may offer more precise estimates of WTP for travel time savings.

The objective of our study is to create a replicable data set using observations from a "framed field experiment"¹ in order to estimate the WTP of motorists for travel time savings. The purpose is to explore a variety of new methods for eliciting the WTP for travel time savings. The reason for choosing a framed field experiment is that "controlled experiments... represent the most convincing method of creating the counterfactual, since they directly construct a control group via randomization" (Harrison and List 2004; p.1014). By using a revealed preference approach in an experimental setting, we address the legitimate concern over hypothetical bias while allowing the experimental methods and resulting data set to be replicated in other settings.

¹ According to Harrison and List (2004), an *artefactual field experiment* is one that employs a non-standard subject pool, an abstract framing, and an imposed set of rules; a *framed field experiment* is the same as an artefactual field experiment, but with a field context in either the commodity, task, or information set that the subjects use; and a *natural field experiment* is the same as a framed field experiment but where the environment is one where the subjects naturally undertake these tasks and where they do not know that they are in an experiment.

Our study consists of 31 subjects recruited from the student population of the College of Business Administration at the University of Central Florida in 2007 and 2008. During individual sessions we inform the subjects that we are interested in toll road usage in the Central Florida area, and ask them to allow us to collect data from their E-pass or Sunpass accounts in exchange for a randomly determined ad valorem subsidy plus a \$10 participation fee. By subsidizing toll expenditures, we are essentially lowering the per-unit cost of consuming a time-saving product (tolls). Our data set will consist of three months of subjects' historical toll road usage and one month of toll road usage when subjects' tolls are subsidized. We also collect information on individual characteristics, including risk attitudes and discount rates, and consider these characteristics in our analysis.

Collecting data on subjects' toll consumption before and after a randomly determined subsidy allows us to estimate the demand or WTP for tolls. Once the aggregate demand curve is estimated, we can extrapolate the demand curve above the unsubsidized price to estimate the consumer surplus gained from subjects' consumption of tolls. This estimate tells us the WTP for tolls, which we will use to find the WTP for travel time savings by developing an empirical function that relates amount of tolls consumed to actual travel time saved. Once we know the amount of time saved by traveling on toll roads for a given origin and destination, and the cost associated with traveling these time-saving routes, we can estimate WTP for travel time savings.²

Our primary hypothesis is that individual WTP for travel time savings is positive. In other words, motorists are willing to pay money to save time. The majority of prior

² The expressions, "value of time," "value of travel time" and "value of (travel) time savings" are synonymous throughout.

transportation studies have found that WTP for travel time savings is positive, although exact estimates have differed in magnitude across each of the studies.³ Thus, our primary hypothesis will test if the same result holds using a revealed preference approach over a replicable data set.

Our second hypothesis is that WTP for time savings is larger than the wage rate for the individual. One qualification in our tests of this hypothesis is that our subject pool consists entirely of students, so their “wage” may not be representative of their likely wage with full-time, permanent employment. We test this hypothesis in order to provide a validity check to our estimates of the value of time. This hypothesis provides a validity check because the maintained assumption in the labor economics literature is that the value of time is equal to the wage rate, at least at the margin. Thus, the hourly wage rate provides a benchmark for inferring the value of time that comes from some existing theory. It is easy to see, and is explained later, that one would normally expect the value of the time to be greater than or equal to the wage rate, at least under the usual assumptions of that labor economics literature.

Our third hypothesis is that WTP for time savings varies across demographics. For example, we would like to see the extent to which individual characteristics such as gender, age, race, etc. are significantly related to individual WTP for travel time savings. The findings of Deacon and Sonstelie (1985) suggest that certain demographics, such as gender, have some correlation with individual values of travel time savings. As our experiment collects similar demographics, we are able to test this hypothesis. Their findings encourage us to test our second hypothesis to see if we find similar or different correlations.

³ As discussed in Section II, Calfee et al. (2001) find very low but positive WTP, Deacon and Sonstelie (1985) find that average WTP is positive and equal to an individual’s after-tax wage rate, and Small et al. (2005) find moderately positive WTP.

Our findings show that the proposed field experiment is feasible, and that a sample of college students places a value of \$22.43 on an hour of time. This estimated value differs significantly from zero and is significantly greater than the average hourly wage rate of our subjects. Moreover, we find that the WTP for travel time savings varies across certain demographics. These findings provide sufficient reason to expand this study to a broader range of subjects in order to conduct a more complete analysis of individual willingness to pay for travel time savings. We conclude by reviewing the simplifying assumptions made within the study and offer extensions of how our data set can be replicated in the future for more complete analysis.

In Section I of the thesis we discuss our motivation for the topic of valuating travel time savings, the theoretical framework of revealed preference theory and the tradeoff between labor and leisure. Section II reviews prior studies on the topic of time valuation in the transportation literature. The experimental design is presented in Section III. Our data and empirical results are presented in Sections IV and V, respectively. In Section VI we offer conclusions and propose extensions of our analysis. Appendix A contains the documents used for recruitment, Appendix B contains the documents used during the individual session and Appendix C contains a copy of the IRB Approval Form. Appendix D contains the discount rate instructions and subject response tables and Appendix E contains the questionnaire presented to subjects. Appendix F contains the payment forms and Appendix G contains the Expressway System Map.

SECTION I MOTIVATION AND THEORY

Estimates of the value that individuals place on their time can be useful in the appraisal of transportation studies. The value of time is an essential ingredient in the cost-benefit analysis of transportation projects, where a large fraction of the benefits of the project often consist of time savings (De Borger, 2007). Time valuation is also a critical element in “value-pricing,” a form of road pricing that can directly benefit motorists through reduced congestion or improved roadways. Moreover, value of time estimates can be used in a variety of fields other than transportation. One example is in the recreational demand literature, where value of time estimates have been used in measuring the economic benefits of outdoor recreation by means of the amount of time people are willing to travel to the recreational site. However, the *ad hoc* methods used by past recreational demand studies to estimate an individual’s value of time are highly arbitrary and subjective (Cesario 1976).

In order to estimate individual WTP for travel time savings, we employ two theories of consumer behavior: Revealed Preference Theory and Labor Supply Theory. Revealed Preference Theory states that the preferences of consumers can be revealed by their purchasing habits. In the transportation context, individuals are faced with a choice between purchasing tolls to save travel time or saving money by choosing a slower toll-free route. Labor Supply Theory recognizes the opportunity cost of time spent on non-work activities in terms of foregone earnings. In the transportation context, this translates into an opportunity cost of time associated with taking the slower or more congested toll-free route. These theories provide the framework to observe an individual’s choice between time savings and money savings, and to relate that choice to an individual’s WTP for travel time savings.

1. Revealed Preference Theory

According to Samuelson's (1948) Theory of Revealed Preference, we can infer whether a given batch of goods is preferred to another batch by comparing the costs of different combinations of goods at different relative price situations. Samuelson originally stated what has since become known as the "Weak Axiom of Revealed Preference" by saying "If an individual selects batch one over batch two, he does not at the same time select two over one" (1938; p.65). We will state Samuelson's definition more formally:

Definition 1 (Weak Axiom of Revealed Preference): If bundle x^1 is revealed preferred to bundle x^2 (written $x^1 \succ x^2$), then it is not the case that bundle x^2 is revealed preferred to bundle x^1 ($x^2 \succ x^1$).

Samuelson (1948) demonstrated graphically how one could use the revealed preference relation to construct a set of indifference curves for the two-good case of utility maximization. Figure 1 represents an individual's tradeoff between the quantities of two goods, X and Y. A movement along any given indifference curve yields the same utility to the consumer as any other point on that same curve. The farther out an indifference curve is from the origin, the more utility the consumer receives from the consumption bundle of goods X and Y, since the amounts of X and Y are greater at higher indifference curves. Once indifference curves are constructed, a linear budget line can be added to find the consumption equilibrium point, A. The budget constraint in this case is that income M must equal the price of good Y times the quantity of good Y plus the price of good X times the quantity of good X: ($M = P_Y(Y) + P_X(X)$).

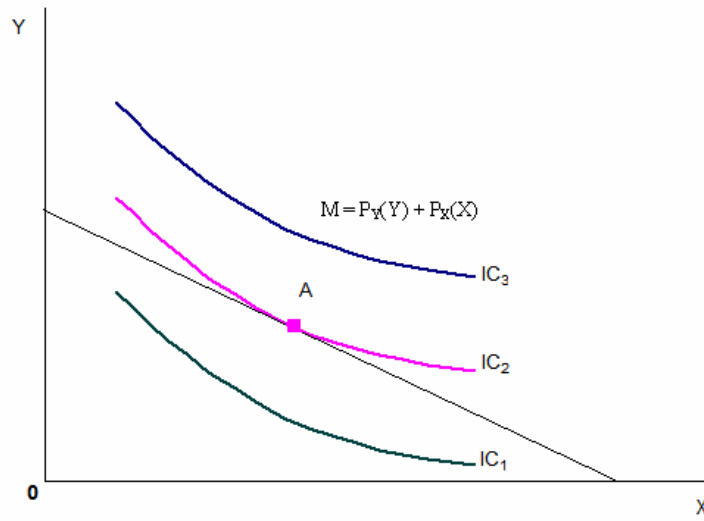


Figure 1: Two-good Utility Maximization

Any indifference curve that exists beyond the budget line is not considered feasible since the individual's budget constrains the choices of consumption bundles. All combinations of goods on or within the budget line could feasibly be bought in preference to what is actually bought, but are not. Hence they are all “revealed” to be inferior to A (Samuelson 1948; p.244). Houthakker (1950) extended Samuelson's two-good case by constructing a general proof for the multiple-good case. This resulted in what is known today as the “Strong Axiom of Revealed Preference.”

Definition 2 (Strong Axiom of Revealed Preference (SARP)): If $x^1 > x^2$, $x^2 > x^3$ and so on until $x^{n-1} > x^n$, then $x^1 > x^n$ for $n=1\dots N$, where N is the total number of bundles.

Not only does SARP provide the necessary and sufficient conditions for observed choices to be consistent with utility maximization, it also provides a tool for empirical, nonparametric analysis of consumer choices.

By observing individual decisions to use toll or non-toll roads, this study analyzes individual choices between saving time and saving money. The extent to which individuals

value their time can be thought of in terms of the tradeoff between time spent earning money and time spent spending consuming goods and services. This concept is known in economics as the labor-leisure tradeoff.

2. Theory of Labor Supply

Labor supply decisions can be viewed as the result of utility maximization, subject to constraints. In the simplest version of the labor supply model of Killingsworth (1983), an individual's utility depends on his tastes and on the amount of market goods C and hours of leisure time L that he consumes. When maximizing utility, the consumer faces several constraints. First, the per-unit price of C is fixed at P , and the price per hour of labor H is assumed to be fixed at W . Second, the total amount of time T equals L leisure hours plus H labor hours ($T=L+H$). Thus, an individual is assumed to forego an hour of wages when choosing one hour of leisure over one hour of work. Lastly, in this simple model, there is no borrowing, saving or transferring payments to future periods. This implies that spending on goods, PC , must equal total income Y from hours worked, WH , assuming zero initial income and zero additional from sources other than labor. Figure 2 illustrates the two-good case for the tradeoff between leisure and consumption.

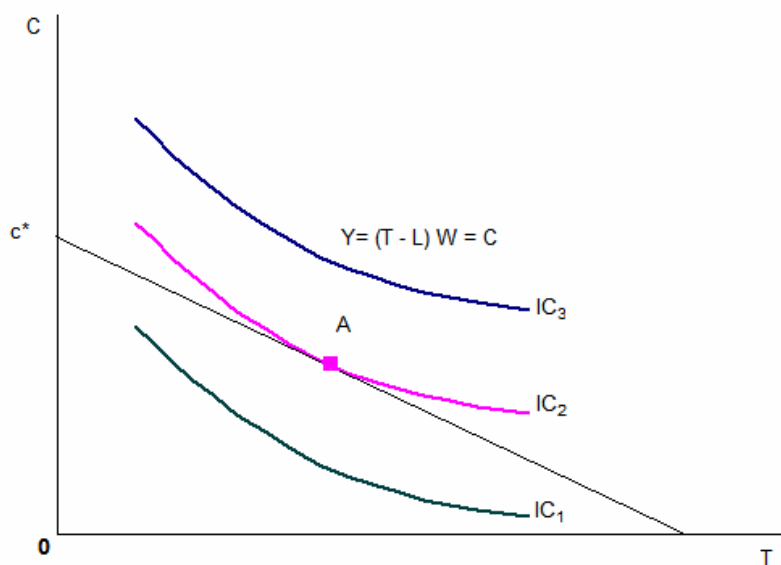


Figure 2: Consumption and Labor Tradeoff

The individual's preferences in Figure 2 are represented as convex indifference curves. At any given point, the slope of the indifference curve is equal to the negative of the ratio of the marginal utility of leisure to the marginal utility of consumer goods at that point. This is called the *marginal rate of substitution of consumer goods for leisure* (Killingsworth 1983; p.3). This is the amount of goods that a consumer is willing to give up in exchange for some amount of leisure evaluated at some combination of C and L.

The constraints facing consumers are represented by the budget line. Suppose a consumer receives a wage rate W for each hour of work and faces prices P. If he does not work at all, and devotes all available time T to leisure, then he can consume C=0. In the other extreme, if he devotes all available time to work, he can consume C'. The combinations (C, L) that the consumer can purchase if he divides his time between labor and leisure are represented by the straight line between C' and T. Points that lie beyond the budget line are unattainable, since his income is too low, while points that lie below the budget line are inefficient since he

could gain additional utility by advancing to a point on the budget line. The optimal (C, L) combination is the one lying on the highest possible indifference curve with the constraint that the consumer remain on or below the budget line, represented by point A.

Following Becker (1965), one may say that an individual spends his “full income” WT , the maximum income attainable when all time is devoted to work, on leisure and consumption of goods so as to maximize utility. Thus, every unit of time spent not working means that fewer units are available for consumption. This concept plays an important role in how individuals value travel time savings, since there is a clear opportunity cost associated with choosing a non-toll route. The non-toll route is perceived to have the benefit of being *toll-free* while having the cost of *additional travel time*. For any given person, the tradeoff between saving time and saving money is dependent on that individual’s indifference curves, or preferences.

3. Labor, Leisure and the Value of Time

It is important to distinguish between the *marginal value of time*, calculated from the marginal tradeoff between money and time, and the *consumer surplus (or value) gained from time savings*. In the labor-leisure framework, the marginal value of time refers to the value of gaining one additional unit of time. *For the purpose of this study, we will refer to the “value of time” as the value gained from some aggregated amount of time savings.* Both interpretations are valid for answering different policy questions, depending on the context. For example, if a government wanted to conduct a cost-benefit analysis of adding another lane to a highway to slightly increase travel time savings, they would be interested in the marginal value of time savings: the value of the next unit of time saved. On the other hand, if one is interested in a motorist’s choice between a toll and non-toll road, such as we are, then the “value of time”

should be interpreted as the consumer surplus gained from the entire amount of time saved by taking a toll road. By examining the labor supply model below, our motivation to use the latter interpretation for value of time estimates will be evident.

According to the conventional labor supply model, utility is maximized subject to constraints on income Y and leisure L . Utility is defined over leisure time L and income Y , where income can be viewed as representing the consumption of a bundle of goods and services. Income is produced daily by working at wage rate W for $(24-L)$ hours. Assuming zero initial and non-wage income, the utility maximization problem is therefore

$$\text{Maximize} \quad U = U(Y, L) \quad (1)$$

$$\text{Subject to the constraint} \quad Y = (24-L) W \quad (2)$$

The Lagrangian for this function is

$$\mathcal{L} = U(Y, L) + \lambda [W (24-L) - Y] \quad (3)$$

The first-order conditions are therefore

$$U_Y - \lambda = 0 \quad (4)$$

$$U_L - \lambda W = 0 \quad (5)$$

where U_Y is the marginal utility of income and U_L is the marginal utility of leisure.

