

**PRACTICAL CONSIDERATIONS IN ESTIMATING CONSUMER
PREFERENCES FROM STATED PREFERENCE DATA:
A CASE STUDY OF THE VALUE OF AUTOMOBILE TRAVEL TIME**

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Introduction

There are many situations in which it is not possible to use market transactions to measure consumer preferences. For example, it is obviously difficult to use market data to estimate consumer preferences for products that are not yet available on the market, and it is also difficult to use market data to determine how consumers would value product attributes that are outside the range of attributes observed in the market (e.g., what value would consumers place on television sets with 48 inch screens when the largest screen available is 36 inches?). To address these problems, researchers have developed surveys that directly ask consumers for their valuations or ask them to state their preferences given a hypothetical set of alternatives. The first approach, commonly referred to as contingent valuation, has been attacked by many analysts and can be fatally flawed. (The most severe problem is termed “embedding,” where consumers’ valuations are invariant to quantities consumed.) The second approach, called stated preference analysis, is not free of methodological concerns, but can overcome most of the problems of contingent valuation.

A credible stated preference analysis must employ a survey that produces an accurate ordering of preferences and must use an appropriate econometric technique to obtain consistent and efficient parameter estimates. This paper explores some practical problems in achieving these objectives in the context of estimating the value of automobile travel time--a critical parameter in determining optimal highway congestion tolls and investment levels. We use a stated preference analysis to estimate this value because it is difficult to infer it from market transactions. That is, mode choice models, which are typically used to estimate the value of travel time, capture differences in the “disutility” from spending time aboard crowded buses or trains versus spending it alone in a car. These differences are

irrelevant and may lead to misleading conclusions if one is simply interested in how much *automobile travelers* who face congestion are willing to pay to save travel time.

We find that commuters' value of automobile travel time is low--much lower than most estimates derived from transportation mode choice models--and surprisingly robust to alternative specifications of preferences, and whether probit or logit techniques are used for estimation. The findings, however, are sensitive to whether one estimates preferences based on *ordinal rankings* or *cardinal ratings*. In particular, it appears that estimates based on cardinal ratings can be very unreliable.

Estimating Commuters' Valuation of Travel Time Savings

The standard approach to estimating the willingness to pay (WTP) to save travel time is to infer it from urban commuters' tradeoff of travel time and travel cost as revealed by their choice of transportation mode (e.g., auto versus bus). We are interested in estimating WTP for a particular segment of commuters--those who travel by auto and currently face some congestion. We are also interested in exploring whether this WTP varies under policies, such as congestion tolls, and travel conditions, such as greater traffic volumes, that currently do not exist.¹ Thus, we use a model to estimate commuters' WTP to reduce travel time under alternative hypothetical scenarios that describe congestion policies, how congestion toll revenue is spent, and important characteristics of the road

¹ There are no congestion tolls on a single public road in the United States. There is a highway in San Diego County where morning and evening rush-hour commuters can pay a fee to have access to a less-congested lane. A private highway in Southern California does have tolls varying by time of day.

system.

Congestion policies include congestion tolls that vary by time of day and technological devices that would provide traffic information to drivers, allowing them to pick the least busy roads. Uses of the toll revenue that could influence commuters' WTP include compensating low-income commuters who cannot afford the tolls, upgrading public transportation, and constructing new roads and maintaining existing ones. Because some uses of the toll revenues may appeal to altruistic behavior that is not usually part of the WTP concept, we must be careful to distinguish between commuters' true WTP and their policy preferences when we interpret our findings. Important characteristics of the road system that might influence WTP include whether the road is public or private and the expected level of traffic growth.

Stated Preference Approach: Because we needed to estimate consumer preferences for alternatives that do not exist, we relied upon stated preference methods that the market research community has developed to assess consumer preferences for new products and new product attributes. A conceptually satisfying method for measuring consumer trade-offs among attributes is to have consumers rank-order several “packages” that involve different combinations of prices and other characteristics. But direct rank-ordering is a demanding task when considering more than a few packages, so we employed a method, used by marketing research firms, that substantially simplifies the process of eliciting rank orderings and thus greatly improves their accuracy.

To begin, we hired a market research firm that draws upon survey respondents who are members of a well-known nationwide mail panel (National Family Opinion) and are accustomed to preference surveys. Each respondent was presented with thirteen alternatives or packages, each on a separate card, that described the essential elements of a commute including the congested and uncongested travel time, the travel cost (usually in the form of a toll), and an indication of whether trucks were allowed on the road.² It is advisable to include an additional attribute such as truck restrictions because it keeps respondents from focussing exclusively on price-time tradeoffs to the exclusion of other important considerations. Including several attributes, however, would make the ranking process quite difficult.

After shuffling the cards to insure a random starting point, the respondent went through the cards one by one and *rated* the “acceptability” of each package on a 10-point scale, where 1 indicated very unacceptable and 10 indicated very acceptable. Respondents were then asked to *rank* the cards from most to least preferred, thereby providing an opportunity to resolve ties among equally rated alternatives. Some of the alternatives were designed to "dominate" others; that is, some provided the same package at a lower price. This design permitted greater precision in estimating willingness to pay because respondents could rank another alternative between two alternatives, one of which dominated the other. In addition, it permitted us to test for the consistency of survey responses.

