IMPLICIT ASSUMPTIONS AND CHOICES AMONG ESTIMATES OF THE VALUE OF TIME

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This paper suggests economic criteria for choosing among estimates of the value of time. Four assumptions that are implicit in most models of the value of time are identified and discussed. The accuracy of an estimate of the value of time depends on whether the data and model underlying the estimate take into account the unrealistic nature of these assumptions, either by excluding observations for which the assumptions are especially incorrect or by modifying the model so that the assumptions may be relaxed.

•TRANSPORTATION economists are faced with a bewildering array of estimates of the value of time. Hensher (1) presents a table of 28 different studies with estimates ranging from 14 to 184 percent of the average wage rate in their samples. What explains this range in estimates of the value of time? What criteria should one use in determining which estimate is most appropriate for a particular purpose? Such questions are particularly important to answer, given the sensitivity of estimates of the benefits of transportation improvements to the values of time underlying them.

This paper suggests some criteria for choosing among alternative estimates of the value of time, by using economic theory as the basis for such criteria. Four assumptions are identified that underlie most modal- and route-split models, from which estimates of the value of time are derived. For each assumption, it is shown what happens to the estimate if the assumption is unrealistic. How data observations should be chosen so that each assumption can be approximately correct or, alternatively, how the modal- or route-split models can be modified so that the assumption can be relaxed is suggested. These suggestions imply criteria that can be used to decide which estimates of the value of time are most appropriate for a given purpose.

The assumptions discussed in this paper underlie a wide range of modal- or route-split models based on discriminant, probit, or logit analysis. Such models all postulate that a commuter's choice between two modes or routes of travel depends partly on the difference in (or ratio of) travel times between the two modes or routes and partly on the difference in (or ratio of) money cost between the two alternatives. Travelers' value of time savings, the amount they would pay to save a given amount of time, is measured by the ratio between the coefficients of these two variables in the discriminant, logit, or probit equations. The discussion in this paper applies to such models whether they are formulated in terms of ratios of or differences in time and money costs. To simplify the exposition, however, I will discuss only differences in time and money costs.

PERFECT KNOWLEDGE OF MODAL CHARACTERISTICS BY TRAVELERS

The first assumption of modal- or route-split models is that travelers believe they have perfect information about the characteristics of all alternatives open to them. As will soon become clear, this assumption can be avoided through a rather unorthodox specification of the modal- or route-split equation. Nevertheless, it is usually implicit in studies attempting to estimate the value of time. Such studies [with one exception known to me (2)] implicitly assume that the responsiveness of travelers to

changes in time and money costs of the alternate mode is independent of the frequency with which travelers make their trips. This assumption would be valid if information about the alternate mode were free, and required no experience or time-consuming inquiries. In this case, travelers on their first trip would acquire as much information as travelers who make the trip every day. If, however, such information is costly, the information possessed by each traveler would depend on the benefit of acquiring such information; this in turn is larger the more often the commuter makes the trip. One would then expect more frequent travelers to be better informed and, thus, more responsive to changes in the time and money costs of the alternate mode.

What is the effect of this assumption, if it is not entirely correct? The less frequent commuters will be less responsive to changes in the differences in time and money costs so that a sample of a relatively high proportion of less frequent commuters will yield coefficients that are smaller in absolute value for the two crucial variables, the differences in time and money costs. If the coefficient on the difference in time cost (ΔT) declines in absolute value at a faster rate than the coefficient on the difference in money cost (ΔM), the less frequent commuters will appear to have smaller values of time. An earlier study (2) found that, on the contrary, the coefficient on ΔM went to zero at a faster rate so that the less frequent commuters appeared to have higher values of time. Regardless of which is generally the case, there is no reason to expect travelers' values of time to differ depending on how often they make a particular trip. Effects such as these are spurious and result from the assumption that there is perfect information when, in fact, travelers' information is imperfect.

This assumption will be roughly correct if all travelers in a sample are daily travelers. Such commuters would have a large incentive to acquire information about the alternatives open to them because the benefit of such information would be quite significant. This suggests one criterion for choosing between estimates of value of time: If the study asks the individuals in the sample how often they made the trip in question and then examines only daily commuters, the value of time estimate will be less biased. Not even among work trips are all travelers daily commuters; therefore, it is important not to simply assume the problem is solved in all studies concentrating on work trips. In an earlier study (2) I found the bias resulting from this assumption to be about 50 percent.