From (4) and (5), $U_L / U_Y = W$. This says that the marginal rate of substitution between labor and leisure is equal to the wage rate. Therefore, according to the conventional labor supply model, an individual's marginal value of time can be approximated by the wage rate.

The conventional labor supply model contains two major assumptions. The first assumption is that a person is free to choose their hours of work. We refer to this as Assumption 1. Under Assumption 1, the person's budget line is continuous. The second assumption is that a person is paid at a constant hourly wage rate W . We will refer to this as "Assumption 2". Under

Assumption 2, a person's budget line is linear. Figure 3 illustrates this point graphically. Under all of these assumptions, the wage rate may be an accurate approximation of one's value of time. However, these assumptions may not be feasible in the real labor market.

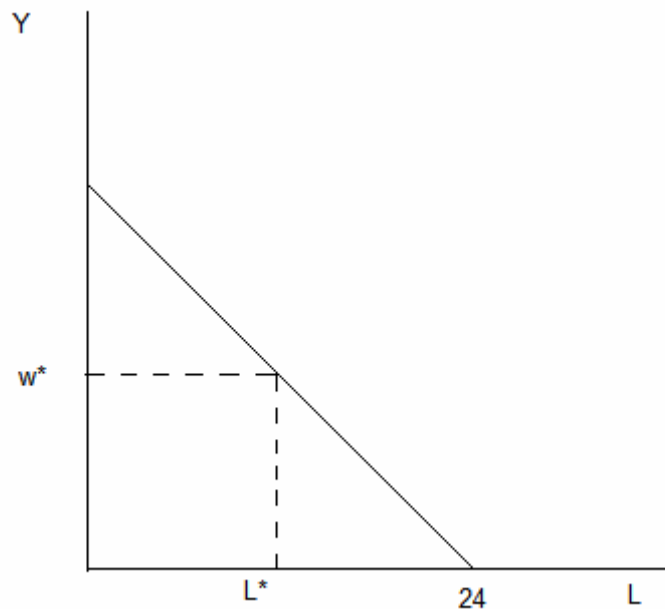


Figure 3: Labor-Leisure Tradeoff

According to Assumption 1, an individual may freely choose to work any amount of hours. However, individuals that are employed full-time may not be free to choose their hours of work for the following reasons: working over-time may not be allowed by the employer, working less than full-time may not be an option since doing so may disqualify the employee from full-time employment benefits, or the employer may dictate a strict hour requirement of the employee who would therefore not be free to choose their hours of work.

According to Assumption 2, a person is paid the same amount per hour regardless of whether they work part-time, full-time or over-time. This assumption does not seem realistic in the labor market since full-time employees are typically paid over-time wages at a higher rate

than their full-time wage and part-time employees are often paid less per hour than full-time employees. Thus, a person's hourly wage rate may vary depending on the number of hours worked.

It is appropriate to relax these assumptions when evaluating the value of time, since they may be unrealistic in the labor market. However, doing so creates two major problems for analysis. Assumption 1 implies that a person's budget line is continuous. Relaxing this assumption creates a discontinuity in the budget line. Assumption 2 implies that the budget line is linear. Relaxing this assumption creates non-linearity of the budget line. Both cases are examined more closely below.

A. Problem 1: Discontinuity of Budget Line

Suppose that a person may choose to work either part-time, *up to* eight hours per day at a given wage rate W_{pt} , or full-time at wage rate W_{ft} . A person who regularly works eight hours or more per day is generally considered a full-time employee. Full-time employees are required to be at their jobs at least eight hours per day and are usually compensated with higher pay, benefit eligibility and paid time off, relative to a part-time counterpart. In other words, if a "part-time" person could work eight or more hours per day, it may be in their best interest to be classified as a "full-time" employee in order to gain the benefits associated with full-time employment. This explains the discontinuity in the budget line between full-time and part-time work hours. Figures 4 and 5 display this point for a part-time and a full-time worker, respectfully.

Figure 4 displays the case of a part-time worker. This worker may choose to work anywhere between zero and eight hours per day.⁴ The slope of the budget line is given by the part-time wage W_{pt} . In this case, the part-time wage rate may be an accurate approximation of an individual's value of time since they may freely trade off one hour of leisure for one hour of part-time wages.

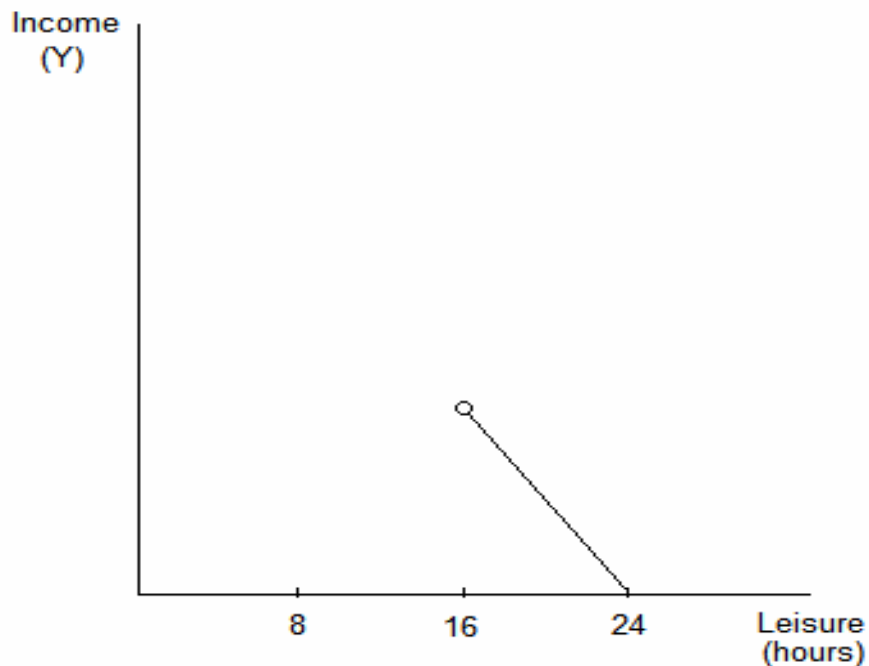


Figure 4: Budget Line of Part-Time Worker

In Figure 5, a single point displays the budget line typical of a full-time worker who has an eight hour daily work limit. This person may not exceed eight hours of work per day and may not work less than the eight hours per day required for full time status. Therefore, this person may not freely trade one hour of leisure for one hour of full-time wages. In this case, the

⁴ Note that even if this person were to work eight hours per day, they would still not receive the same wage rate as the full-time worker displayed in Figure 5. That is $W_{pt} < W_{ft}$.

marginal value of time cannot be estimated at point A since the entire budget line consists of a single point.

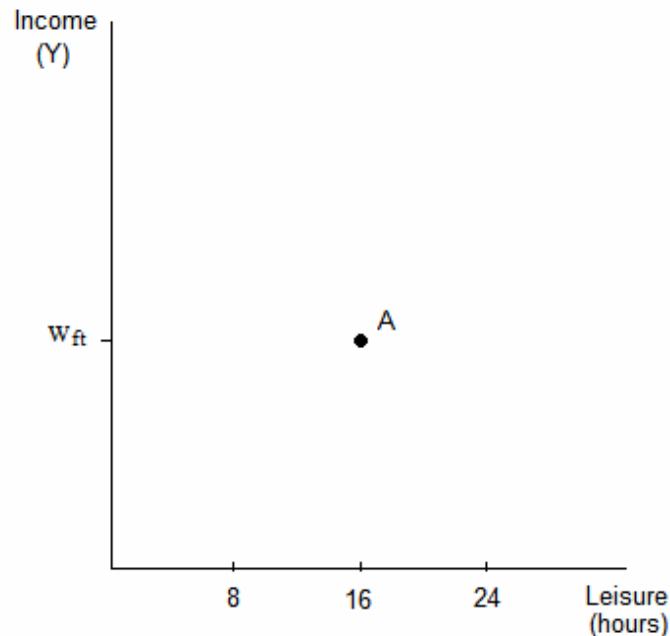


Figure 5: Constrained Budget Line of Full-Time Worker

We have shown in the cases above that relaxing Assumption 1 allows for discontinuity in the budget line. As a result the marginal value of time, which is approximated by the marginal tradeoff between income and leisure, cannot be calculated for every point along the budget line. *Thus, the wage rate can only be used to approximate the value of time when individuals are free to choose their hours of work.*

B. Problem 2: Non-linearity

For a linear budget line, the marginal and infra-marginal values of time are the same at any given point along the budget line, assuming a constant wage rate. In this case, the wage rate would be a good approximation of an individual's value of time. However, individual wage

rates typically increase as the numbers of hours worked increases. This can cause the budget line to be non-linear by offering a different wage depending on the number of hours worked. For example, a person who works part-time would receive less per hour than a person who works full-time, and a person who earns over-time wages is typically paid at an even higher hourly rate ($W_{pt} < W_{ft} < W_{ot}$). Strictly speaking, this would be called “piecewise linearity”. With non-linearity present, using the wage rate to approximate the value of time will likely result in inaccurate estimations of an individual’s value of time.

In order to avoid the problems associated with Assumptions 1 and 2, our study estimates the value of time using the consumer surplus gained from travel time savings, instead of approximating the value of time by the wage rate. This consumer surplus is estimated by the area under an extrapolated linear demand curve. The exact procedure to make this estimation is explained in detail in Section IV. To support our methodology, we will review a literature that exemplifies some of the problems associated with approximating the value of time by the wage rate.

C. Estimating the Value of Time in Recreational Literature: An Illustration

Recreational demand studies have encountered problems with the assertion that the value of an individual’s time is equal to the wage rate. We will review this literature beginning with the pioneering method of Hotelling-Clawson-Knetsch.⁵ This method is more popularly known as the “travel-cost” method and is explained in detail by Clawson (1959), Knetsch (1963) and Clawson-Knetsch (1966).

⁵ The terminology follows Cicchetti et al. (1973).

The fundamental problem with the application of the Hotelling-Clawson-Knetsch (HCK) method in the recreation context is that the time-cost of the trip to a recreation site is ignored. “Failure to explicitly incorporate this aspect of recreation site usage into the HCK analysis results in the imputation of a demand curve which is biased downward from its true position,” (Cesario-Knetsch 1970).

Cesario (1976) points out that the problem with attempting to incorporate travel-costs into the HCK analysis is that the valuation placed on travel time by individuals is highly subjective. Moreover, “Travel time and travel distance are usually so highly correlated that it is impossible to distinguish empirically between their separate effects” (Cesario 1976; p.33). The author cites several studies that attempted to overcome this problem by incorporating travel time valuations in HCK travel demand models in “ad hoc and highly arbitrary ways” (p.33).

Cesario (1976) estimates the value of time for an individual under two main assumptions: (1) individuals can adjust working and leisure hours to suit their preferences, and (2) that different degrees of disutility are associated with different kinds of work. The author also distinguishes between defining time as a “resource” and time as a “commodity”. See Cesario (1976; p. 33-34) and DeSerpa (1971). Cesario (1976) defines the value of time (as a commodity) as the amount one is willing to pay to save time spent traveling. Here, the author discusses the idea of saving time in Footnote 6 (p.34):

“Strictly speaking, time cannot really be saved in the sense of being stored for future use. When a unit of time is saved in one activity it must be used in another as it becomes available. This fact of life presents no unusual problems, but it does lead to the conclusion that the value of time for any individual will undoubtedly fluctuate dramatically over the course of even one day.”

We will refer to the “conclusion” that Cesario speaks of as the “timing of time” and address this issue subsequently.

Given his assumptions Cesario (1976) finds that the value of leisure time should be somewhat less than the wage rate, where the difference between the two is determined by the extent of the marginal disutility of labor. In order to support his findings, Cesario (1976) reviews the empirical results of a number of studies with similar findings. Using these results, the author concludes on the basis of evidence of past studies that the average value of time with respect to non-work travel is between one-fourth and one-half of the wage rate. “Despite the empirical problems mentioned above, these results must be considered as a major finding; they are too consistent to be ignored” (p.37). The author closes his argument by stating “It is clear from these findings that the use of the marginal wage rate for the value travel-time values in recreation benefit estimation is inappropriate, both from the theoretical and practical points of view” (Cesario 1976; p.37).

McConnell (1975) was among the first to consider the role of time in the context of the recreationalist’s utility maximization problem. Again it is assumed that the consumer may freely choose their hours of work. The author defines the cost of consuming a unit of outdoor recreation as the sum of travel costs and the value of forgone earnings over the entire trip. McConnell’s findings are in agreement with those of Cesario (1976) and Cesario-Knetsch (1970): using the travel-cost method while ignoring the opportunity cost of time underestimates the marginal value of recreation and the quantity of recreation consumed. Unlike previous studies, McConnell (1975) adds that it is possible to for an individual earning no market wage to put zero value on the opportunity cost of their time: “With no alternative source of earnings, the individual will not use the time for other recreation activities” (p.331). This assertion is later

challenged by Shaw (1992; p.109), where the author argues that “Individuals with no observable market wage do not necessarily have a low, or zero “value” of time... [they] may be unemployed by choice (retired or between jobs), employed in non-market work, or involuntarily unemployed.”

Smith et al. (1983) evaluate the appropriate treatment of the opportunity cost of travel time using information on the usage of a large number of recreation sites. The authors recall two main formulations of the consumer choice process adopted by the majority of earlier studies. In the first formulation, a composite market good and recreation trips provide utility (McConnell 1975, McConnell-Strand, 1981). In the second, income and the amounts of work and leisure time enter the utility function directly (Cesario, 1976).

Smith et al. (1983) specify a travel-cost demand model such that the treatment of the opportunity cost of travel time is a testable hypothesis, allowing the theoretical arguments for valuing time at “scarcity” and “commodity” values to be evaluated statistically. The authors test a “Full-Cost Hypothesis,” based on the work of McConnell (1975) and a “Cesario Hypothesis,” based on Cesario (1976) to see which hypothesis is better for estimating the cost of travel time in the recreational context. They find that both hypotheses should be rejected, implying that “the time constraints facing individual recreationists are complex and that simple approximations to relate the opportunity cost of time to the wage rate will not be able to accommodate all applications” (Smith et al. 1983; p.275). The authors add that their model “does not suggest an empirically feasible approach for treating time costs because more detailed information on the time constraints facing recreationists is required than is available” (p.275).

Smith et al. (1983) also conclude that the treatment of the cost of onsite time is important to the empirical analysis of the opportunity cost of travel time in recreation models. They note

that in order to adequately deal with the problems posed by the lack of a theoretically appropriate definition of the opportunity cost of time, more information is needed on the nature of the time constraints facing individuals.

Bockstael et al. (1987) is another study that attempts to define a method for estimating the value of time. The authors begin by assuming, unlike Cesario (1976) and DeSerpa (1971), that travel time does not influence utility levels. They focus on time as a scarce resource, instead of a commodity. Then, they incorporate the work of Killingsworth (1983), who argues that “Only individuals who choose their hours of work can adjust their marginal rates of substitution of goods for leisure to the wage rate...All others can be found at corner solutions where no such equimarginal conditions hold and the wage rate cannot serve as the value of leisure time” (p.295). Thus, Bockstael et al. (1987) analyze the wage rate as an approximation of the value of time for individuals who are free to choose their hours of work and for those who are not. Their model lends support to our position that it is not reasonable to assume that all individuals are free to choose their hours of work.

After a clear exposition of the labor supply literature (see Bockstael et al. 1987, pg 296), the authors assume that for individuals at interior solutions in the labor market, at least some component of work time is “discretionary” and that this time can be traded for money. Here, the wage rate is found to reflect the individual’s value of time because work and leisure can be traded at the margin. For individuals who did not have flexibility in their work hours (i.e., those without “discretionary” time) the marginal value of time was not equal to the individuals wage rate. They estimate the value of time to be \$17/hr on average, which was approximately equal to the mean wage rate for individuals with a flexible work week, and \$60/hr on average for individuals with a fixed work week, a much higher rate than the mean labor market wage.