² There was always a package where no toll was charged but this package included the highest commute time. Because changes in automobile operating costs with respect to changes in commute times are likely to be very small, we did not include automobile operating costs in travel costs.

The experience of the market research firm with this technique plus their in-house and field pretests indicated that respondents were comfortable with their task.³ We confirmed this by performing consistency tests and a sensitivity analysis based on a debriefing of respondents in which they evaluated the credibility of the survey.

Our application of stated preference is borrowed from the market research toolkit and therefore is representative of what profit-maximizing firms do when they must gather preference data upon which to make research and development plans. This approach is quite different from many of the contingent valuation methods employed to estimate the non-use value of public goods. These methods have generated much controversy in the economics profession, but this controversy is not relevant here.⁴

Sample, Scenarios, and Packages: The stated preference models were estimated from a random sample of 1,170 respondents. Survey respondents were automobile commuters in major U.S. metropolitan areas who regularly drove to work and faced some congestion.⁵

³ The survey was administered in December 1993 by Alison-Fisher, Inc., a Southfield, Michigan, marketing consulting firm. Demographic characteristics, including income, were obtained from the survey respondents. The stated preference studies in MVA Consultancy and others (1987) were based on surveys that are comparable to the one used here. These studies obtained credible estimates of modal choice parameters.

⁴ See, for example, the debate between Hanemann (1994) and Diamond and Hausman (1994). In our analysis, people are asked to rank something they *are* familiar with. The question sequence is not a factor. Respondents do face a budget constraint. And respondents are not given the opportunity to give a single response that they perceive to be socially appropriate.

⁵ More than 90% of the commuters in the entire Alison-Fisher household panel commuted at least four days a week. We only included commuters whose commute speed was *below* a free-flow (uncongested) threshold. For commutes greater than 50 minutes the free flow speed was assumed to be 60 mph, for commutes between 21-50 minutes the free flow speed was assumed to be 40 mph.

Response rates were roughly 67 percent approximately three weeks after the mailing, slightly better than the usual response rates for the National Family Opinion panel.

Separate samples of commuters were drawn for each of thirteen commuting/road pricing scenarios (see table 1). Thus respondents stated their preferences in the context of a single scenario. The first two scenarios seek to provide perspective on a major concern with stated preference analysis--policy bias. That is, when the time savings are the result of a public intervention, such as tolls, estimates of commuters' WTP may to some extent capture commuters' preferences for or against tolls rather than their true WTP. Thus, the first two scenarios involve paying for a "smart car" technology to reduce travel time under implicit and explicit congested travel conditions.⁶ Because the time savings in these scenarios are not the result of tolls, the WTP estimates obtained from them will provide a useful comparison with the WTP estimates derived from the scenarios that include tolls. Indeed, because each respondent ranked packages for only *one* scenario, the respondents in the first two scenarios were not even aware that we

Assuming somewhat lower free flow speeds did not have much affect on the composition of the sample. Based on the 1990 National Personal Transportation Survey, average speeds in major urbanized areas for these commutes during peak travel periods were much lower than the free flow threshold speeds. The highest average commute speed in our sample, roughly 40 mph, was achieved by travelers whose commute exceeded 61 minutes. Average speeds for travelers in our sample whose commute was below 61 minutes ranged from 22-29 mph. These average speeds are very similar to those reported in the National Personal Transportation Survey, indicating that commuters in the sample did face significant congestion.

⁶ In our survey, the wording we used was that a "SMART BOX" is available that can automatically guide you to the best route during your commute. Your commute will take less time, because the box will guide you to shorter or less crowded roads, or guide you around trouble spots.

Table 1
Scenarios

<i>Scenario</i>	<i>Description</i>
1	"smart cars" - no tolls - no congestion component
2	"smart cars" - no tolls
3	toll roads - unspecified use of revenues
4	toll roads - revenues to maintenance and construction
5	toll roads - revenues to state highway fund
6	toll roads - revenues to mass transit
7	toll roads - revenues to the poor
8	public toll roads - unspecified use of revenues
9	private toll roads - unspecified use of revenues
10	public toll roads - revenues to maintenance and construction
11	private toll roads - revenues to maintenance and construction
12	toll roads - flat traffic growth -unspecified use of revenues
13	toll roads - rapid traffic growth - unspecified use of revenues

were considering tolls as a policy option to reduce congestion. Tolls are introduced in the third scenario. Scenarios 4-7 present alternative ways that the toll revenue could be spent.⁷ Scenarios 8-11 distinguish between public and private toll roads, and scenarios

⁷ We did not include a scenario that explicitly asked respondents to assume that the toll revenue would be used to support a general reduction in income or property taxes because this assumption would probably be viewed with considerable skepticism.

12-13 distinguish between flat and rapid traffic growth.