For nonwork trips, it is usually difficult to find individuals who make the trip daily. As long as a few such individuals can be found, however, it is not necessary to restrict the sample size so that the bias discussed can be avoided. One can build into the modal- or route-split equation interaction terms that control the effect of the frequency of the trip on the coefficients of ΔT and ΔM. A simple specification is

$$L(x) = a_0 + (a_1 + a_2F)\Delta M + (a_3 + a_4F)\Delta T + \ldots \quad (1)$$

where F is the frequency with which the individual makes the trip, and L(x) is the logit, which, in this model, determines the mode choice. The ellipsis represents whatever other variables, such as driver's income, which seem to be relevant to the mode choice. This equation would actually be estimated as

$$L(x) = a_0 + a_1\Delta M + a_2F\Delta M + a_3\Delta T + a_4F\Delta T + \ldots \quad (2)$$

where $F\Delta M$ and $F\Delta T$ are the interaction terms. The value of time for commuters of frequency F would then be $-(a_3 + a_4F)/(a_1 + a_2F)$. By inserting the value of F into Eq. 2, which represents daily commuters, one can obtain a more accurate estimate of the value of time than if the interaction terms were left out and nondaily commuters were included in the sample. This method has been applied (2) with good results. The coefficients of the interaction terms and the other variables were statistically significant,

and those of the predicted signs were interesting; plausible estimates of the value of time resulted. For off-peak work trips, the value of travel time was estimated as approximately $1.91 per adult per hour, compared with $2.95, which was the value when the effect of imperfect information was not taken into account.

IDENTICAL LEVELS OF COMFORT BETWEEN MODES

A second assumption of modal-split models is that the two modes have identical levels of comfort and other intangible characteristics. This assumption is necessary so that the single value of time derived from such models will make economic sense. To see this clearly, one must recognize that the value of time savings on any particular mode is composed of two parts: the opportunity cost of travel time, which is independent of the mode chosen, and the utility or disutility of traveling, which is specific to the mode chosen. The more positive the utility (or less negative the disutility) of traveling is, the lower the amount a traveler will pay to save travel time will be. Thus, if two modes have different levels of comfort, they will have different values of time savings. In this case, to derive one number and call it the value of time between the two modes is meaningless from an economic point of view. One would be estimating neither the value of time on one mode nor the value of time on the other mode, but rather a compromise would be reached between the two. The estimate would be closer to the value of time on the mode that the majority of the individuals in the sample use. Thus, it would be inappropriate to use the estimate of the value of time when time savings on the mode are valued. This is less commonly used in the sample.

There are three ways in which this problem can be avoided. The first is to examine not only choices within a particular mode but also those between two routes or lines of travel. In this case, the assumption of identical, intangible characteristics will be roughly correct. The difficulty is that it is often impossible to find a route-split situation for the mode desired; therefore, one is forced to resort to modal-split situations. A second alternative is to reformulate the model of the value of time so that the assumption is unnecessary (4). This can be done by considering separately the travel times of the two modes by estimating different coefficients for the two travel times. The difficulty here is that the two travel times will be highly correlated with each other, and this makes estimation extremely difficult. It is not sufficient for one to simply insert a new variable into the modal-split equation and purport to measure the comfort level of the mode, for, by doing so, one implicitly assumes that the coefficient on ΔT (and thus the value of time) is independent of this comfort level. If, however, the comfort level could be accurately measured (which is doubtful), it would be appropriate to multiply the difference in this variable by ΔT and thus capture the effect of differing comfort levels on the value of time.

The third and most practical alternative is to alter the overall ratio of observations, e.g., between the two modes, so that most of the observations are on the mode whose value of time one wants to measure. In this way the resulting estimate will approximate the desired value of time. This suggests a second question the user of estimates of the value of time might ask before choosing which estimate to use: On which mode did the majority of observations appear? The answer will, in general, be crucial to an intelligent interpretation of the estimate of the value of time.

Note that if the assumption of identical, intangible characteristics is approximately correct, altering the overall ratio of observations, e.g., between the two alternative modes or routes, will leave the estimate of the value of time approximately unchanged. This fact (2) is convenient for analysts attempting to estimate the value of time because it means that they need not sample the population being studied so that the overall modal- or route-split ratio exactly equals the ratio in their samples. For large samples, it is sufficient that each subpopulation is randomly sampled (the two subpopulations are the groups using each mode); an unrepresentative overall modal-split ratio will affect only the constant term in the modal-split equation.