Shaw (1992) explores why the relationship between the value of time and the wage rate does not hold, contrary to prior literature. The author focuses on the difference between the value of time and the opportunity cost of time by noting that there is an opportunity cost associated with engaging in leisure in terms of forgone earnings. The model is set up based on this opportunity cost. The author finds that the opportunity costs of time are much higher than the average wage rate of those in the sample who were employed. Shaw (1992) also describes the differences between defining time as a commodity or a resource, and states that both methods are correct, depending on the underlying assumptions of each model. “It seems that the best approach is to consider the set of assumptions on a case-by-case basis and choose those that most reflect the realism of the activity in question” (p.111).

Within the article, Shaw (1992) reiterates the importance of the “timing of time” mentioned earlier. “At what time individuals are observed during the course of the year, week, or day may influence the relevant opportunity cost of time because individuals may allocate time differently at different times of the year or week, and thus the next best alternative activity may change” (p. 110). This issue was previously addressed by Cesario (1976), who noted that the value of time to an individual can fluctuate dramatically even over the course of a day. In the setup of our model, we avoid the issue of the “timing of time” altogether by collecting data in real-time. As we collect data on the day and time that subjects use toll roads, we observe their decisions at the moment they are making them, not before or after the fact. This is an important point because we are able to avoid the problem of biasing our data by collecting observations at a time other than when the decision is being made, as the above authors have addressed.

Each of the studies summarized above attempted to resolve the issue of how to accurately estimate the value of time in the recreation demand context. The common result is that there is

no concrete way of measuring an individual's value of time, or time savings for that matter. Some studies assumed that consumers freely choose their hours of work, some assumed a utility or disutility associated with travel, the argument of whether to include time as commodity or scarcity value was addressed repeatedly, and the "timing of time" problem was presented. These studies found highly differing values for individual's time. Some were closely approximated by the wage rate, while others were not.

In the end, the most common result was that the underlying assumptions of each empirical model affected the outcome. "The choice of arguments determines the theoretical relationship between the opportunity cost of time and the wage rate," (Shaw 1992; 112). Cesario (1976) and Bockstael et al. (1987) both suggest that researchers have used "ad hoc" and "highly arbitrary" methods of estimating individual's value of time. Smith (1983) recognizes this problem and adds: "The existing recreation literature does not provide an unambiguous theoretical justification for distinguishing the valuation assigned to the travel and onsite time components of a recreational experience" (p.262). The findings of these studies show that there is no clear-cut way of estimating an individual's value of time, even under the most popular assumption: that individuals are free to choose their hours of work. We will carry this result forward to our analysis and attempt to estimate the value of time to individuals by avoiding the above problematic assumptions altogether.

Now that we have discussed the problems associated with relaxing Assumptions 1 and 2, we will attempt to avoid these problems by designing an empirical model that estimates the value of time by the consumer surplus gained from travel time savings. The set up of our empirical model allows us to estimate an individual's value of time *without* assuming that the person can freely choose their hours of work and *without* assuming a constant wage rate that is independent

of the number of hours worked. Our model estimates the value of time by assuming that the WTP for travel time savings is equal to the consumer surplus gained from travel time savings. This model is described in detail in Section III.

SECTION II TRANSPORTATION LITERATURE: THE VALUE OF TRAVEL TIME SAVINGS

1. Value of Time

In 1965, Gary S. Becker proposed *A Theory of the Allocation of Time*. Before Becker, the allocation and efficiency of non-working time received little attention from economists. In this pioneering contribution, Becker notes a large secular decline in the work week due to economic development, and suggests that the allocation and efficiency of non-working time may be of increasing importance to economists. He notes that while economists have fully grasped the importance of forgone earnings [opportunity cost] in the educational process, they have not been equally sophisticated about other non-working uses of time. He adds that all non-work activities have opportunity costs associated with them and proposes that the full cost of these activities should incorporate their market prices as well as the forgone value of the time used on such activities.

Becker (1965) analyzes the effect that changes in earnings, other income, goods prices, and the productivity of working and consumption time have on the allocation of time. He finds that an increase in wages would induce a decline in the amount of time spent on non-working activities since time would become more expensive. In other words, it is costly to partake in non-working activities when forgone earnings are accounted for. Becker (1965) concludes that since non-working activities have an opportunity cost associated with them, more attention should be paid to the efficiency and allocation of non-working time. Becker (1965; p.510) specifically cites transportation as one of the few opportunities to evaluate the cost of time based on actual behavior:

The importance of the value placed on time has encouraged experiment with different methods of determination: from the simple view that the value of an hour equals the average hourly earnings to sophisticated considerations of the distinction between standard and overtime hours, the internal and external margins, etc. The transportation field offers considerable opportunity to estimate the marginal productivity or value of time from actual behaviour.

Our study follows Becker's suggestion of estimating the value of time from actual behavior by conducting a revealed preference field experiment that studies the use of toll roads in Central Florida.

More recent literature in the field of time valuation includes transportation studies that elicit the value of travel time savings to motorists. Deacon and Sonstelie (1985) use people's choices from a natural experiment to estimate the value of time spent waiting as a function of individual characteristics. Calfee et al. (2001) use a stated preference survey to estimate motorist WTP for travel time savings. While Deacon and Sonstelie (1985) find that motorists have a large and significant value of time savings on average, Calfee et al. (2001) finds that this value is low. These conflicting findings deserve more extensive examination before we attempt to estimate the value of time savings to motorists.

A. A Natural Experiment

Deacon and Sonstelie (1985) estimate the value of time of motorists using data from a unique natural experiment. In 1980 a number of gas stations were required to lower their prices as a result of gasoline price controls. Consequently, motorists were faced with a choice between waiting in line at a low-priced station or paying a higher price at a station with no wait. By making this choice, motorists revealed information about the opportunity cost of their time. Deacon and Sonstelie (1985) survey customers from one of the low-price regulated stations and

two high-priced (control) stations, collecting information on individual and vehicle characteristics. Their data set consists of 170 observations, 109 of which are customers from the low-priced station and 61 from the high-cost stations. Motorists were given a survey eliciting information on income, employment, marital status, number of passengers, day of week the purchase took place, and number of gallons bought.

Deacon and Sonstelie (1985) find that the group of motorists who chose to wait in line at the low-cost station tend to purchase more, have higher tank capacities, are accompanied by passengers less often, and that the group contained a higher percentage of unemployed and a lower percentage of fully-employed people. More interesting is their finding that in four of the five mutually exclusive income categories, they cannot reject the hypothesis that the wage falls within the bounds for the value of time; the exception being the lowest income class. Thus, those who chose to wait in line for lower prices had systematically lower waiting costs per gallon than the general population. By using revealed preference logic, Deacon and Sonstelie (1985) conclude that the estimates of the value of time are closely approximated by the individual's after-tax wages. However, the observations in this study are based on a data set that pertains to a *one-time event* that cannot easily be replicated. Thus, the finding that an individual's wage rate is a good approximation of their value of time is not able to be validated. By designing a framed field experiment, our study will attempt to produce a *replicable* data set on the use of toll roads so that our results may be validated by future studies.

B. A Hypothetical Survey

Calfee et al. (2001) use a stated preference survey to estimate commuter's WTP for travel time savings. The surveys were given to 1,170 automobile commuters in major U.S.

metropolitan areas who regularly drive to work and face congestion. Each respondent was presented with thirteen alternatives or packages that described the essential elements of a commute, including congestion times and travel costs. These hypothetical times and costs were stated with certainty, as is usual in conjoint choice studies. Respondents rated the “acceptability” of each alternative on a ten-point scale where “1” meant “very unacceptable” and “10” meant “very acceptable”; then respondents ranked the alternatives breaking ties when necessary. Using conventional ordered and mixed logit econometric models, Calfee et al. (2001) find that the average WTP to reduce travel time is low and does not exhibit much variation among motorists.⁶ They warn that while their findings are robust, extreme caution should be used in estimating stated preferences based on respondents’ ratings due to the problem of hypothetical bias. We view this warning as support for our attempt use a revealed preference approach to estimate WTP for travel time savings.

2. Value of Reliability and Safety

In addition to time savings, the use of toll roads may have other important attributes such as reliability of travel time and perception of safety. Theory suggests that a traveler’s expected total travel cost rises with travel-time uncertainty if it is costly to arrive early or late at a destination (Noland and Small, 1995). Additionally, a motorist could perceive a toll road as more or less safe due to its level of congestion, speed limit, and other characteristics. Since reliability and safety perceptions may have confounding influences on a motorist’s decision to

⁶ Mixed logit is a general statistical model for estimating utility functions. The standard logit and probit model’s coefficients (or betas) are fixed, which means that the betas are the same for everyone. Mixed logit has betas that differ over respondents, allowing the distribution of the population density function of the parameters over the population to be modeled with a variety of distributions.

take a toll versus a non-toll road, each should be controlled for when evaluating the value of travel time.

A. A Combined Revealed Preference and Stated Preference Study

Small et al. (2005) study the distribution of motorist preferences for travel time reliability by applying a mixed logit model to combined revealed and stated preference data on commuter choices. The authors estimate the distribution of values, allowing for both observed and unobserved heterogeneity, by analyzing a sample of motorists in a value-pricing experiment in the Los Angeles area. Their study combines three samples of people traveling on California State Route 91 (SR91). The first sample is a telephone stated preference survey of 438 respondents; the second and third samples are from a two-stage mail survey. The first stage collected revealed preference data on the actual trips of 84 respondents while the second stage presented the same 81 respondents with stated preference scenarios. By combining revealed and stated preference data, the authors are able to obtain statistically precise estimates while allowing for possible differences between actual and hypothetical behavior. Their model defines the value of time as the change in utility given a change in time divided by the change in utility given a change in toll difference. The value of reliability or “predictability” is defined as the change in utility given a change in reliability difference divided by the change in utility given a change in toll difference.

Small et al. (2005) find that the commuter’s average value of time is \$21.46/hour and average value of reliability is \$19.56/hour. “To put these figures in perspective, the median time savings for the express lanes was 3.3 minutes...while the unreliability in the free lanes averaged 1.6 minutes. Thus, the average commuter would pay \$1.18 for the time savings and \$.52 for

improved reliability, implying that time savings accounts for roughly *two-thirds* of the attraction of using the express lanes” (Small et al. 2005; p.1378). They conclude that travel time and its reliability are highly valued by motorists and are considerably higher when measured in real as opposed to hypothetical scenarios.

The work of Small et al. (2005) is a significant contribution to the field of travel time valuation. Finding that roughly one-third of the attraction of using express lanes comes from reliability implies that motorists value express lanes for more than just time savings.⁷ Thus, the value of reliability is an important confounding factor to control for in future studies when estimating motorist value of travel time. Additionally, the fact that the values were more robust for real scenarios offers additional support for using a revealed preference approach.

B. More Hypothetical Surveys

Another factor that may influence the choice between using toll and non-toll roads is a motorist’s perception of safety. If a person thinks that a toll road is safer than a non-toll road, then there are confounding effects to consider when evaluating that person’s value of time based on the use of such roads. Conversely, if a person thinks that a non-toll road is safer, then safety perception may offset any time savings associated with the use of a toll-road. In either case, perceptions of safety are an essential consideration.

Hultkrantz et al. (2006) report the results of a contingent valuation study of improved urban road safety in Sweden. They estimate WTP for a maximal safety enhancement intended to completely eliminate fatal and serious-injury outcomes of road accidents. WTP is derived within both private and public good framework, that is, the safety enhancement is offered to some

⁷ Due to the nature of the SR91 study, the term “express lanes” used by Small et al. (2005) for the highway in California is equivalent to our use of the term “toll-roads” for highways in Central Florida.

subjects as a private good and to others as a public good, and WTP is elicited accordingly. Respondents in the study are also asked to state their confidence in their response. Then the Blumenschein et al. (1998) “certainty approach” is used *ex post* to mitigate hypothetical bias, revealing what Hultkrantz et al. refer to as “conservative estimates”.⁸ They find that WTP for risk reduction within the public-good framework is positive, but lower than within the private-good framework by 60%. They conclude that even under conservative estimates, WTP for public safety improving measures is higher than currently assumed in Sweden. Overall, the finding that the WTP for enhanced transportation safety is positive implies that motorists value travel safety to some extent. Thus, it is necessary to control for the confounding effects from the value of safety when estimating motorist’s WTP for travel time savings.

In a separate study, Andersson and Lundborg (2007) examine individual’s perception of their own mortality risk. The data on risk perception originated from a Swedish contingent valuation survey from Persson et al. (2001). The analysis is undertaken for two mortality risks: overall and road-traffic, where road-traffic risk is assumed to be more voluntary and controllable compared with overall risk. In the study, a Bayesian learning model is used to predict how new information or experiences will affect the risk perceptions. They find that low-risk groups over-assessed and high-risk groups under-assessed their own road-traffic mortality risk; that both groups over-assessed their overall mortality risk; and that individuals perceive risk of their own age group more accurately. The latter finding implies that individuals are able to identify risks associated with their own age group more accurately than the risks of other age groups.

⁸ Blumenschein et al. (1998) found that hypothetical bias could be mitigated by the use of qualitative or quantitative certainty scales to *ex post* select “reliable” yes responses.

These findings are important since an individual's perception of risk influences their behavior and consequently the optimal tradeoff between risk reductions and other consumption (Andersson and Lundborg (2007)). In other words, individual perception of risk can influence the decision to take a toll or non-toll road. Thus, it is also necessary to control for risk attitudes when estimating a motorist's WTP for travel time savings.

3. Summary

It is apparent from these studies that individuals value reliability and safety in addition to time savings when choosing between toll and non-toll roads. Not controlling for these values could produce biased estimates of the WTP for travel time savings since they are part of the motorist's choice to take a toll or non-toll road. To avoid biased estimates, it is necessary to control for the confounding effects of reliability and safety during statistical analysis by evaluating risk attitudes using the procedures described in Section III.

SECTION III EXPERIMENTAL DESIGN

The purpose of our experimental design is to demonstrate a sound method of creating a replicable data set that encompasses a wide range of individual characteristics including individual risk attitudes, discount rates, and demographics. Although our analysis is limited for the purpose of this pilot study, we see these data as providing the basis for a wide range of analyses into the determinants of the value of time, the value of access to toll roads over non-toll roads, and the pricing of time sensitive attributes in general. The following paragraphs explain the process used to collect observations on individual risk attitudes, demographics and discount rates.

Observations on subject's use of toll roads are collected in two phases. In the first phase, subjects provide us with their past three months usage of toll roads. The reason for collecting the subjects' *past* three months' statements is to obtain a baseline of observations on the subject's un-subsidized or "pre-subsidy" toll road usage. We refer to the past three months' activity as the subject's "historical" usage. In the second phase, subjects are provided with a randomly determined *ad valorem* subsidy for a one-month time period. The amount of this subsidy is told to the subject at the beginning of the study. This way, subjects are aware that they may purchase tolls at a "discounted" rate during the one-month time period.

Collecting data on both subsidized and un-subsidized toll consumption allows us to estimate subjects' demand for tolls at different prices. The four months of data are aggregated across all subjects and used to estimate a linear demand curve for toll roads. Then, we extrapolate the demand curve in order to calculate the consumer surplus gained from subjects'

use of toll roads. We assume that this consumer surplus is equal to the WTP for tolls, and develop an empirical function to convert WTP for tolls to WTP for travel time savings.

1. Risk Attitudes and Demographic Characteristics

The thirty-one subjects used in our study were recruited from a separate experiment conducted by Harrison, Hofler, and Rutström (HHR) at the University of Central Florida in 2007 and 2008. The HHR experiments elicited information on each subject's risk attitudes and demographics, and all subjects were paid at the end of those experiments for their participation and performance on decision tasks. Recruiting subjects from this separate experiment enabled us to use the data collected by HHR for this pilot study at no additional cost.