Packages were formulated with maximum one-way commute times of either 60 or 40 minutes. Respondents whose *reported* commute times were 51-60 minutes or 61-70 minutes were asked to rank packages that had a 60 minute maximum commute time. Respondents whose reported commute times were 21-30 minutes, 31-40 minutes, or 41-50 minutes were asked to rank packages that had a 40 minute maximum commute time. As an illustration, exhibit 1 presents scenario 7 and the packages that the respondents to this scenario faced. Respondents to the other scenarios also faced these packages. The prices and times included in the packages are plausible and, as discussed later, allowed respondents to reveal a willingness to pay within a wide range of possible values. Beginning with scenario 2 we draw a distinction between congested and uncongested travel time thus enabling us to determine whether people value the components of their commute time differently.

Econometric Issues

We noted that the preference data were generated by respondents who first rated each of the 13 alternatives on an acceptability scale of 1 to 10, and then broke ties in order to provide a full ranking. Thus the data generate dependent variables that reflect discrete and ordinal preferences. A number of econometric approaches to estimating these preferences are possible. One approach is to use the respondents *ratings* as the dependent variable and estimate the determinants of these ratings by ordered probit.⁸ This model assumes

⁸ Greene (1993) contains a description of the ordered probit model.

that packages are rated according to where the utility provided by each package falls within the range of a continuous utility function. For example, if a respondent rated four packages on a 10-point scale and gave ratings of 2, 4, 7, and 7, then the model assumes that the utility from the first package was between 2.0 and 2.9, and so on. The likelihood function thus includes estimable parameters that

Exhibit 1

Scenario 7

Please read the scenario carefully:

- We are interested in your preferences for ways to improve your commute to and from work. One possibility would be to charge tolls on congested roads. Tolls would reduce traffic and allow cars to move faster. Another consideration is a law to keep trucks off the major commute routes. This would improve traffic safety and smooth the flow of traffic.
- *Half the toll revenues will be used to compensate low income commuters who otherwise could not afford to pay tolls while commuting to work.*
- Keep in mind that the higher tolls will allow traffic to move faster, thus making the commute take less time. You can assume that the tolls will be collected automatically using electronic devices. The devices would not disrupt your journey or infringe on your privacy.
- You can also assume that part of your commute will be congested and part will be uncongested. On congested portions, traffic will be slow, with frequent delays. On uncongested portions, traffic will move at about the speed limit. You can therefore think of your commute time as consisting of two parts: time spent in congested traffic, and time spent in uncongested traffic.

Each commuting alternative described is identical in every way except the following items:

- ➡ TOLL (ONE WAY)
- ➡ TRAVEL TIME: (based on minutes ONE WAY) Congested, Uncongested, and Total Travel.
- ➡ TRUCKS ON THE ROAD? Whether or not trucks are permitted on the road.

In order to understand your preferences for the different kinds of commuting choices, I have combined the above 3 elements into sets of alternatives available.

Each of these alternatives is described on a card in the deck enclosed with this instruction sheet.

Step 1: Please shuffle the deck of cards.

Step 2: Examine each of the alternatives on the cards and tell me how acceptable you find each alternative by circling the appropriate number on the bottom of each card (See Question 1 on the card).

Step 3: Now that you have rated each of the alternatives, I would like you to take the cards and place them in order of your preference, from most preferred to least preferred.

Step 4: After you are satisfied with the order, simply number the cards from "1" to "13" in the order you have sorted them (See Question 2 on the card).

Step 5: Please return the instruction sheet and cards in the enclosed postage-paid envelope.

Thank you so much for your help with this study.

Exhibit 1

40-MINUTE MAXIMUM PACKAGES:

<i>Package</i>	<i>Price (One Way)</i>	<i>Travel Time (minutes ONE WAY)</i>			<i>Trucks On the Road?</i>
1	\$0.00	40			Trucks
2	\$0.35	30			Trucks
3	\$0.70	30			Trucks
4	\$1.00	30			Trucks
5	\$0.35	20			Trucks
6	\$0.70	20			Trucks
7	\$1.35	20			Trucks
8	\$2.00	10			Trucks
9	\$3.35	10			Trucks
10	\$0.35	40			No Trucks
11	\$0.70	30			No Trucks
12	\$1.75	20			No Trucks
13	\$4.00	10			No Trucks

<i>Package</i>	<i>Price (One Way)</i>	<i>Travel Time (minutes ONE WAY)</i>			<i>Trucks On the Road?</i>
		<i>Congested Time</i>	<i>Uncongested Time</i>	<i>Total Time</i>	

1	\$0.00	30	10	40	Trucks
2	\$0.35	20	10	30	Trucks
3	\$1.35	20	10	30	Trucks
4	\$0.35	10	20	30	Trucks
5	\$0.70	10	20	30	Trucks
6	\$0.35	10	10	20	Trucks
7	\$1.35	10	10	20	Trucks
8	\$2.00	0	10	10	Trucks
9	\$3.35	0	10	10	Trucks
10	\$0.35	30	10	40	No Trucks
11	\$0.70	20	10	30	No Trucks
12	\$1.75	10	10	20	No Trucks
13	\$4.00	0	10	10	No Trucks