COMPLETE ACCOUNTING OF ALTERNATIVES OPEN TO TRAVELERS

The third implicit assumption of modal- and route-split models is that they account for all alternatives open to travelers. This assumption is especially suspect during peak hours when traveling at alternative times rather than on alternative modes becomes an important option to the typical commuter. During peak hours, travel times change so rapidly that leaving a few minutes earlier or later can significantly affect the time cost of the trip. When this is true, a change in the difference in travel time between modes will have a second effect besides the usual one of a substitution between modes: Substitution will occur between times of travel. If this latter substitution is not taken into account (and available data generally preclude properly accounting for it), the coefficient on ΔT will be misleadingly small. It will fail to reflect the significant way in which commuters reveal their values of time. The result is that the value of time during peak hours will, in general, be underestimated.

The relevance of this problem is essentially restricted to peak hours. It is also much less serious for rapid transit than for automobile travel, because variation of travel times on rapid transit (e.g., subways, not buses) will usually be smaller than for travel times on the highway. This suggests that samples in which subway or railroad users dominate will be less subject to this source of bias. This, of course, is of little help to those who desire accurate estimates of the value of time for peak-hour automobile travel. Unless studies appear that use data broken down by time of day of trip as well as by the mode or the route and that use sophisticated multinomial choice models, one must simply keep in mind a possible source for a negative bias in peak-hour estimates. [Even so, available evidence suggests that the value of time during peak hours is more than twice the value of time during off-peak hours for the same type of trip (2). This difference is evidently due to the greater disutility of traveling during peak hours.]

ACCURATE MEASUREMENT OF TRAVELERS' PERCEPTIONS

The fourth implicit assumption of models attempting to estimate the value of time is that the differences in (or ratios of) time and money costs in the analyst's data set are accurate measures of the differences in (or ratios of) time and money costs perceived by travelers. This is a troublesome assumption because, as was argued earlier, travelers' information about ΔT and ΔM is imperfect. If either variable changes objectively and an equal change does not occur in the perceptions of the people in the sample, these individuals will respond differently from the way they would have answered had the change been fully perceived. In this case, the response that reflects the individuals' values of time will be confounded with the response (or lack of it) that reflects their misinformation. This type of problem can arise with either measured data, in which ΔT and ΔM are measured with engineering estimates, or with reported data, in which the individuals report ΔT and ΔM. In particular, it is misleading to call reported data perceived data because the individuals may be misreporting their perceptions.

This assumption is distinct from the assumption that individuals in the sample think they have perfect information of ΔT and ΔM (i.e., that they are certain of their perceptions). Uncertainty may be present whether or not misperception occurs. Similarly, misperception may occur whether or not travelers are uncertain.

The problem here is that the travelers' perceptions are not directly observed by analysts of the value of time. This should not prevent discussing their role in travelers' behavior; the analysis, after all, rests on the existence of another variable that is not directly observed: the traveler's value of time. But the fact that one cannot observe travelers' perceptions makes it difficult to do more than speculate on which data, measured or reported, are more appropriate for estimating the value of time. Such speculations are discussed elsewhere (2, 3, 4). Here I wish to discuss ways in which

one might empirically determine which data are more appropriate.

The first and most direct way is to see which data better predict, by use of the same model specification, a given set of mode or route choices. By this criterion, a previous study (5) indicates that reported data are superior. Further comparisons of this kind would be most valuable, particularly if they examine the behavior of the same set of individuals so that strict comparability is possible. A second way of empirically determining which data are more appropriate is (a) to specify a model of either travelers' perceptions or reports and (b) to test the implications of this model. This was attempted (2) for reported data by assuming that the greater individuals' incentive is to misreport (justify) their perceptions, the more they will have invested in their choices. Given this assumption, no support was found for the hypothesis that travelers systematically misreport their perceptions to justify their choices.

These two sources of evidence, then, both tend to support reported data over measured data for the purposes of estimating the value of time. Thus, another criterion for choosing between estimates of the value of time would be that those based on reported data are, in general, more accurate. This result, of course, is subject to change, given new evidence of the types discussed.

SUMMARY

This paper identified four assumptions implicit in most studies attempting to estimate the value of time. These assumptions were shown to have important implications for which data and which model specifications are more appropriate for estimation of the value of time. In particular, biases tend to result when

1. Nondaily travelers are included in the sample, unless the model is specified to take account of their uncertainty of mode characteristics;
2. The two modes examined differ significantly in intangible characteristics, unless this also is properly accounted for in the model;
3. Cross-time substitutions take place, particularly during peak hours; or
4. Significant misperception by travelers occurs when measured data are used.

One can often avoid these biases, and estimates that do so can be distinguished from those that do not if the sources of these errors are kept in mind.

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