The HHR sessions use an extension of the Hey and Orme (2004) method of inferring individual risk attitudes developed by Harrison and Rutström (2008). The original Hey and Orme (2004) method uses an extensive Random Lottery Pair design to estimate utility functionals over lotteries for individuals. It is "random" in the sense that the lotteries in each pair and in the sequence in which the lotteries are presented to subjects are not ordered.⁹ The advantage of the Random Lottery Pair design is that it is easy for subjects to understand and it is incentive compatible. Hey and Orme (2004) use pie charts to display the probabilities of the lotteries they present to subjects. This design presents the subject with a series of paired lottery choices to make one at a time. The resulting data are used to estimate a series of utility functionals defined over these lotteries.

Harrison and Rutström (2008) extend the Hey and Orme (2004) procedure by implementing both gain and loss frameworks while simultaneously eliciting individual

⁹ Holt and Laury (2002) use an ordered lottery pair design.

characteristics. See Harrison and Rutström (2008; Appendix B) for complete experimental design. Specifically, Harrison and Rutström (2008; p.69) assume a Constant Relative Risk Aversion (CRRA) utility function and develop a method of structural estimation to infer individual risk attitudes (p.69). Specifically, they assume the utility function $U(y) = y^{1-r}/(1-r)$ for $r \neq 1$. Here, r is defined as the coefficient of CRRA. This coefficient r is estimated using maximum likelihood, where $r = 0$ is interpreted as risk-neutrality, $r < 0$ to risk-loving, and $r > 0$ to risk-aversion. Thus, the estimation methods developed by Harrison and Rutström (2007) allow one to infer individual risk attitudes from latent choices under uncertainty.

An individual's choice between taking a toll or a non-toll road can be naturally thought of as a choice between two lotteries. The "safe" lottery is the *toll road* lottery which has a smaller variance in travel time. The "unsafe" lottery is the *non-toll road* lottery where the variation in travel time is larger. Assuming that risk-averse individuals take the "safe" route in terms of travel time variance, the data collected during the HHR sessions could be used to control for risk attitudes in a more comprehensive analysis.¹⁰

2. Individual Sessions

At the end of each HHR session, after subjects complete all of their tasks and are waiting to be paid, a short script is read to them. Subjects are given a brief description of our study and asked if they would like to sign up for a short *information session*, at which point they may opt "in" or "out" of our study. Appointment sheets are provided for subjects to sign up for an

¹⁰ Analysis of individual risk attitudes will not be conducted within this pilot study; the purpose of this discussion is to cover the methods one would use in a comprehensive analysis of the value travel time savings.

individual time slot. A short checklist of required documentation is provided to subjects who choose to sign up for the information session.

When subjects come to their scheduled information session, the description of our study is re-read to remind them of our purpose. Next, the research assistant provides a copy of the instructions and carefully goes over the requirements of the study with the subject. The subject is asked if they have any questions, and then is asked to opt “in” or “out” of the study. Subjects who opt “in” immediately proceed to their *individual session*.

During the individual session, the subject’s *ad valorem* toll subsidy is determined by rolling two 20-sided die and one 10-sided die. The outcome of the three rolls is summed to determine the subject’s subsidy for toll expenditures, which can range between a minimum of 3% and a maximum of 50% of the subject’s total expenditure on tolls. The subsidy amount and date range are recorded on the instruction form.¹¹ The subject is asked to sign one copy of the form and is given a second copy for their records.¹² At this point the informed consent form is also signed. The subject is asked their first and last name, the last four digits of their Social Security Number, mailing address for payment purposes, phone number, email address, and make and model of their vehicle, all of which are recorded in our subject database.

Subjects who do not currently have an E-pass or Sunpass transponder are provided with one by the research assistant. These subjects are asked to set up their own Sunpass account using our borrowed transponder. They are also informed that we are loaning them the transponder and that they are required to return it to us or purchase it at cost at the end of one month in order to

¹¹ The date range includes the dates that the subsidy is in effect. For our pilot study, this is one month from the date of the subject’s individual session.

¹² In addition to the subsidy amount, date range and subject’s signature, the instruction form also includes the subject’s printed name, subject ID number (same as in HHR sessions), date of signature, and office hours for payment collection.

receive payment. Subjects who already have a transponder are asked to log themselves into their account and email the research assistant their past three months' statements. The research assistant provides any necessary computer assistance to the subjects.

Additionally, if there is more than one transponder on a given account, the subject is asked to identify which transponder belongs to their vehicle, and the transponder number is recorded in our database. The subject is first asked for their vehicle make and model, and later asked if there is more than one transponder on their account. This ensures that the transponder claimed by the subject is actually theirs.

Next, subjects are asked to take a discount rate test similar to the one used in Coller, Harrison and Rutström (2003). Discounting is an important consideration since subjects will be paid their subsidy (plus a \$10 participation fee) at the end of one month, rather than the day of their individual session. For this task, we consider two possible time horizons for the future payment: 15 days and 30 days. The two different time horizons were given to the subjects in random order, so as to control for order effects. By eliciting discount rates, it is possible to statistically account for any discounting by the subjects.¹³

The general question presented to subjects to elicit their discount rate is simple: "Do you prefer \$25 today or \$25 + x at a later date, where x is some positive amount?" If the subject prefers \$25 per day and is risk-neutral, we can infer that the discount rate is higher than x percent per day. If the subject prefers the \$25 + x , we can infer that the discount rate is x percent per day or less. From the format of this test, we would expect subjects to reject the option of waiting for money when there is no return ($x = 0$), and take the future income option at some point as we

¹³ Analysis of individual discount rates will not be conducted within this pilot study; the purpose of this discussion is to cover the methods one would use in a comprehensive analysis of the value travel time savings.

increase x . The point at which the subject *switches* from choosing current income to future income provides an interval estimate of the subject's discount rate. The subject is asked to choose between current income (option A) and future income (option B) for 15 different payoff alternatives. After the subject has written a response for each payoff alternative, we select one at random for actual payment. In this way, the results from one question do not generate income effects which may influence the answers to other questions (Harrison et al. 2002). Finally, subjects are asked to fill out a short questionnaire on their usual travel habits. The purpose of this questionnaire is to account for any atypical travel that might take place during the course of study (i.e., if the subject is planning a trip or has a new job that requires them to change daily driving routes).

Once all tasks are complete, subjects are reminded to email their statements at the end of one month in order to receive their subsidy and \$10 participation payment. These payments are offered in order to provide an incentive for subjects to submit the information asked of them. Subjects are given the option to come to posted office hours to pick up their payment in cash or to have a check mailed to them. The latter option is provided for subjects who may not be on campus regularly or prefer to have a check sent. Subjects are also informed that if their cash payment is not picked up within two weeks, a check will automatically be mailed to the address they have provided us in order to ensure payment. For subjects who earn a reward from the discount rate test the day of their individual session, payment is made in cash and the appropriate receipt forms are filled out and signed. Otherwise, a signed promissory note is given to the subject with the date of future payment. Following the individual sessions, as monthly email statements come in from subjects, the new data is added to the subject's three previous statements sent during the individual session. Once all monthly statements are collected from

each subject, all data on toll road usage are merged into one master spreadsheet and prepared for statistical analysis.

3. Converting Tolls to Time Savings

This segment discusses the relationship between the dollar amount of tolls consumed by subjects and the amount of travel time saved from the use of toll roads. In other words, an empirical function that converts WTP for tolls into WTP for travel time savings is developed here. In order to utilize this function we must first calculate the amount of travel time saved by subjects from their use of toll roads. We do this by comparing the travel times between toll and non-toll roads.

First, each toll road in Central Florida is divided into numbered segments which are bounded by the main toll plazas (MTPs) located at the endpoints of each segment. Our dataset contains the time of day, day of week, and frequency that these segments are used by our subjects as well as the cost in dollars required to use these toll segments. In most cases, a single trip using a toll road from point A to point B would require traveling on multiple segments, resulting in sequences of segment numbers for a given subject. By examining these sequences of numbers it is possible to identify and analyze the exact routes of each subject. As a result, individual time savings estimates would vary by subject, segment of toll road traveled, time of day and day of week of travel, and the origin and destination of the subject's whole trip. However, due to time constraints and computational complexity, we will limit our analysis to the average daily toll expenditures on the toll-road segments *most commonly traveled* by all subjects for the purposes of this pilot study.

In order to calculate travel time savings, the distance and travel time are recorded for each of the most commonly traveled toll road segments and the non-toll alternative routes. To do this, we propose pooling estimates from an actual “army” of test-drivers and an online Geographic Information System such as Google Directions.¹⁴ Again, due to time constraints, the student “army” consists of only one graduate student driver from the University of Central, Florida Department of Economics, for the purposes of this pilot study.

The test-driver is asked to record the time and distance it takes to drive the on most commonly traveled segments, using toll roads in one direction and non-toll roads in the other direction. To control for order effects, the direction in which the toll roads will be taken is randomly determined by the toss of a coin. Therefore, the toll road could be taken from point A to point B and the non-toll road taken back from point B to point A, or *vice versa*. The time savings is then calculated as the difference in travel times between using toll and non-toll roads.

The online Geographic Information System estimates come from Google’s online driving directions. Google Directions provides estimates of the distance and the time it takes to travel from a given origin to a given destination. Additionally, Google Directions provides the option to select “Avoid Highways” so that distance and time estimates are available separately for toll and non-toll routes. This online system offers a second source of distance and time data, which helps ensure accuracy of overall estimates of travel time savings.

The estimates from Google Directions are combined with the test-driver’s distance and time records to calculate the average amount of time saved by using toll roads for each of the most popular segments. Additionally, the cost in dollars required to travel each segment was

¹⁴ The URL for Google Directions is www.maps.Google.com

previously collected during the two phases of this study. These calculations are presented in

Table 1.

| Segment 1 | Toll Road Segment | Non-Toll Alternative Route |
|-------------------------------------|---------------------------|-----------------------------------|
| Actual Travel Time | 17 minutes | 29 minutes |
| Google Travel Time | 22 minutes | 26 minutes |
| Total Difference | 5 minutes | 3 minutes |
| Average of Actual and Google | 19.5 minutes | 27.5 minutes |
| Estimated Time Savings | $27.5 - 19.5 = 8$ minutes | |
| Toll Cost (\$) | \$1.25 | |
| Conversion (min/\$) | 6.4 | |
| | | |
| Segment 2 | Toll Road Segment | Non-Toll Alternative Route |
| Actual Travel Time | 10 minutes | 22 minutes |
| Google Travel Time | 13 minutes | 20 minutes |
| Total Difference | 3 minutes | 2 minutes |
| Average of Actual and Google | 11.5 minutes | 21 minutes |
| Estimated Time Savings | $21 - 11.5 = 9.5$ minutes | |
| Toll Cost (\$) | \$1.00 | |
| Conversion (min/\$) | 9.5 | |
| | | |
| Segment 3 | Toll Road Segment | Non-Toll Alternative Route |
| Actual Travel Time | 5 minutes | 9 minutes |
| Google Travel Time | 5 minutes | 7 minutes |
| Total Difference | 0 minutes | 2 minutes |
| Average of Actual and Google | 5 minutes | 8 minutes |
| Estimated Time Savings | $8 - 5 = 3$ minutes | |
| Toll Cost (\$) | \$1.00 | |
| Conversion (min/\$) | 3.0 | |

Table 1: Time Calculations for Segments 1, 2, and 3

The amount of time saved per dollar spent on tolls is calculated by dividing the amount of time saved (in minutes) by the total toll expenditure (in dollars).

$$\textit{Time Savings (min.)} / \textit{Toll Expenditure (\$)} = \textit{Cost of Time Savings} \quad (6)$$

This ratio can be thought of as a type of conversion rate, or exchange rate, converting dollars spent on tolls to dollars spent on time savings. Using this conversion rate, the same analysis that is used to estimate consumer surplus from consumption of tolls can be used to estimate consumer surplus from travel time savings. This analysis is explained in Section IV.

SECTION IV DATA ANALYSIS

1. Estimating Consumer Surplus from Consumption of Tolls

A. Constructing the Aggregate Linear Demand Curve

We begin our analysis by estimating an aggregate linear demand curve from our subjects' actual consumption of tolls, assuming homogeneous preferences. Refer to Figure 6 below, where $Price = [1 - (\text{Subsidy}/100)]$ and $Quantity (\$) = \text{average daily toll consumption}$.

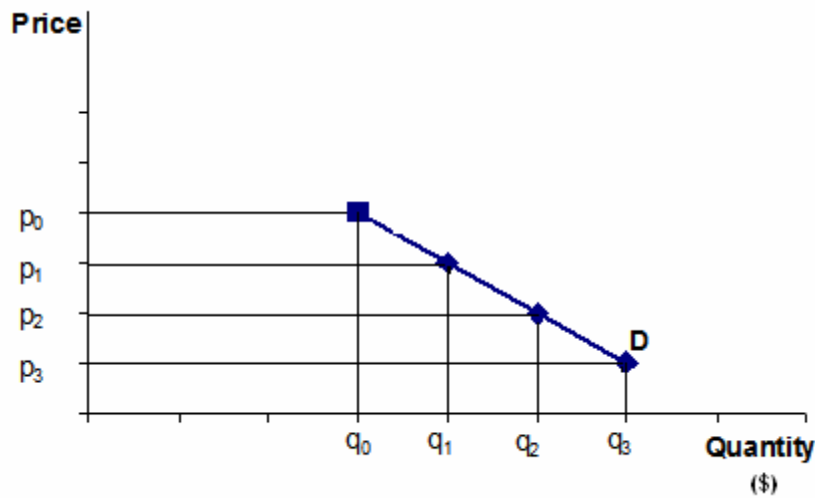


Figure 6: Aggregate Linear Demand Curve

The price p_0 denotes the original average daily price of tolls before the subsidy. The data on quantity demanded at p_0 is collected from each subject's historical toll usage. The prices p_1 , p_2 , and p_3 correspond to the subsidized toll prices, which are less than p_0 and known to the subject beforehand (this procedure was explained in Section III). We estimate the aggregate demand curve D based on the amount of the subject's subsidy and the Quantity (\$) data we collect on their subsidized toll usage.

The Quantity (\$) that is referred to in Figure 6 is the average daily toll consumption. The reason for calculating *average daily* toll consumption is to normalize the different number of

days within the pre-subsidy and subsidized periods. This figure can be calculated for each subject by summing the total amount of dollars spent on tolls during a given period and then dividing by the number of days in that period. Alternatively, this figure could have also been calculated by summing the total amount of dollars spent on tolls during a given period and then dividing by the number of days during that period that tolls were actually used. This would also be a valid way to normalize the Quantity in the two treatment conditions so that they are comparable, although it would require an extension of our statistical model to explain why the subject uses the toll on some days and not on other days, and that interesting extension is beyond the scope of this pilot analysis. We will use the former interpretation of Quantity (\$) for our analysis, where we account for all days in the period whether or not tolls are used. Using the conversion formula developed in Equation 6, we will eventually convert Quantity (\$) to Quantity (min.) in order to estimate the demand for time savings in minutes.

B. Extrapolating the Aggregate Linear Demand Curve

Once the aggregate demand curve below p_0 is estimated for observed choices, we extrapolate the upper part of the demand curve for the unobserved choices as illustrated in Figure 7. This extrapolation entails predicting the demand curve for prices that are “out of sample.”