Exhibit 1

60-MINUTE MAXIMUM PACKAGES:

<i>Package</i>	<i>Price (One Way)</i>	<i>Travel Time (minutes ONE WAY)</i>	<i>Trucks On the Road?</i>
1	\$0.00	60	Trucks
2	\$0.50	45	Trucks
3	\$1.00	45	Trucks
4	\$1.50	45	Trucks
5	\$0.50	30	Trucks
6	\$1.00	30	Trucks
7	\$2.00	30	Trucks
8	\$3.00	15	Trucks
9	\$5.00	15	Trucks
10	\$0.50	60	No Trucks
11	\$1.00	45	No Trucks

12	\$2.50	30	No Trucks
13	\$6.00	15	No Trucks

<i>Package</i>	<i>Price (One Way)</i>	<i>Travel Time (minutes ONE WAY)</i>			<i>Trucks On the Road?</i>
		<i>Congested</i>	<i>Uncongested</i>	<i>Total</i>	
		<i>Time</i>	<i>Time</i>	<i>Time</i>	
1	\$0.00	45	15	60	Trucks
2	\$0.50	30	15	45	Trucks
3	\$2.00	30	15	45	Trucks
4	\$0.50	15	30	45	Trucks
5	\$1.00	15	30	45	Trucks
6	\$0.50	15	15	30	Trucks
7	\$2.00	15	15	30	Trucks
8	\$3.00	0	15	15	Trucks
9	\$5.00	0	15	15	Trucks
10	\$0.50	45	15	60	No Trucks
11	\$1.00	30	15	45	No Trucks
12	\$2.50	15	15	30	No Trucks
13	\$6.00	0	15	15	No Trucks

define the intervals in the utility function and parameters that capture the influence of each independent variable.

The ordered probit model appears to fit well with the way the ratings data were generated, but the use of ratings data has two

potentially important flaws. One is that the information obtained by breaking ties is usually lost.⁹ A more serious problem is that respondents are likely to start with different “anchors” in the ratings exercise. Thus the respondent that generated ratings of 2,4,7, and 7 in the example given above could have a utility function (up to a linear transformation) that is identical to a respondent who gave ratings of 5,7, 10, and 10. Aggregating data based on a variety of anchoring strategies could yield inaccurate estimates of how respondents trade off attributes, even if respondents’ actual trade-offs were similar.

As an alternative, one could directly analyze the *rankings* data with ordered probit, but this could raise a different problem because the behavioral assumptions underlying the ordered probit model may be inconsistent with the nature of the choice process. For example, if a respondent rank-orders ten packages from 1 to 10, the probit model assumes that the packages are equally *spaced* in terms of utility. (In this model, the ranking, rather than the rating, is assumed to have fallen into a specific interval in a continuous utility function.) In all likelihood, respondents will tend to have preferences that “bunch” some packages together and space others apart. This may not be an empirical problem, however, because uneven utility spacings tend to be “smoothed” as respondents’ orderings are aggregated.

Finally, one could use the Beggs, Cardell, and Hausman (1981) rank-ordered logit model instead of ordered probit to analyze

⁹ This information was obtained when respondents broke ties in the process of forming rankings. One could possibly use this information to readjust ratings.

the rankings data. This model also assumes that orderings are the result of a utility-maximizing process. It makes full use of all the ranking information by repeatedly applying the multinomial logit model to an “exploded” data set. The choice sets for each logit model consist of a ranked choice and the lower ranked alternatives (i.e., it is assumed that the top-ranked alternative was chosen from the entire choice set, the second-ranked item was chosen from the remaining alternatives, and so on). This is a purely ordinal model that makes no assumptions about utility intervals, thus it does not appear to suffer from ordered probit’s “spacings” problem. But, as in other econometric contexts, the difference between the (ordered) logit and probit models is not great. Logit models assume that the ratio of choice probabilities is equal to the ratio of the choices’ utilities (i.e., this is an interpretation of the independence from irrelevant alternatives property). Thus the logit model imposes its own spacings restriction, which, for example, could make it appear that a particular alternative has much greater *utility* than it actually has simply because it is consistently chosen over a slightly less attractive alternative.

Because we do not have theoretical grounds for choosing between rankings or ratings data, or between ordered logit or ordered probit, we explored these alternative approaches in estimating our stated preference models.¹⁰ Whether one uses ratings or rankings data, ordered probit estimates a utility function in which the coefficient for each influence (price, congested time, uncongested time, and whether trucks are on the road) indicates the effect on utility of a change in the attribute. When respondents are asked to rate

¹⁰ The SST econometrics package was used to perform the ordered probit estimations and the LIMDEP econometrics package was used to perform the ordered logit estimations. Because there are multiple observations from the same individual, the t-statistics that are reported are upper bounds.

packages on a 1 to 10 scale (with 10 indicating the greatest satisfaction), we expect the sign for price, travel time, and the dummy variable indicating trucks on the road to be negative because higher prices and times and trucks on the road bring worse ratings. When respondents are asked to rank packages, with the most favored package ranked number 1, and so on, the expected signs are positive because higher values of the variables bring worse rankings. Finally, rank-ordered logit also estimates a utility function in which the coefficient for each variable indicates the effect on utility of a change in the variable. The expected signs of the coefficients in this model are negative because higher values of the variables should reduce the likelihood of a better (numerical) ranking.

Estimation Results

The final survey responses were first checked to see that respondents gave rational orderings. In particular, we found that respondents always rated and ranked a "dominated" alternative below a "dominating" alternative.¹¹

Maximum likelihood parameter estimates of the ordered probit model based on the ratings data are presented in table 2.¹² Although most of the parameter estimates are statistically reliable, the travel time and trucks on the road coefficients always have

¹¹ For example, package 2 in the 40 maximum scenarios (\$0.35 price, 30 minute travel time, and trucks on the road) was always rated and ranked below package 5 (\$0.35 price, 20 minute travel time, and trucks on the road).

¹² We estimated models that explicitly included income by interacting it with other variables, but this did not lead to changes in our findings. We also specified separate travel time coefficients for discrete intervals of travel time, but this did not lead to improvements in the model.

incorrect positive signs and the price coefficients have incorrect signs in many scenarios. These unsatisfactory estimates suggest that the “anchoring” problem noted above can prevent one from obtaining credible estimates of stated preferences based on ratings data.

We obtain much more encouraging results by estimating the ordered probit model based on rankings data (see table 3). Generally, the price and congested travel time coefficients have the expected positive sign and are statistically reliable. Interestingly, uncongested travel time and the presence of trucks on the road generally have statistically insignificant effects. Uncongested travel time could be reduced by raising speed limits, improving road design, and so on. According to our findings, however, commuters are only willing to pay to reduce *congested* travel time. Uncongested time may not be perceived to be onerous because it enables commuters to relax before work and to decompress after work.¹³ It has been alleged by the Association of

¹³ Kathleen Deveny and Gabriella Stern, "Another Day, Another Three-Hour Commute," Wall Street Journal, December 2, 1994 report the following conclusion from a consulting firm that tracks consumer behavior--"For people who work hard and then return to a house of fractious children, time alone in the car allows them to decompress. The car is an oasis between those two worlds."

Table 2
Ordered Probit Parameter Estimates Based On Ratings

<i>Scenario</i>	<i>Price (cents)</i>		<i>Congested Time (min.)</i>		<i>Uncongested Time (min.)</i>		<i>Trucks on the Road</i>		<i>Number of Observations**</i>
	<i>Coefficient</i>	<i>T-statistic</i>	<i>Coefficient</i>	<i>T-statistic</i>	<i>Coefficient</i>	<i>T-statistic</i>	<i>Coefficient</i>	<i>T-statistic</i>	
1*	-0.0001	-0.80	0.0233	15.60			0.3986	5.49	728
2	-0.0002	-0.94	0.0026	1.05	0.0478	8.91	0.2973	3.52	715
3	-0.0003	-1.40	0.0037	1.56	0.0491	9.42	0.2944	3.54	780
4	0.0007	3.42	0.0158	6.50	0.0797	15.26	0.3571	4.63	832
5	0.0002	0.68	0.0124	4.53	0.0629	10.69	0.4500	5.53	715
6	0.0009	4.07	0.0257	10.12	0.0481	8.87	0.5960	8.09	871
7	0.0006	2.44	0.0185	6.68	0.0532	9.02	0.5869	7.38	741
8	0.0007	2.93	0.0175	6.62	0.0594	10.49	0.5301	6.82	780
9	-0.0013	-5.40	0.0024	0.90	0.0383	6.66	0.4225	5.39	806
10	0.0008	3.56	0.0145	5.24	0.0578	9.75	0.5360	6.56	715
11	-0.0011	-4.98	0.0058	2.20	0.0413	7.26	0.2993	3.71	767
12	0.0005	2.34	0.0198	7.14	0.0589	9.91	0.5920	7.21	702
13	-0.0021	-7.63	0.0057	1.90	0.0426	6.66	0.2678	3.08	676

*Travel time in scenario 1 was not broken down into congested and uncongested components. For this scenario, the travel time coefficient is the effect of total travel time.