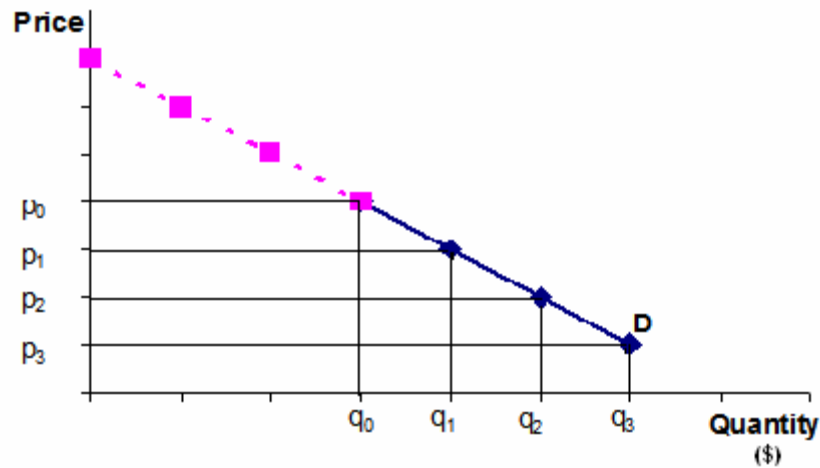


Figure 7: Extrapolated Linear Demand Curve

Predicting out of sample to extrapolate the aggregate demand curve has advantages and disadvantages. The advantage is that we are able to directly measure consumer surplus from the consumption of tolls by calculating the area under the demand curve and above the price p . The disadvantage is that there are prediction errors associated with predicting out of sample.

There are two separate reasons why the prediction errors might be larger or smaller in this study. First, the prediction is sensitive to the size of the sample used. Since this pilot study has only 31 subjects, the prediction error may be relatively large. In extensions of this study where the number of subjects is much larger, the prediction error will decrease as the sample size increases. Second, the prediction error becomes larger as we move farther away from the domain of the observed data. (The *domain* of our sample is defined here as the original and subsidized prices of tolls, or the range between p_0 and p_3 in figure 7.)

The extrapolated portion of the demand curve in Figure 7 shows that we are estimating the quantity of tolls that would be demanded if the price of those tolls were higher than currently charged by toll authorities. As we move to higher and higher prices from the prices actually

faced by our subjects, the prediction error becomes larger.¹⁵ These prediction errors can be represented statistically as confidence intervals. As we move farther from the domain, the prediction error increases and the confidence intervals around the mean value fan outward as represented in Figure 8.

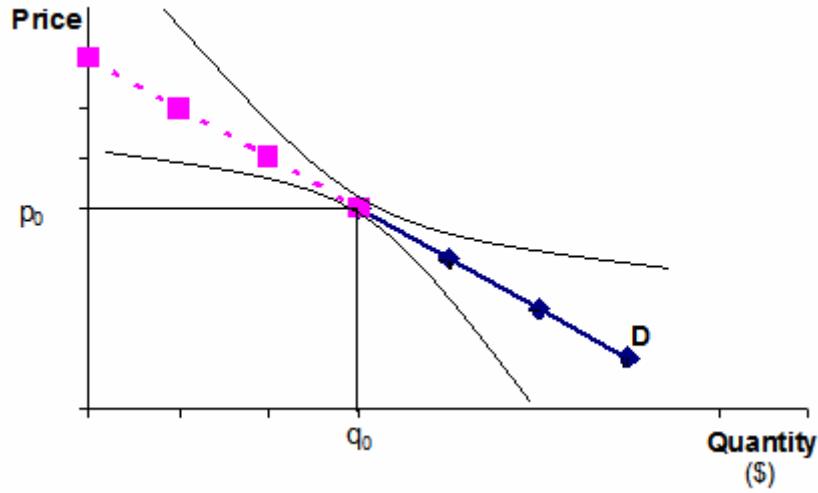


Figure 8: Confidence Intervals

We will account for these prediction errors in our analysis by including the standard errors in our consumer surplus calculations. Equation 7 contains the econometric formula used to estimate the aggregated linear demand curve:

$$Q = \alpha + [\beta (Price)] + \varepsilon \quad (7)$$

Here, α is the constant term, β is the price coefficient, ε is the error term with a mean of zero and a variance to be estimated, and pre-subsidy Price is normalized to 1. Once the entire aggregate demand curve is estimated, we can calculate the expected consumer surplus as the area

¹⁵ Since our data set includes three months of tolls priced at p_0 and one month of tolls priced less than p_0 , the domain for our purposes will be weighted to be closer to p_0 than the range $[p_0, p_3]$.

under the demand curve and above any given price p . Since the consumer surplus is identically equal to the WTP for tolls by construction, we can use the consumer surplus to estimate the WTP for travel time savings via the conversion formula developed in Section III.

2. Estimating Consumer Surplus from Time Savings

Using Equation 8, the transition from estimating consumer surplus from toll consumption to estimating consumer surplus from time savings is fairly straightforward.

$$\text{Average Daily Toll Consumption} \times \frac{\text{Time Savings (min.)}}{\text{Toll Expenditure (\$)}} = \frac{\text{Quantity of Time Savings}}{\text{Time Savings}} \quad (8)$$

Multiplying the average daily quantity of tolls consumed (in dollars) by the conversion rate from Equation 6 gives the quantity of time savings consumed (in minutes) at any given price. Thus, a new aggregate demand curve can be estimated for quantity of time savings as illustrated in Figure 9.

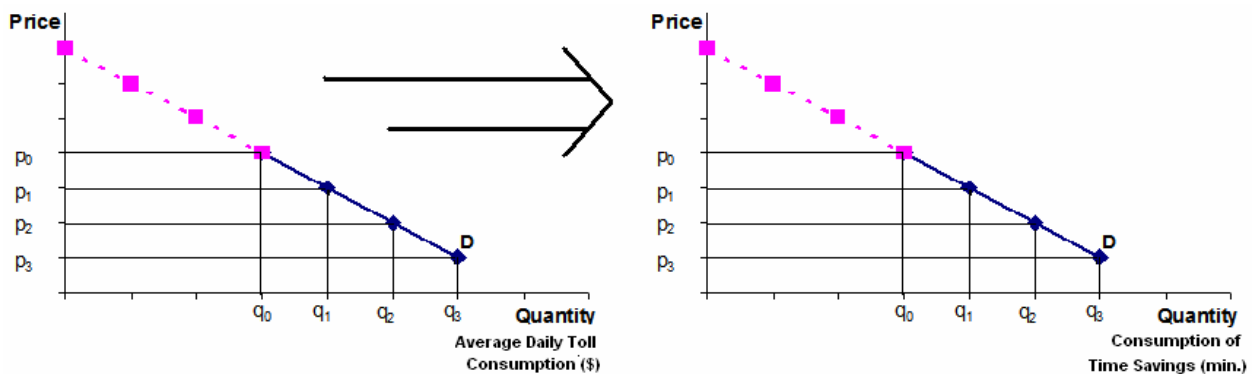


Figure 9: Conversion from Toll Consumption to Time Savings

The process used to calculate the consumer surplus from the consumption of travel time savings is exactly the same as for the consumption of tolls. The consumer surplus triangle is illustrated in Figure 10, where $A=\alpha$, $B=\alpha+\beta$, $C\equiv 1$, and $D=\alpha/\beta$.

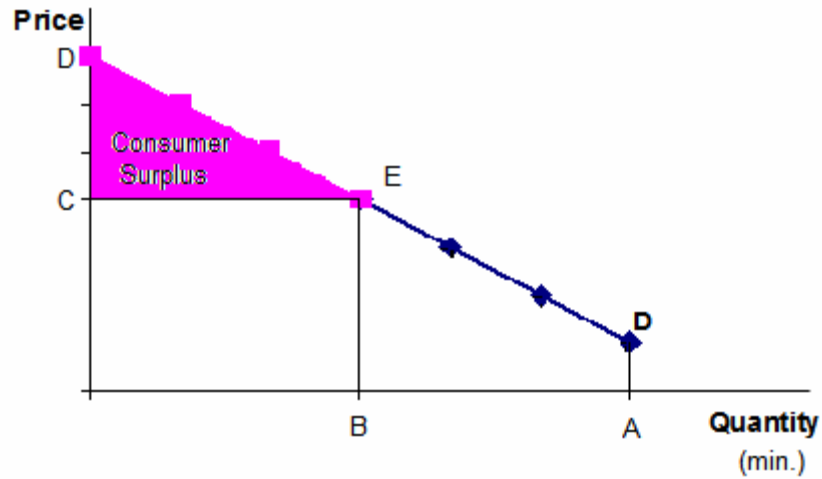


Figure 10: Consumer Surplus Estimation

Equation 9 presents the formula used to calculate the area of the consumer surplus triangle.

$$\Delta DCE = [((\alpha/\beta)-1) X (\alpha+ \beta)]/2 \quad (9)$$

Again, the area of this consumer surplus triangle is identically equal to the WTP for travel time savings by construction.

3. Sample Selection and Stratified Demographics

Based on our recruitment process, we will also consider sample selection in our analysis. Sample selection can occur for a number of reasons and we are able to statistically measure the likelihood of subjects selecting into our study based on the individual demographics collected in

the HHR sessions. One factor that may have affected subjects' choice to participate in our study is that two female graduate students were involved in the recruitment process. This could have resulted in more or less males or females signing up for the study since the choice of recruiter may have an influence on subjects' participation decisions. Also, we did not recruit subjects from every HHR session, and our sample selection estimates are based on the demographic information of subjects from all of the HHR sessions. Moreover, if a certain group of individuals such as "Catholics" or "Rich" (as characterized by HHR) has a high or low value of time savings and are more or less likely to select into our study, then sample selection may bias our estimates. Lastly, by stratifying our demographics, we can analyze the interaction between individual characteristics and the price one is willing to pay for time savings. Our statistical estimates of individual WTP for travel time savings are presented in Section V.

SECTION V RESULTS

1. Distance and Time Estimates: Actual vs. Online

Following the procedure designed in Section III, distance and time measurements were generated for the most commonly traveled toll segments and the corresponding non-toll alternative routes. These measurements were taken between the hours of 10:00 am and 4:00pm for the three most commonly traveled segments of the toll roads.¹⁶ The measurements from the test-driver’s actual drive are presented in Table 2. Not surprisingly, the distance estimates obtained from Google Directions were exactly the same as the test-driver’s actual distance measurements *for every toll-road segment and every non-toll alternative route*.

| | Google Distance | | Actual Distance | | Google Time | | Actual Time | |
|------------------|-----------------|---------------|-----------------|---------------|---------------|---------------|---------------|---------------|
| | Toll | Non Toll | Toll | Non Toll | Toll | Non Toll | Toll | Non Toll |
| Segment 1 | 15.7 miles | 13.3 miles | 15.7 miles | 13.3 miles | 22 minutes | 26 minutes | 17 minutes | 29 minutes |
| Segment 2 | 10.6 miles | 11.5 miles | 10.6 miles | 11.5 miles | 13 minutes | 20 minutes | 10 minutes | 22 minutes |
| Segment 3 | 5.0 miles | 4.0 miles | 5.0 miles | 4.0 miles | 5 minutes | 7 minutes | 5 minutes | 9 minutes |

Table 2: Actual vs. Google Distance and Time Measurements

The test-driver’s time measurements varied consistently from the estimates obtained from Google Directions. For *every* toll road segment, Google overestimates the travel time actually obtained by the test-driver by an average of four minutes. In other words, according to Google a given trip on a toll road should take approximately four minutes longer than it actually does.

¹⁶ Appendix G contains the Expressway System Map which highlights these three routes.

Alternatively, Google consistently underestimated the travel time for non-toll roads by an average of two minutes.

There are a number of explanations for why the Google estimates varied from the test-driver's measurements. The most likely explanation is that Google calculates travel times for toll and non-toll roads by dividing the speed limit (miles per hour) by the distance (in miles) for a given segment or route. This would explain the overestimation of travel time on toll road segments since motorists tend to exceed the speed limit on the less congested toll roads.¹⁷

Google's underestimation of travel time for non-toll roads can be explained in the same way. If Google uses only the speed limit in calculating the expected travel times on non-toll routes, without accounting for factors such as congestion and the number of traffic lights, then Google's travel time calculations would tend to underestimate the actual travel time. This is because motorists cannot maintain the speed limit when congestion and traffic lights are present.

Overall, Google's overestimation of travel time for toll roads and underestimation for non-toll roads increased as the distance of the segment or route increased. In other words, for very short segments, Google time estimates had little variance from the estimates obtained by the test-driver. But as the length of the segment or route increased, Google tended to increasingly overestimate the travel time on toll-roads and underestimate the travel time on non-toll roads.

The largest difference between Google travel time estimates and actual travel time measurements occurred for the longest toll road segment and corresponding non-toll alternative route. In this case, the difference in travel time was five minutes on the toll road segment and

¹⁷ Although not reported here, speeding by motorists can actually be verified from the data set we collected from subjects since the distance (in miles) and time (in seconds) are recorded for every segment between toll plazas.

three minutes on the non-toll route. Table 3 provides a sample calculation for the longest toll road segment and corresponding non-toll alternative route.

| | Toll Road Segment | Non-Toll Alternative Route |
|-------------------------------------|---------------------------|-----------------------------------|
| Actual Travel Time | 17 minutes | 29 minutes |
| Google Travel Time | 22 minutes | 26 minutes |
| Total Variance | 5 minutes | 3 minutes |
| Average of Actual and Google | 19.5 minutes | 27.5 minutes |
| Estimated Time Savings | $27.5 - 19.5 = 8$ minutes | |

Table 3: Segment 1 Time Savings Calculation

A second reason that the time estimates may have differed between Google and actual travel times is because there is only one data point for the actual travel times: there was only one person in the “army” of test-drivers. In a more complete analysis, where the number of test-drivers is sufficiently large, the Google estimates may not be needed. The reason for incorporating the Google estimates during the Pilot study is to reduce the estimation error associated with having calculations from only one test-driver.

By averaging Google estimates with actual travel times, we are able mitigate the discrepancy between the two estimates. Then we compare the averages from the toll road segments to the averages of the non-toll alternative routes to estimate the amount of time saved by taking the toll road instead of the non-toll alternative. This estimate of time savings is entered

into the conversion formula developed in Section III in order to convert dollars spent on tolls to dollars spent on travel time savings. In principle this conversion could have been undertaken using more segment-specific and time-specific measurements of time savings.