**Number of observations equals the number of respondents times the number of packages placed in order (=13).

Table 3
Ordered Probit Parameter Estimates Based On Rankings

Scenario	Price (cents)		Congested Time (min.)		Uncongested Time (min.)		Trucks on the Road		Number of Observations**
	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	
1*	0.0046	24.52	0.0226	15.24			-0.0512	-0.07	728
2	0.0050	23.44	0.0433	17.58	-0.0014	-0.27	-0.0360	-0.43	715
3	0.0039	19.11	0.0356	14.85	0.0087	1.67	-0.0237	-0.29	780
4	0.0051	24.12	0.0384	15.92	-0.0047	-0.90	0.0346	0.45	832
5	0.0061	24.95	0.0410	14.89	-0.0118	-2.00	0.0603	0.73	715
6	0.0048	21.52	0.0295	11.60	0.0044	0.81	0.1146	1.54	871
7	0.0057	22.99	0.0336	12.12	-0.0033	-0.55	0.0867	1.08	741
8	0.0055	23.45	0.0307	11.56	-0.0047	-0.83	0.1862	2.37	780
9	0.0056	23.65	0.0357	13.36	-0.0057	-1.00	0.1133	1.47	806
10	0.0053	21.75	0.0309	11.17	0.0033	0.56	0.0287	0.35	715
11	0.0059	25.17	0.0337	12.67	-0.0059	-1.05	0.0848	1.06	767
12	0.0058	22.60	0.0333	11.96	0.0001	0.01	0.0264	0.32	702
13	0.0068	25.46	0.0347	11.76	-0.0068	-1.08	0.0227	0.27	676

*Travel time in scenario 1 was not broken down into congested and uncongested components. For this scenario, the travel time coefficient is the effect of total travel time.

**Number of observations equals the number of respondents times the number of packages placed in order (=13).

American Railroads, among others, that commuters feel less safe when they have to share the road with trucks. While this may be true, our estimates suggest that commuters are not willing to pay even a small amount of money to keep trucks off the road.¹⁴

The ordered-logit parameter estimates based on rankings are generally consistent with the ordered probit estimates based on rankings (see table 4). Generally, the price and congested travel time coefficients have the expected negative sign and are statistically reliable. The coefficient for uncongested travel time also has the expected negative sign, and in contrast to the ordered probit results, is statistically reliable in the majority of scenarios. But its coefficient is roughly three times as small as the coefficient for congested travel time, thus the logit and probit models strongly suggest that uncongested time is not perceived to be as onerous as congested time.¹⁵ Finally, the presence of trucks on the road has a statistically insignificant effect in most scenarios.

Differences and similarities among the parameter estimates are even clearer when we use them to calculate commuters' willingness to pay (WTP) to reduce travel time. WTP estimates are obtained as the ratio of the (congested) travel time coefficient to the price coefficient,

¹⁴ One might argue that the trucks on the road variable was statistically insignificant in most scenarios because it was an extra dimension that was difficult for respondents to handle cognitively, thus they dismissed it. However, similar applications of the stated preference approach taken here have included extra dimensions that were found to be statistically significant (see, for example, Calfee and Winston (1993)).

¹⁵ Based on a route choice model, MVA Consultancy and others (1987) found that the value of travel time in congested traffic was as much as 50% higher than in free flow.

Table 4
Ordered Logit Parameter Estimates Based On Rankings

Scenario	Price (cents)		Congested Time (min.)		Uncongested Time (min.)		Trucks on the Road		Number of Observations**
	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic	
1*	-0.0095	-36.73	-0.0570	-33.03			-0.2830	-3.24	728
2	-0.0085	-32.04	-0.0777	-27.48	-0.0288	-4.62	-0.2599	-2.56	715
3	-0.0063	-25.49	-0.0539	-19.97	-0.0198	-3.38	-0.1151	-1.21	780
4	-0.0084	-30.91	-0.0605	-22.07	-0.0116	-1.91	-0.1218	-1.32	832
5	-0.0097	-30.27	-0.0638	-20.40	-0.0094	-1.38	-0.0696	-0.70	715
6	-0.0081	-28.80	-0.0501	-17.42	-0.0281	-4.53	-0.1284	-1.47	871
7	-0.0096	-30.13	-0.0598	-18.80	-0.0168	-2.46	-0.1436	-1.51	741
8	-0.0083	-28.08	-0.0469	-15.53	-0.0093	-1.42	-0.1608	-1.71	780
9	-0.0089	-29.72	-0.0581	-19.13	-0.0180	-2.78	-0.0825	-0.89	806
10	-0.0083	-25.93	-0.0438	-13.96	-0.0167	-2.50	0.0245	0.25	715
11	-0.0092	-29.55	-0.0478	-16.14	-0.0104	-1.61	-0.0226	-0.24	767
12	-0.0100	-30.74	-0.0612	-19.43	-0.0251	-3.72	-0.0775	-0.78	702
13	-0.0109	-30.26	-0.0583	-17.12	-0.0152	-2.11	0.1024	1.00	676

*Travel time in scenario 1 was not broken down into congested and uncongested components. For this scenario, the travel time coefficient is the effect of total travel time.