2. Sample Selection Results

The demographic variables used for our analysis are defined in Table 4, along with each variable’s description. Apart from Age and Age 18, which are measured in years, each variable is coded as a binary variable taking on values of 0 or 1.

| Variable name | Variable Description |
|---------------|--|
| Age | Age of the subject in years |
| Age18 | Number of years over the age of 18 |
| Female | Female |
| NonWhite | African, African-American, Asian, Asian-American Hispanic, Hispanic-American, Mixed Race, Other |
| Business | Major is Business Administration |
| Rich | Own income or parental income >\$80k in 2006 |
| GPALow | Low GPA (below 3.24) |
| Work | Work full-time or part-time |
| Catholic | Catholic religious beliefs |
| OthChristian | Other Christian religious beliefs |

Table 4: Variable Names and Descriptions

Table 5 presents the descriptive statistics of the subjects who selected into our study from the HHR sessions. The mean age of subjects in our study was 21, the youngest subject was 18, and the oldest subject was 28 years old. Therefore, the minimum and maximum values for Age18 are 0 and 10 respectively. The mean of Age18 can be interpreted as the number of years subjects are over the age of 18 on average.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|--------------|-----|----------|-----------|-----|-----|
| Age | 31 | 21.25806 | 1.843326 | 18 | 28 |
| Age18 | 31 | 3.258065 | 1.843326 | 0 | 10 |
| Female | 31 | .4193548 | .5016103 | 0 | 1 |
| NonWhite | 31 | .3225806 | .475191 | 0 | 1 |
| Business | 31 | .4193548 | .5016103 | 0 | 1 |
| Rich | 31 | .3870968 | .4951376 | 0 | 1 |
| GPAlow | 31 | .483871 | .5080005 | 0 | 1 |
| Work | 31 | .483871 | .5080005 | 0 | 1 |
| Catholic | 31 | .4516129 | .5058794 | 0 | 1 |
| OthChristian | 31 | .2258065 | .4250237 | 0 | 1 |

Table 5: Descriptive Statistics of Subjects in Our Study

As Table 5 illustrates, 41% of our subjects are female, 32% are non-white, 41% are business majors, 38% have an annual income over \$80k, 48% have low GPAs, 48% work, 45% are Catholic and 22% are of a non-Catholic Christian religion. We compare these percentages to the group of students who did not select into our study in order to determine the extent to which sample selection may be present. Table 6 presents the comparable descriptive statistics for the subjects that did not select into our study but had the opportunity to do so.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|--------------|-----|----------|-----------|-----|-----|
| Age | 68 | 22.38235 | 3.878873 | 18 | 36 |
| Age18 | 68 | 4.382353 | 3.878873 | 0 | 18 |
| Female | 68 | .3970588 | .4929263 | 0 | 1 |
| NonWhite | 68 | .3676471 | .4857495 | 0 | 1 |
| Business | 68 | .5 | .5037175 | 0 | 1 |
| Rich | 68 | .4705882 | .5028453 | 0 | 1 |
| GPAlow | 68 | .6470588 | .4814377 | 0 | 1 |
| Work | 68 | .4852941 | .5034996 | 0 | 1 |
| Catholic | 68 | .2205882 | .4177262 | 0 | 1 |
| OthChristian | 68 | .3088235 | .4654432 | 0 | 1 |

Table 6: Descriptive Statistics for Subjects Not in Our Study

By comparison, the group of subjects that did not select into our study contained individuals very slightly older in age, slightly fewer females, more non-whites, more business majors, more individuals with income over \$80k, more individuals with a low GPA, the same percentage of working individuals, fewer Catholics, and more individuals with other Christian

beliefs. Individuals with very high income were less likely to select into our study. Thus, if the “rich” in our study have a high value of time savings, then our sample estimates of the value of time may be biased downward since fewer “rich” subjects were represented in our sample. On the other hand, “Catholics” were more likely to select into our study. Thus, if the “Catholics” have a high value of time savings, then our sample estimates may be bias upward since a high percentage of “Catholics” selected into our study.

We will use a simple probit model to identify the effect that demographic characteristics have on selection into our study. The overall probability of subjects selecting into our study from the HHR experiments is 27%. Table 7 reports the estimated effect of each demographic characteristic on the decision to select into the study. The “X” column is the average sample value for the characteristic.

| Variable | dy/dx | Std. Err. | z | P> z | [| 95% C.I. |] | X |
|-----------|-----------|-----------|-------|-------|----------|----------|---|---------|
| Age18 | -.0278414 | .01764 | -1.58 | 0.115 | -.062419 | .006736 | | 4.0303 |
| Female* | -.0480638 | .1072 | -0.45 | 0.654 | -.258168 | .16204 | | .40404 |
| NonWhite* | -.1191529 | .10358 | -1.15 | 0.250 | -.322162 | .083856 | | .353535 |
| Business* | -.0475284 | .10195 | -0.47 | 0.641 | -.247338 | .152282 | | .474747 |
| Rich* | -.1260563 | .09847 | -1.28 | 0.201 | -.319058 | .066945 | | .444444 |
| GPAlow* | -.1408883 | .10724 | -1.31 | 0.189 | -.35107 | .069294 | | .59596 |
| Work* | -.0322576 | .09847 | -0.33 | 0.743 | -.225249 | .160734 | | .484848 |
| Catholic* | .2746702 | .12318 | 2.23 | 0.026 | .033237 | .516104 | | .292929 |
| OthChr~n* | -.0170593 | .11995 | -0.14 | 0.887 | -.252158 | .21804 | | .282828 |

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table 7: Estimated Marginal Effects of Demographic Characteristics

Since the probit estimator is a nonlinear function of demographic characteristics, it is difficult to directly interpret the coefficients on the individual characteristics that discretely come from the estimated model. Therefore, Table 7 reports the *marginal effects* from the probit

estimation of (dy/dx) . For all individual characteristics with an asterisk, (dy/dx) represents the effect on the estimated probability of selection into the experiment from a discrete change of the dummy variable from 0 to 1. For Age18, (dy/dx) represents the marginal change about the mean age (in years over 18) of 4.0303. The only individual characteristic that is statistically significant at the 5% or 10% level from Table 7 is “Catholic”. The coefficient of “Catholic” from Table 7 can be interpreted to mean that individuals who are Catholic are 27.5% more likely to select into our study than those who are non-Catholic. Thus, we must consider the possibility of sample selection bias resulting from this characteristic when we examine the final results.

3. Individual WTP for Travel Time Savings

The raw data used in our main econometric regression is presented in Table 8. The column “id” is the randomly assigned subject identification number, “subs_” is the treatment period which is either before the subsidy or during the subsidy, “Paid” is the dollar amount paid in tolls for the whole period, “Days” is the number of days in each period, “Spaid” is the average daily payment in dollars on tolls during the period, “Convert” is the conversion factor between toll expenditures and minutes saved (in minutes per dollar), “Ssaved” is the daily minutes saved during the period, “Subsidy” is the percentage subsidy offered, and “Price” is the pre-subsidy price of tolls normalized to 1.

There are a few noteworthy observations here. First, there is one subject that selected into our study but did not use the toll roads at all and therefore had no historical or subsidized toll usage data. Therefore, our results from here on are for a total of 30 subjects. Second, there are three subjects who did not use the toll roads at all during the subsidized month. These are subjects #370, #475 and #782 and are therefore referenced only in the “Before Subsidy” row in

Table 8. Although the reason for the inactivity remains unknown, it is possible that these subjects were out of town during this time. Lastly, there are two subjects, #372 and #1338, that received new transponders at the beginning of the study, and therefore had no historical data on their usage of toll roads. These subjects are therefore only referenced in the “Subsidized” row in Table 8. The remaining subjects presented in Table 8 have both “Before Subsidy” and “Subsidized” observations of toll road usage.

| id | subs_ | Paid | Days | Spaid | Convert | Ssaved | Subsidy | Price |
|------|----------------|-------|------|----------|---------|----------|---------|-------|
| 164 | Before subsidy | 39 | 107 | .364486 | 6.3 | 2.296262 | 0 | 1 |
| 164 | Subsidized | 21 | 31 | .6774194 | 6.3 | 4.267742 | 36 | .64 |
| 267 | Before subsidy | 199.5 | 107 | 1.864486 | 6.3 | 11.74626 | 0 | 1 |
| 267 | Subsidized | 71.25 | 31 | 2.298387 | 6.3 | 14.47984 | 29 | .71 |
| 309 | Before subsidy | 2.5 | 9 | .2777778 | 6.3 | 1.75 | 0 | 1 |
| 309 | Subsidized | 38 | 31 | 1.225806 | 6.3 | 7.722581 | 23 | .77 |
| 370 | Before subsidy | 39.5 | 95 | .4157895 | 6.3 | 2.619474 | 0 | 1 |
| 372 | Subsidized | 53.5 | 31 | 1.725806 | 6.3 | 10.87258 | 17 | .83 |
| 474 | Before subsidy | 81.15 | 392 | .2070153 | 6.3 | 1.304196 | 0 | 1 |
| 474 | Subsidized | 18.3 | 31 | .5903226 | 6.3 | 3.719032 | 26 | .74 |
| 475 | Before subsidy | 1 | 73 | .0136986 | 6.3 | .0863014 | 0 | 1 |
| 515 | Before subsidy | 60.4 | 101 | .5980198 | 6.3 | 3.767525 | 0 | 1 |
| 515 | Subsidized | 33.25 | 31 | 1.072581 | 6.3 | 6.757258 | 32 | .68 |
| 578 | Before subsidy | 66.4 | 385 | .1724675 | 6.3 | 1.086545 | 0 | 1 |
| 578 | Subsidized | 7.4 | 31 | .2387097 | 6.3 | 1.503871 | 38 | .62 |
| 681 | Before subsidy | 69.75 | 383 | .1821149 | 6.3 | 1.147324 | 0 | 1 |
| 681 | Subsidized | 44.35 | 31 | 1.430645 | 6.3 | 9.013064 | 25 | .75 |
| 719 | Before subsidy | 49.5 | 391 | .1265985 | 6.3 | .7975703 | 0 | 1 |
| 719 | Subsidized | 21.75 | 31 | .7016129 | 6.3 | 4.420161 | 28 | .72 |
| 782 | Before subsidy | 36.25 | 43 | .8430232 | 6.3 | 5.311047 | 0 | 1 |
| 887 | Before subsidy | 93.75 | 385 | .2435065 | 6.3 | 1.534091 | 0 | 1 |
| 887 | Subsidized | 2.5 | 31 | .0806452 | 6.3 | .5080645 | 14 | .86 |
| 1196 | Before subsidy | 54 | 380 | .1421053 | 6.3 | .8952632 | 0 | 1 |
| 1196 | Subsidized | 15 | 31 | .483871 | 6.3 | 3.048387 | 32 | .68 |
| 1338 | Subsidized | 6.5 | 30 | .2166667 | 6.3 | 1.365 | 25 | .75 |
| 1442 | Before subsidy | 48.5 | 109 | .4449541 | 6.3 | 2.803211 | 0 | 1 |

| | | | | | | | | |
|-------|----------------|-------|-----|----------|-----|----------|----|-----|
| 1442 | Subsidized | 46 | 31 | 1.483871 | 6.3 | 9.348388 | 19 | .81 |
| 1543 | Before subsidy | 54.15 | 99 | .5469697 | 6.3 | 3.445909 | 0 | 1 |
| 1543 | Subsidized | 11.55 | 30 | .385 | 6.3 | 2.4255 | 31 | .69 |
| 1648 | Before subsidy | 7.5 | 25 | .3 | 6.3 | 1.89 | 0 | 1 |
| 1648 | Subsidized | 13.5 | 31 | .4354839 | 6.3 | 2.743548 | 23 | .77 |
| 1852 | Before subsidy | 53 | 96 | .5520833 | 6.3 | 3.478125 | 0 | 1 |
| 1852 | Subsidized | 10 | 30 | .3333333 | 6.3 | 2.1 | 36 | .64 |
| 1957 | Before subsidy | 75.8 | 392 | .1933674 | 6.3 | 1.218214 | 0 | 1 |
| 1957 | Subsidized | 26.25 | 31 | .8467742 | 6.3 | 5.334678 | 15 | .85 |
| 2058 | Before subsidy | 68.75 | 104 | .6610577 | 6.3 | 4.164664 | 0 | 1 |
| 2058 | Subsidized | 45.5 | 30 | 1.516667 | 6.3 | 9.555 | 18 | .82 |
| 2161 | Before subsidy | 34.5 | 97 | .3556701 | 6.3 | 2.240722 | 0 | 1 |
| 2161 | Subsidized | 7.75 | 30 | .2583333 | 6.3 | 1.6275 | 32 | .68 |
| 2163 | Before subsidy | 24 | 380 | .0631579 | 6.3 | .3978947 | 0 | 1 |
| 2163 | Subsidized | 27 | 31 | .8709677 | 6.3 | 5.487097 | 23 | .77 |
| 13102 | Before subsidy | 92.95 | 382 | .2433246 | 6.3 | 1.532945 | 0 | 1 |
| 13102 | Subsidized | 10.25 | 31 | .3306452 | 6.3 | 2.083065 | 23 | .77 |
| 16110 | Before subsidy | 16.75 | 387 | .0432817 | 6.3 | .2726744 | 0 | 1 |
| 16110 | Subsidized | 14.5 | 31 | .4677419 | 6.3 | 2.946774 | 37 | .63 |
| 16111 | Before subsidy | 90.45 | 387 | .2337209 | 6.3 | 1.472442 | 0 | 1 |
| 16111 | Subsidized | 41.8 | 31 | 1.348387 | 6.3 | 8.494839 | 29 | .71 |
| 17114 | Before subsidy | 14.75 | 382 | .0386126 | 6.3 | .2432592 | 0 | 1 |
| 17114 | Subsidized | 4.5 | 31 | .1451613 | 6.3 | .9145162 | 26 | .74 |
| 19118 | Before subsidy | 50.5 | 392 | .1288265 | 6.3 | .8116072 | 0 | 1 |
| 19118 | Subsidized | 1.25 | 31 | .0403226 | 6.3 | .2540323 | 28 | .72 |
| 19119 | Before subsidy | 41.1 | 384 | .1070312 | 6.3 | .6742969 | 0 | 1 |
| 19119 | Subsidized | 4.5 | 31 | .1451613 | 6.3 | .9145162 | 39 | .61 |
| 21125 | Before subsidy | 54.75 | 384 | .1425781 | 6.3 | .8982422 | 0 | 1 |
| 21125 | Subsidized | 7 | 31 | .2258064 | 6.3 | 1.422581 | 21 | .79 |

Table 8: Raw Subject Data

From these data, one can see the total amount of tolls paid by subjects during the unsubsidized and subsidized periods (Paid), the number of days in each period (Days), the average daily payment in tolls during the respective periods (Spaid), the conversion rate from Equation 6 (Convert), the average daily minutes saved during the period (Ssaved), the amount of

the subsidy (Subsidy) and the resulting price (Price normalized to one less the subsidy- so $Price=1-(Subsidy/100)$).

The summary statistics for the raw data are presented in Table 9. The mean for the treatment period is .49 meaning that most of our subjects had both “Before Subsidy” and “Subsidized” observations. The average dollar amount paid in tolls (Paid) by our subjects is \$38.62 per period. The average number of days per period is 140. The average daily payment in dollars on tolls is \$0.52. The conversion rate is the same (6.3) for all subjects. The number of minutes saved per day by subjects is 3.33 on average. The average subsidy paid across all subjects is 13.18%. Finally, the average price of tolls is \$0.86.

Summary Statistics:

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|----------|-----|----------|-----------|----------|----------|
| subs | 55 | .4909091 | .504525 | 0 | 1 |
| Paid | 55 | 38.62364 | 34.16404 | 1 | 199.5 |
| Days | 55 | 139.6909 | 154.2988 | 9 | 392 |
| Spaid | 55 | .528761 | .522698 | .0136986 | 2.298387 |
| Convert | 55 | 6.3 | 0 | 6.3 | 6.3 |
| Ssaved | 55 | 3.331194 | 3.292997 | .0863014 | 14.47984 |
| Subsidy | 55 | 13.18182 | 14.40562 | 0 | 39 |
| Price | 55 | .8681818 | .1440562 | .61 | 1 |

Table 9: Summary Statistics from Raw Subject Data

For our analysis, we will use a fixed-effects panel regression to estimate the parameters α and β . Fixed effects regression is a method for controlling for omitted variables in panel data when the omitted variables vary across entities (individuals) but do not change over time. Examples of such individual characteristics are race, gender and religion. By assuming fixed-effects, we are imposing time independent effects for each observation such that any changes in

the dependent variable must be due to influences other than these fixed characteristics. Table 10 presents the results of the fixed-effects panel regression.