**Number of observations equals the number of respondents times the number of packages placed in order (=13).

Table 5
Value of Congested Time Based On Different Estimation Methods

Scenario	Value of Congested Time (dollars/hour)			Value of Congested Time as a Proportion of Hourly Wage		
	Ordered Probit Based On Ratings	Ordered Probit Based on Rankings	Ordered Logit Based on Rankings	Ordered Probit Based On Ratings	Ordered Probit Based on Rankings	Ordered Logit Based on Rankings
1*	-97.07	2.92	3.61	-4.99	0.15	0.19
2	-7.92	5.21	5.47	-0.36	0.24	0.25
3	-7.86	5.47	5.16	-0.39	0.27	0.26
4	13.49	4.48	4.33	0.63	0.21	0.20
5	47.80	4.02	3.93	2.73	0.23	0.22
6	17.65	3.69	3.70	0.90	0.19	0.19
7	19.47	3.55	3.74	0.82	0.15	0.16
8	16.10	3.35	3.38	0.83	0.17	0.18
9	-1.14	3.83	3.93	-0.05	0.17	0.17
10	10.51	3.49	3.17	0.48	0.16	0.14
11	-3.06	3.40	3.12	-0.15	0.16	0.15
12	21.64	3.47	3.67	1.02	0.16	0.17
13	-1.65	3.06	3.21	-0.08	0.14	0.15
Average	2.15	3.84	3.88	0.10	0.18	0.19

*Travel time in scenario 1 was not broken down into congested and uncongested components. For this scenario, the travel time coefficient is the effect of total travel time.

multiplied by 60 to yield an hourly value. The calculations, presented in table 5, reveal that commuters' WTP as a fraction of their wage based on the ordered probit model using ratings are very unstable, and take on implausible negative values. In contrast, the WTP/wage estimates based on the ordered probit and logit models using rankings are stable and nearly identical.

Of substantive significance is that the average commuter does not appear willing to pay much to reduce congested travel time under any scenario. Average WTP per hour ranges from 14 to 27 percent of the gross hourly wage, with an average over the entire sample of ordered probit and logit estimates of 18 percent and 19 percent respectively---conspicuously lower than most of those based on transportation mode choice and route choice models.¹⁶ Small (1992) concludes from a survey of mode choice models that a reasonable average value is 50 percent of the gross wage, while Miller's (1989) survey of route choice models yields an average value closer to 60 percent of the gross wage. Small points out that estimates of the value of time do vary among industrialized cities from 20 to 100 percent of the gross wage, thus our estimates can be interpreted as being at the very low end of previous estimates derived from mode choice models.¹⁷

¹⁶ This finding is not sensitive to the fact that we typically decomposed travel time into congested and uncongested time. In scenario 1, we did not perform this decomposition but still obtained an estimate of the WTP/wage that is consistent with the estimates in the other scenarios.

¹⁷ It might be argued that our respondents' low value of time reflects their lack of faith in the effectiveness of tolls or, in some instances, lack of altruistic behavior. But it will be recalled that the time savings that could be achieved in the first two scenarios were derived from a technological device, not tolls, and that commuters' WTP in these scenarios were comparable to their WTP in the scenarios involving tolls.

The findings obtained from the rankings data are not biased in the sense of being constrained by our survey design. The choices allowed respondents to reveal a willingness to pay within a wide range of possible values. This is apparent from simple simulations. For example, if respondents order packages according to the shortest travel time, regardless of cost, their revealed value of time is estimated to be \$46/hour. If respondents order packages randomly, their revealed value of time is statistically insignificant. Finally, the pre-tests, consistency tests, and sensitivity analyses indicate that respondents were not overburdened by their task and that the survey was credible.¹⁸

It is not surprising that our estimates diverge from those usually obtained from a mode choice or route choice model because those models include factors, which although not relevant for our purpose, do influence the value of travel time. We are interested in the value that long distance auto commuters (not all commuters) place on their travel time on a given route. Value of time estimates derived from a mode choice model reflect the relative comfort, convenience, privacy, and so on of auto versus transit, which will generally increase the value of travel time because transit modes are less desirable than auto in these respects. The implicit assumption

¹⁸ In our companion paper, Calfee and Winston (1997), we conducted many sensitivity analyses including asking respondents at the end of the survey whether they had difficulty making any assumptions required by the survey and estimating separate models for those that answered “yes,” estimating separate models for commuters who regularly commuted on toll roads, and estimating models where we replaced the trucks on the road variable with the *variation* in travel time. Estimates of the WTP/wage based on these explorations were very similar to the estimates reported above. We have also argued that our methodology does not suffer from many of the shortcomings that plague contingent valuation studies. Nonetheless, it is noteworthy that WTP estimates obtained from a contingent valuation methodology are generally criticized as being upward biased. In contrast, our WTP estimates are generally *lower* than previous estimates.

that is made in many mode choice models is that commuters have the same travel time parameter for all modes. One could avoid this assumption by specifying different travel time coefficients for, say, bus and auto. A potential problem would still persist, however, because the estimate of the auto time coefficient is still based on the assumption that auto users and bus users have the same auto time coefficient. If bus users do not choose auto because they attach a higher disutility to time spent driving in congestion than auto users, then the auto time coefficient, given our interest, would still be inflated. Similarly, estimates of the value of time derived from a route choice model reflect the aesthetics, probability of getting a ticket, and stress from delays caused by traffic lights between alternative routes. These factors will undoubtedly lead to a higher value of automobile travel time compared with an estimate that is not concerned with including these effects.