Here, “R-sq overall” can be interpreted as the fraction of the variation in Quantity that is explained by the variation in Price. There were 30 subjects who provided us with 55 observations: 25 subjects had 2 observations and 5 subjects had only one observation. The F-statistic tests that the coefficients on the individual characteristics such as race, religion, and gender are all jointly zero. Our model is statistically significant at the 1% level, with a p-value of 0.0008.

| | | | |
|-----------------------------------|----------------------|---|--------|
| Fixed-effects (within) regression | Number of obs | = | 55 |
| Group variable: id | Number of groups | = | 30 |
| R-sq: within = 0.3414 | Obs per group: min = | | 1 |
| between = 0.0000 | avg = | | 1.8 |
| overall = 0.0748 | max = | | 2 |
| corr(u_i, Xb) = -0.0587 | F(1, 29) | = | 13.93 |
| | Prob > F | = | 0.0008 |

(Std. Err. adjusted for 30 clusters in id)

| Ssaved | Coef. | Robust Std. Err. | t | P> t | [95% Conf. Interval] | |
|--------|-----------|---------------------|-------|-------|----------------------|-----------|
| Price | -7.410722 | 1.985476 | -3.73 | 0.001 | -11.47148 | -3.349967 |
| _cons | 9.765048 | 1.723754 | 5.66 | 0.000 | 6.239575 | 13.29052 |

| | |
|---------|--|
| sigma_u | 2.9722708 |
| sigma_e | 2.0931205 |
| rho | .6684849 (fraction of variance due to u_i) |

Table 10: Fixed-Effects Panel Regression

The term “_cons” is the coefficient estimate of the constant term which corresponds to α in our regression equation. This value can be thought of as the amount of tolls that would be consumed if price = 0. The coefficient estimate of the “Price” term corresponds to β in our regression equation. The Price coefficient -7.41 can be interpreted as the change in Q, the

average daily time savings, given a one unit change in the pre-subsidized price of tolls. Thus, when the subsidy is equal to zero, $Q=9.76-7.41(1)= 2.35$ minutes of time savings per day. If the subsidy was equal to 25%, then $Q=9.76-7.41(.75)=4.2$ minutes of time savings per day. The p-values of the Price and constant coefficient estimates are 0.001 and 0.000 respectively, which indicates that these estimates differ significantly from zero. The negative coefficient on the Price variable suggests a downward sloping demand curve. This downward sloping demand curve is consistent with our theoretical priors about the law of supply. The coefficients “sigma_u” corresponds to the panel-level standard deviation and “sigma_e” corresponds to the standard deviation of the error term ϵ .

Table 11 reports the consumer surplus, which is derived from the panel regression from Table 10 above. Here, the consumer surplus is calculated from the formula presented in Equation 9.

| Ssaved | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|---------|----------|-----------|------|-------|----------------------|----------|
| base | 2.354326 | .2617219 | 9.00 | 0.000 | 1.819045 | 2.889608 |
| height | .3176919 | .1204325 | 2.64 | 0.013 | .0713798 | .564004 |
| csMIN | .3739752 | .1833421 | 2.04 | 0.051 | -.0010016 | .748952 |
| csHOURL | 22.43851 | 11.00053 | 2.04 | 0.051 | -.0600945 | 44.93712 |

Table 11: Consumer Surplus Estimates

The consumer surplus in Table 11, labeled as CSmin, is calculated from the base and height of the consumer surplus triangle, using the Delta Method (Oehlert, 1992). The Delta Method is a method in statistics used to calculate a non-linear function of estimated coefficients whereby the standard errors are carried along correctly on each of the individual coefficients. CShour is calculated simply by multiplying the CSmin by a factor of 60 in order to convert from minutes into hours. The result of our first hypothesis test from Table 11 is that our subjects’

average value of saving an hour of time is \$22.43. This value is significant at the 5.1% level.

Thus, we can reject the hypothesis that WTP for travel time savings is zero, in favor of it being positive.

In order to test our second hypothesis, that the average wage rate is equal to the WTP for travel time savings, we first calculate the average hourly wage rate of the subjects in our sample. This figure is calculated by adding every individual's hourly wage rate and then dividing that total by the number of subjects in our sample. There were a total of nine non-working individuals who were assigned an hourly wage rate of zero and included in this calculation. Table 12 presents the statistical test of hypothesis two. Here, CSHOURdiff is the estimator for the difference between the average wage rate (\$7.77 per hour) and the CShour used earlier to estimate the WTP for travel time savings (\$22.43 per hour).

| Ssaved | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] |
|------------|----------|-----------|------|-------|----------------------|
| CSHOUR | 22.43851 | 11.00053 | 2.04 | 0.051 | -.0600945 44.93712 |
| CSHOURdiff | 14.66851 | 11.00053 | 1.33 | 0.193 | -7.830095 37.16712 |

Table 12: Difference Between the Wage Rate and Consumer Surplus

The p-value for the CSHOURdiff coefficient estimate is .193 which can be interpreted using a one-sided hypothesis test. In this case, the correct p-value is $.193/2=.965$ which is differs significantly from zero at the 10% level. *Therefore, individual WTP for travel time savings (\$22.43) is significantly greater than (\$7.77) the average wage rate of individuals in our sample.*

4. Stratified Demographics

The stratified demographic characteristics of our sample are presented in Table 13. Note that none of the p-values here are statistically significant. It is most likely the case that the p-values here are not statistically significant due to the small number of subjects present in our

sample. Nevertheless, these data can still give us some idea about the value of time savings for each demographic characteristic.

| Strat. Variable | Value | Ssaved | Coefficient | Std. Error | z | P> z | Lower CI | Upper CI |
|-----------------|----------------------------|--------|-------------|------------|------|-------|-----------|----------|
| Female=0 | Male | CSHour | 12.22217 | 8.326135 | 1.47 | 0.160 | -5.344438 | 29.78878 |
| Female=1 | Female | CSHour | 48.65928 | 39.04402 | 1.25 | 0.239 | -37.27603 | 134.5946 |
| Nonwhite=0 | NonWhite | CSHour | 24.97334 | 14.59254 | 1.71 | 0.103 | -5.569203 | 55.51588 |
| Nonwhite=1 | White | CSHour | 18.23533 | 17.41419 | 1.05 | 0.322 | -21.15831 | 57.62897 |
| Business=0 | Nonbusiness Major | CSHour | 12.51264 | 9.463439 | 1.32 | 0.205 | -7.548954 | 32.57423 |
| Business=1 | Business Major | CSHour | 43.335 | 27.80067 | 1.56 | 0.145 | -17.23746 | 103.9075 |
| Rich=0 | Not Rich | CSHour | 15.45508 | 9.761673 | 1.58 | 0.132 | -5.140244 | 36.05041 |
| Rich=1 | Rich | CSHour | 35.77225 | 29.08581 | 1.23 | 0.244 | -28.24518 | 99.78969 |
| GPALow=0 | High GPA | CSHour | 13.91444 | 12.43714 | 1.12 | 0.282 | -12.76058 | 40.58946 |
| GPALow=1 | Low GPA | CSHour | 32.71823 | 18.80878 | 1.74 | 0.104 | -7.622587 | 73.05905 |
| Work=0 | Not Working | CSHour | 18.38819 | 12.72074 | 1.45 | 0.169 | -8.725434 | 45.50181 |
| Work=1 | Working | CSHour | 27.87612 | 21.11944 | 1.32 | 0.210 | -17.74967 | 73.5019 |
| Catholic=0 | Non-Catholic | CSHour | 26.69121 | 15.57551 | 1.71 | 0.107 | -6.507216 | 59.88963 |
| Catholic=1 | Catholic | CSHour | 19.30992 | 15.55582 | 1.24 | 0.236 | -14.29638 | 52.91623 |
| OthChristian=0 | Non-Christian or Catholic | CSHour | 21.14919 | 12.43356 | 1.7 | 0.102 | -4.571589 | 46.86996 |
| OthChristian=1 | Christian and Non-Catholic | CSHour | 26.20634 | 14.65405 | 1.79 | 0.134 | -11.4631 | 63.87578 |

Table 13: Stratified Demographic Characteristics

Table 13 reveals the value of time savings for each individual characteristic. According to our estimates, females have a much higher value of time than males, whites seem to value their time more than non-whites, business majors value their time much more highly than non-business majors, the “rich” value their time more than twice as much as “non-rich”, individuals with a low GPA seem to value their time more than those with a high GPA, the working

individuals value their time more than those who do not work, non-Catholics value their time more than Catholics, and other-Christians value their time more than non-Christian individuals.

Some of these results are rather intuitive. For example, it seems obvious that individuals who work, are “rich,” and that are business majors would value their time more than those who do not work, are not rich, and are not business majors. Some of the other characteristics are less obvious, but no concrete statistical inferences can be made about the demographics do to the lack of statistical significance. We believe this to be the result of having a small sample size of subjects in the pilot study.

By calculating the t-statistic, to test the null hypothesis that the mean estimates are the same for each of the individual characteristics presented in table 13, we are able to more formally test for significant differences between these characteristics. The results of these t-tests are presented in Table 14:

| Strat. Variable | Value | Nobs | Coefficient | Std. Error | Significance of t-test |
|-----------------|----------------------------|------|-------------|------------|------------------------|
| Female=0 | Male | 17 | 12.22217 | 8.326135 | 0.011 |
| Female=1 | Female | 11 | 48.65928 | 39.04402 | |
| Nonwhite=0 | NonWhite | 19 | 24.97334 | 14.59254 | 0.332 |
| Nonwhite=1 | White | 9 | 18.23533 | 17.41419 | |
| Business=0 | Nonbusiness Major | 14 | 12.51264 | 9.463439 | 0.0018 |
| Business=1 | Business Major | 13 | 43.335 | 27.80067 | |
| Rich=0 | Not Rich | 17 | 15.45508 | 9.761673 | 0.046 |
| Rich=1 | Rich | 11 | 35.77225 | 29.08581 | |
| GPAlow=0 | High GPA | 13 | 13.91444 | 12.43714 | 0.0053 |
| GPAlow=1 | Low GPA | 14 | 32.71823 | 18.80878 | |
| Work=0 | Not Working | 15 | 18.38819 | 12.72074 | 0.173 |
| Work=1 | Working | 13 | 27.87612 | 21.11944 | |
| Catholic=0 | Non-Catholic | 13 | 26.69121 | 15.57551 | 0.229 |
| Catholic=1 | Catholic | 14 | 19.30992 | 15.55582 | |
| OthChristian=0 | Non-Christian or Catholic | 21 | 21.14919 | 12.43356 | 0.46 |
| OthChristian=1 | Christian and Non-Catholic | 6 | 26.20634 | 14.65405 | |

Table 14: T-Test of Individual Characteristics

The “Significance of t-test” column provides the estimates of the p-values for each individual characteristic. At the 10% level of significance, we can reject the assumption that there is no difference between Females and Males, Business Majors and Non-business Majors, Rich and non-Rich, and individuals with a low GPA and individuals with a high GPA since all of these characteristics are statistically significant. In other words, there is a statistically significant difference in WTP for time savings between Females and Males, Business Majors and non-Business Majors, Rich and non-Rich, and individuals with a low GPA and Individuals with a high GPA. On the other hand, there is no statistically significant difference between Whites and non-Whites, Workers and non-Workers, Catholics and non-Catholics and Other-Christians and non-Christian, non-Catholic individuals since these characteristics were not statistically significant.

The overall result of our hypotheses is that individuals are willing to pay positive amounts of money to save time. The amount they are willing to pay (\$22.43) is greater than the average hourly wage rate of individuals in our sample (\$7.77). Additionally, we can reject the null hypothesis that WTP for travel time savings is homogeneous across demographics such as gender, college major, income level, and GPA. These results provide sufficient reason to expand beyond the limitations of this study to conduct a more complete analysis of individual willingness to pay for travel time savings.

SECTION VI CONCLUSION AND EXTENSIONS

The objective of this pilot study was to create a replicable data set using observations from a framed field experiment for the purpose of exploring a variety of new methods for eliciting the WTP for travel time savings. Due to the methodological nature of this study, we made several simplifying assumptions and limited the statistical analysis to strictly estimating the WTP for travel time savings. We conclude by reviewing the simplifying assumptions made within the study and offer extensions of how our data set can be replicated in the future for more complete analysis.

For the purpose of estimating WTP for travel time savings, we assumed that the demand curve was linear and continuous. We extrapolated the upper half of the demand curve in order to calculate the consumer surplus gained from time savings. We assumed that this consumer surplus is exactly equal to the WTP for travel time savings. We discussed the problems that may arise when predicting out-of-sample and we use confidence intervals in our study to estimate the upper and lower bounds of WTP for travel time savings. Our recommendation for future studies is to use larger sample sizes in order to mitigate the prediction errors associated with predicting out of sample.

Additional simplifications were implemented within the experimental design. The number of “army” of test-drivers was equal to one for this pilot study. We recommend that a group of test-drivers record distances and times for randomly determined origins and destinations as described in the experimental design in Section III. This would help to ensure more precise measurements: having multiple test-drivers record distance and time measurements for the same routes would mitigate possible recording error, traffic congestion and/or any other unusual

occurrences on a given route. Additionally, this pilot study uses distance and time measurements for the *most commonly traveled* routes. For a more complete analysis, we recommend collecting measurements for *all* toll-road segments and their corresponding non-toll alternative routes whenever possible. Moreover, we suggest providing a subsidy over a longer period of time. This pilot study subsidized subjects for one month due to time restrictions, but for a more extensive analysis, more observations on subjects consumption of subsidized tolls would be crucial.

The experimental design of this pilot study demonstrated a sound method of creating a replicable data set in an empirical setting. Using the documents and procedures contained in Section III and the appendices of this thesis, one can replicate this study on a larger scale to create a data set that will not only provide estimates of WTP for time savings, but will also elicit information on individual risk attitudes, discount rates, and demographics. These data can then be used in more extensive analyses to account for subjects' perception of safety and reliability, monetary discounting, and to test whether individual characteristics have a significant impact on transportation choices. Thus, we see these data as providing the basis for a wide range of analyses into the determinants of the value of time, the value of access to toll roads over non-toll roads, and the pricing of time sensitive attributes in general.

Our findings show that the proposed field experiment is feasible, and that a sample of college students places a value of \$22.43 on an hour of time. This estimated value is significantly greater than zero and significantly greater than the average hourly wage rate of our subjects. Moreover, we find that the WTP for travel time savings varies across certain demographics. These findings provide sufficient reason to expand this study to a broader range

of subjects in order to conduct a more complete analysis of individual willingness to pay for travel time savings.

APPENDIX A
RECRUITMENT DOCUMENTS

DETAILS OF STUDY

Good Afternoon, I'd like to take a moment to tell you about a separate study you might be interested in.

We are conducting a study on the use of toll roads in Central Florida. If you decide to participate, you will be paid every month in cash to let us collect data on your use of toll roads, and have a percentage of your monthly toll expenses paid for by us. This percentage will be randomly determined and will vary from person to person depending on the roll of a die.

If you sign up today, you are only agreeing to a 15 minute information session, at which point you can opt "in" or "out" of this study. If you opt "in" you will provide us with some basic information about yourself, take a short questionnaire, complete a decision task, and be compensated with a minimum of \$25 in addition to the monthly compensation we will pay you for collecting data on your use of toll roads.

All data collected will be confidential and will in no way be associated with your personal information or Social Security Number. Some of your decisions from today's tasks will be used for this study as well.

If you do not currently have an E-pass or Sunpass account, don't worry. We have made arrangements to pay for a new transponder for a few individuals who do not already have an account.

If you would like to sign up for a 15 minute information session, please sign up for a specific time and day on the appointment sheet provided. If you are not able to attend either of these days, please provide your name and email address so that we can contact you to schedule an appointment.

Thank you for your time. Does anyone have any quick questions?

**CHECKLIST OF INFORMATION AND DOCUMENTATION
NEEDED FOR RESEARCH STUDY**

Please have the following with you:

- Social Security Number (Last four digits)
- Photo Identification
- Email address
- Mailing address where you want your money sent
- Access to your E-pass/Sunpass account*, including user name and password. We will not ask you to give us this information; you only need it to log yourself in.

*(unless you are new to E-pass/Sunpass)

Room 303M, BAI

Day _____

Time _____

APPOINTMENT SIGN-UP SHEET

Meeting

ROOM 303M

Date:

| | First and Last Name | Email Address | ID # | Phone Number | Do you currently have Epass/Sunpass? |
|---------|----------------------------|----------------------|-------------|---------------------|--------------------------------------|
| 9:00 AM | | | | | |
| 9:15 | | | | | |
| 9:30 | | | | | |
| 9:45 | | | | | |
| 10:00 | | | | | |
| 10:15 | | | | | |
| 10:30 | | | | | |
| 10:45 | | | | | |
| 11:00 | | | | | |
| 11:15 | | | | | |
| 11:30 | | | | | |

APPENDIX B
INDIVIDUAL SESSION FORMS

DESCRIPTION OF STUDY

We are conducting a study on the use of toll roads in Central Florida. If you decide to participate, you will be paid in cash to let us collect data on your use of toll roads, and have a percentage of your monthly toll expenses paid for by us. This percentage will be randomly determined and will vary from person to person depending on the roll of a die. If you agree to participate, we will roll the die here today, and you will know the percentage that applies to your toll expense.