The most likely explanation of why we have found that automobile commuters actually have a low value of travel time is that those commuters who have a high value of travel time are not in our sample because they have made residential and workplace location decisions that result in a short commute and/or one with little congestion.¹⁹ These decisions also include the broader residential choice of type of urban community (e.g., a heavily congested city such as Los Angeles compared with a relatively uncongested city such as Columbus, Ohio). Indeed, it is likely that workplace and residential adjustments in response to congestion have helped stabilize the

¹⁹ The theoretical tradeoff between travel costs and housing costs is discussed in Strotz (1964). Miller (1989) surveys the few empirical studies that attempt to estimate the value of travel time based on housing choice and finds that they yield estimates that are roughly 50 to 60 percent of the wage--similar to estimates produced by mode choice and route choice studies. Miller notes, however, that although these estimates may yield a broad picture of how a family values travel time, serious concerns have been raised as to whether these models can accurately separate out the impact of accessibility on housing price.

"national" level of congestion. As shown in Table 6 (also see Gordon and Richardson (1994)), the percentage of peak period traffic that uses highways with traffic volume exceeding 80 percent of design capacity, an indicator of congestion, rose steadily on urban interstates during the 1980s but has been relatively constant during the 1990s.

Those commuters who face congested commutes have undoubtedly made tradeoffs: cheaper housing, bigger yards, better schools and so on. Therefore some of the respondents who have long commutes may attach additional utility to living further away from urban centers and attach relatively lower disutility to spending time driving to work (or anywhere else). These preferences will naturally lead to a low value of time.²⁰

Conclusions

Because of the difficulties with using market data, we have used stated preference methods to estimate the value of automobile travel time. Despite several potential methodological pitfalls, it appears that we have obtained credible estimates of an important economic parameter using this methodology. Our exploration suggests that extreme caution should be used in estimating stated preferences based on respondents' ratings of alternatives, and that one should always corroborate any findings derived from ratings data by estimating stated preferences based on respondents' rankings. It does appear that rank-ordered probit and logit models are likely to produce similar findings.

²⁰ There are undoubtedly some commuters whose WTP is low because they have equipped their car with features, such as a phone, that make their commute in congested traffic less onerous.

Table 6
Percentage of Peak-Period Vehicle-Miles Traveled on Urban Interstates
With Volume-to-Capacity Ratios Exceeding 0.80
Selected Years, 1981-1994

<i>Year</i>	<i>Percentage of Urban Peak-Period Vehicle-Miles</i>
1981	49
1983	53
1985	61
1987	64
1989	69
1990	69
1991	70
1992	70
1993	69
1994	68

Source: U.S. Federal Highway Administration, Highway Statistics, 1995.

Our 1997 companion paper focusses on the substantive implications of the empirical analysis. It is worth noting here that our finding of a low value of automobile travel time casts doubt that the (direct) net benefits from optimal congestion tolls, which depend on this value, are large. This conclusion could have only been revealed by a stated preference analysis. If it is correct, it may change the nature of the urban transportation policy debate, which has largely focussed on the reasons why policymakers have not pursued congestion tolls.

REFERENCES

- Beggs, Steven, Cardell, Scott, and Hausman, Jerry, "Assessing the Potential Demand for Electric Cars," Journal of Econometrics, 17, September 1981, pp. 1-19.
- Calfee, John E. and Winston, Clifford, "The Consumer Welfare Effects of Liability for Pain and Suffering: An Exploratory Analysis," Brookings Papers on Economic Activity: Microeconomics, No. 1, 1993, pp. 133-196.
- Calfee, John E. and Winston, Clifford, "The Value of Automobile Travel Time: Implications for Congestion Policy," Brookings working paper, May 1997.
- Diamond, Peter A. and Hausman, Jerry A., "Contingent Valuation: Is Some Number Better than No Number?," Journal of Economic Perspectives, 8, Fall 1994, pp. 45-64.
- Gordon, Peter and Richardson, Harry W., "Congestion Trends in Metropolitan Areas," in National Research Council, Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion, vol. 2., National Academy Press, Washington, DC, 1994.
- Greene, William H., Econometric Analysis (second edition), Prentice Hall, Englewood Cliffs, New Jersey, 1993.
- Hanemann, W. Michael, "Valuing the Environment through Contingent Valuation," Journal of Economic Perspectives, 8, Fall 1994, pp. 19-43.
- Miller, Ted, "The Value of Time and the Benefit of Time Saving," Urban Institute working paper, Washington DC, July 1989.
- MVA Consultancy, Institute of Transport Studies University of Leeds, and Transport Studies Unit University of Oxford, The Value of Travel Time Savings, Policy Journals, Newbury, Berks, U.K., 1987.

Small, Kenneth A., Urban Transportation Economics, Harwood Academic Publishers, Philadelphia, Pennsylvania, 1992.

Strotz, Robert, "Urban Transportation Parables," in Julius Margolis editor, The Public Economy of Urban Communities, Johns Hopkins Press, Baltimore, Maryland, 1964.