All data collected will be confidential and will in no way be associated with your personal information or Social Security Number. Some of your decisions from the last experiment you participated in will be used for this study as well.

If you do not currently have an E-pass or Sunpass account, don't worry. We have made arrangements to pay for a new transponder for a few individuals who do not already have an account.

Next, we will show you a set of instructions so that you can see exactly what is asked of you during the study. At that point, you can opt "in" or "out" of the study.

Do you have any questions at this point?

INSTRUCTIONS FOR STUDY

SID _____

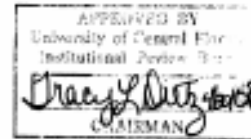
1. Attend Initial Session where you will provide Name, email, mailing address, last four digits of SSN, and phone number.
 - Sign consent form
 - Perform a task which pays a minimum of \$25
 - Take a short paper survey
 - Log into your E-pass/Sunpass account, if you have an existing account. Email us your statements from July, August and September.
 - Roll a die to determine your subsidy percentage for the next month. The subsidy applies to monthly toll road usage and does not apply to parking or any other service E-pass/Sunpass may provide. The total amount paid for the subsidy will not exceed \$100.

2. At the end of one month, email us the statement from your online E-pass account ***in EXCEL format (.CSV)***. Sunpass users will need to email their statements in comparable spreadsheet format.
 - You will receive \$10 plus the subsidy percentage determined today, for the one month that we receive your statements.
 - This money will be paid to you in cash if you visit the office located in room **303A** during office hours stated below, or by check via US mail at your request. If you do not pick up your cash within two weeks of payout availability, a check will be sent to the address you provide us.

If you would like to address any questions or concerns, you may contact the researchers at UCFResearch@gmail.com and/or schedule an appointment.

| | | |
|---------------------|---------------|-------------|
| | | |
| Subsidy | Subsidy Dates | |
| | | |
| Student Name | Signature | Date Signed |
| Office Hours: _____ | | |

APPENDIX C
IRB APPROVAL FORM



Department of Economics

Informed Consent Form

The following information is provided so that you can decide whether you wish to participate in the present research study. Even if you agree to participate, you are free to withdraw at any time. Should you decide to withdraw, you will forgo your earnings, however. Your participation is voluntary, and is not a class requirement. You must be 18 years or older to participate.

This study investigates the way in which people make economic decisions. You will receive detailed instructions concerning today's experiment in a moment. You will be asked to answer some descriptive questions about yourself and to make decisions which will affect the payoffs to yourself, and may also affect the payoffs to others that participate in the study. All your decisions will be made in private, and will not be revealed to other participants. Your task will be performed on a computer or by filling in paper forms. We do not expect the experimental session to last more than 1 or 2 hours (whichever you were informed of in the recruitment), and you will be paid in cash at the end of the session. Your payment will depend on your own decisions, possibly on the decisions made by others, and also on chance, and you will be given more detail about this at the start of the experiment. A standard participation fee of \$5 is paid in addition to any earnings you may make in the task itself.

The study does not involve any physical or psychological risks. Be assured that your name will not be associated in any way with the research findings. The data from the experiments will be stored on computers, but completely separate from your personal data. All decisions stored in the data files will have references only to an anonymous participant ID. If you participate in more than one study by the Economics department, your decisions in one task may be linked to your decisions in another task, but this will be done only by linking the anonymous participant ID numbers. Access to your personal information is restricted to UCF researchers using the lab for scientific research purposes and will be used only for tracking your participation and for recruitment purposes. Your responses in these experiments may be collated with the SAT or ACT scores you have on file at UCF, but again there will be no association of this information with your name or SSN after the scores have been collated. Any questions you might have about this project can be sent to econlab@bus.ucf.edu. We guarantee that we are not attempting to deceive any participants in any way during the study. The instructions you will receive will accurately explain the task and how earnings are determined.

Do not hesitate to ask questions about these procedures. At the end of the experiment you may request a brief description of the purpose and results of the experiment. This will be e-mailed to you when the series of experiments are completed in several months. Information regarding your rights as a research volunteer may be obtained from the IRB Coordinator, Institutional Review Board (IRB), University of Central Florida (UCF), 12201 Research Parkway, Suite 501, Orlando, Florida 32826-3246; Telephone: (407) 823-2901.

Sincerely,

Glenn W. Harrison and Elisabet Rutström, Professors of Economics, Principal Investigators

I have read the procedures above. I voluntarily agree to participate in this study, and I have received a copy of this description.

Signature of Subject

Date

Department of Economics, College of Business Administration, UCF
P.O. Box 161400 • Orlando, FL 32816-1400 • Phone: (407) 823-3266
State University System of Florida • An Equal Opportunity and Affirmative Action Institution

APPENDIX D
DISCOUNT RATE TESTS

DECISION TASK

An example of your decision task is shown on the next page. Each decision is a paired choice between an **Option A** and an **Option B**. When presented with the actual decisions we ask that you select your preferred option in each row and record these in the final column.

The decisions all have a similar format. For example, look at Decision 1 at the top of Task I. Option A pays \$25 today and Option B pays \$25.02 fifteen days from now. If you choose Option B you will earn an annual return of 2% on the \$25 you choose to receive 15 days from now. Since this is compounded daily, your annual *effective* interest rate is 2.02%. The annual effective interest rate is the rate earned on the initial balance, \$25 here, plus interest earned on all interest accumulated in the preceding compounding periods. The only difference in the other fourteen decisions is that as you move down the table the payoffs for Option B increase.

We will present you with two tasks of fifteen such decision problems. The only difference between them is that the payment date for Option B will differ. You have a 1-in-15 chance of being paid for one of the decision problems in one of the two sets.

We will select that decision by first rolling a six-sided die numbered 1 to 6 to determine which task is used for your payment. Task I will be used for your payment if the number on the die is 1-3 and Task II will be used if the number on the die is 4-6. Once the task is selected, we will then roll a ten-sided die numbered 1 to 10 and a six-sided die numbered 1 to 6 to determine which decision is used for your payment. In the event that a 6 is rolled for the decision, subject will reroll until a number between 1 and 5 is achieved.

As you will not know in advance which decision will determine your earnings, you should treat each decision as if it is to count for payment.

For the selected decision we will pay you according to your selected option.

You will then receive the money at the date you chose. You will either receive payment today with written confirmation, or you will choose between collecting payment at our office or having a check mailed to your primary address at the specified date.

You may ask any clarification questions at this time.

TASK I.

| Payoff Alternative | Payment Option A (pays amount below today) | Payment Option B (pays amount below in 15 days) | Annual Interest Rate (AR) | Annual Effective Interest Rate (AER) | Preferred Payment Option (Circle A or B) |
|---------------------------|--|---|----------------------------------|---|--|
| 1 | \$25 | \$25.02 | 2.00% | 2.02% | A B |
| 2 | \$25 | \$25.03 | 3.00% | 3.05% | A B |
| 3 | \$25 | \$25.04 | 4.00% | 4.08% | A B |
| 4 | \$25 | \$25.05 | 5.00% | 5.13% | A B |
| 5 | \$25 | \$25.08 | 7.50% | 7.79% | A B |
| 6 | \$25 | \$25.10 | 10.00% | 10.52% | A B |
| 7 | \$25 | \$25.13 | 12.50% | 13.31% | A B |
| 8 | \$25 | \$25.16 | 15.00% | 16.18% | A B |
| 9 | \$25 | \$25.18 | 17.50% | 19.12% | A B |
| 10 | \$25 | \$25.21 | 20.00% | 22.13% | A B |
| 11 | \$25 | \$25.26 | 25.00% | 28.39% | A B |
| 12 | \$25 | \$25.37 | 35.00% | 41.88% | A B |
| 13 | \$25 | \$25.53 | 50.00% | 64.81% | A B |
| 14 | \$25 | \$25.79 | 75.00% | 111.53% | A B |
| 15 | \$25 | \$26.06 | 100.00% | 171.45% | A B |

SID _____

TO _____

TASK II.

| Payoff Alternative | Payment Option A (pays amount below today) | Payment Option B (pays amount below in 30 days) | Annual Interest Rate (AR) | Annual Effective Interest Rate (AER) | Preferred Payment Option (Circle A or B) |
|---------------------------|--|---|----------------------------------|---|--|
| 1 | \$25 | \$25.04 | 2.00% | 2.02% | A B |
| 2 | \$25 | \$25.06 | 3.00% | 3.05% | A B |
| 3 | \$25 | \$25.08 | 4.00% | 4.08% | A B |
| 4 | \$25 | \$25.10 | 5.00% | 5.13% | A B |
| 5 | \$25 | \$25.16 | 7.50% | 7.79% | A B |
| 6 | \$25 | \$25.21 | 10.00% | 10.52% | A B |
| 7 | \$25 | \$25.26 | 12.50% | 13.31% | A B |
| 8 | \$25 | \$25.31 | 15.00% | 16.18% | A B |
| 9 | \$25 | \$25.37 | 17.50% | 19.12% | A B |
| 10 | \$25 | \$25.42 | 20.00% | 22.13% | A B |
| 11 | \$25 | \$25.53 | 25.00% | 28.39% | A B |
| 12 | \$25 | \$25.74 | 35.00% | 41.88% | A B |
| 13 | \$25 | \$26.06 | 50.00% | 64.81% | A B |
| 14 | \$25 | \$26.61 | 75.00% | 111.53% | A B |
| 15 | \$25 | \$27.17 | 100.00% | 171.45% | A B |

SID _____

TO _____

APPENDIX E
QUESTIONNAIRE

QUESTIONNAIRE

SID _____

Past driving: Has anything changed in the past three months that may have changed your driving patterns or preferences? i.e. having a child, being involved in a serious accident, getting a new car, etc.

Have you moved within the past three months?

Does anyone besides you pay for your E-pass/Sunpass account?

Have you changed jobs or taken on an additional job in the past three months?

Do you drive as part of your job?

Do you have any travel plans for the next month? Where to and roughly when?

What is your current wage rate?

_____ per Hour Week or Year?

APPENDIX F
PAYMENT RECEIPTS

SUBJECT RECEIPT FOR FUTURE PAYMENTS

SID: _____

On _____ payment will be available for winnings as follows:

\$ _____ for Decision Task _____, payoff number _____.

Subject may either pick up cash in our office BAI Room 303A during office hours on or after the above specified date, or request to have a check mailed to the address they have provided.

Please initial the box if you would like to have a check mailed to you:

Note: If cash is not picked up within two weeks of availability, a check will automatically be mailed to the address you have provided us.

Signed: _____
Glenn W. Harrison Date

NOTICE: Contact Professor Harrison at UCFResearch@gmail.com if your address changes.

FUTURE PAYMENT COMMITMENT RECEIPT

SID: _____

On _____ payment will be available for winnings as follows:

\$ _____ for Decision Task _____, payoff number _____.

Please initial the box if you would like to have a check mailed to you:

Note: If cash is not picked up within two weeks of availability, a check will automatically be mailed to the address you have provided us.

Signed: _____

Last 4 digitis of SSN: _____

PAYMENT RECEIPT

for Participation in Economics Experiment

Date: _____

I hereby verify that I have participated in an Economics Experiment on the date stated above and that I was paid the following amount in compensation:

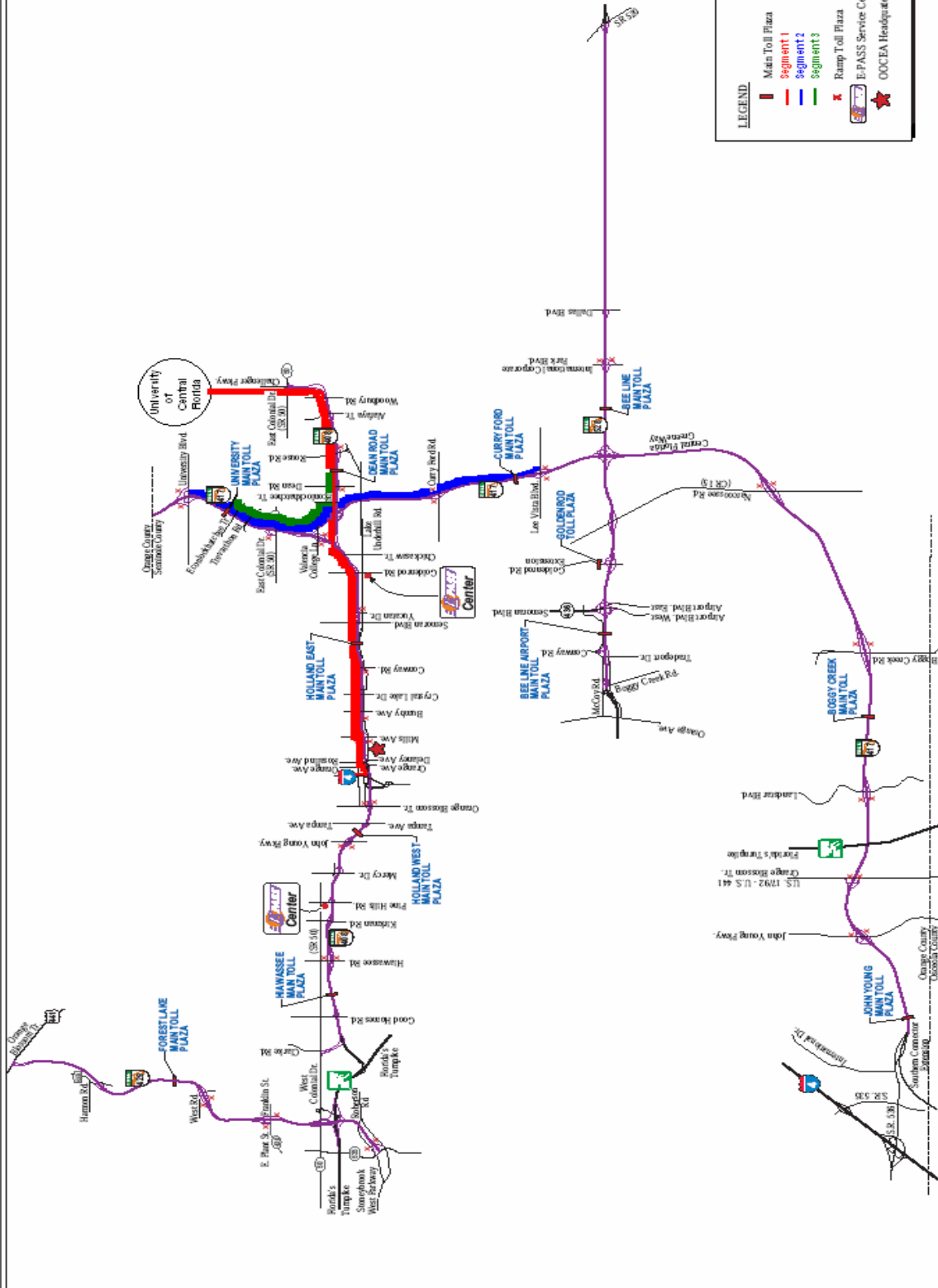
Payment amount _____

Printed Name: _____

Signature: _____

SSN (last 4 digits): _____

APPENDIX G
EXPRESSWAY SYSTEM MAP



TOLL PLAZA LOCATION MAP OCEA EXPRESSWAY SYSTEM

- TOLL 408**
- TOLL 417**
- TOLL 528**
- TOLL 429**



04/2014-10/2014

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