

Stated Preference Analysis of Values of Travel Time in the Netherlands

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A major program undertaken by Hague Consulting Group on behalf of the Dutch Ministry of Transport and Public Works is summarized. The topic investigated was travelers' valuations of savings or losses in travel time, often referred to as "value of time." Theory and previous research are outlined. The design of the study, including stated preference and revealed preference analyses, are summarized, and empirical results are presented. A number of conclusions are provided. The emphasis is on the stated preference data collection and analysis. The study provided monetary values of time changes that vary simultaneously along several household, personal, and situational dimensions, including the level of traffic congestion and the amount of free time and income available. The results contain the appropriate variables that, together with forecasts from the Netherlands National Traffic Model, can be applied to provide economic policy evaluations at a detailed level.

A major program of applied research undertaken by Hague Consulting Group on behalf of the Dutch Ministry of Transport and Public Works is described. The topic investigated was travelers' valuations of savings or losses in travel time. The context of the research was one in which substantial professional and public interest had been focused on rising congestion on the major road network in the Netherlands and in which a series of national forecasts anticipated large increases in both car traffic and congestion, even with a substantial program of road building. Two major factors causing the growth are (a) expectations that ownership of cars by the elderly (the middle-aged of the 1980s) will be far higher than at present and (b) expectations that the availability of cars to women and their possession of drivers' licenses will increase along with their participation in the work force (1).

Because of the prospect of large increases in travel time, several major initiatives were under way to investigate measures (including road pricing) to accommodate increasing mobility and reduce time losses in traffic congestion. The costs and benefits of the measures will eventually be appraised for periods up to 25 years in the future.

Assuming that wealth and leisure increase for all, the shifts in the composition of the Dutch traveling population (by age, sex, occupation, income, and so on) can be expected to affect the overall average valuation of gains or losses in travel time, but in an initially unknown manner.

The purpose of the research reported here was to provide empirical evidence for the different valuations of subgroups of travelers in today's circumstances in a form that would allow future valuations to be generated for different scenarios. This information was required to establish guidelines for eval-

uating projects concerned with investment in, or control of, transportation systems in the Netherlands. The principal aim was to contribute to formal evaluations, including (but not restricted to) formal cost-benefit appraisals in which the costs of a project are compared with the potential benefits, including changes in travel time, accident rates, and operating costs, all converted to monetary values.

The theoretical background for the study will be discussed briefly. The data sets assembled for the study will be described, with the focus on the "stated preference" (SP) information. The analysis results will be discussed and final conclusions and recommendations will be given.

The emphasis is on the SP research and results. A more detailed treatment of the theoretical background for the study and of the application of the research findings can be found in the final project report (2) and will be the topic of future publications.

THEORETICAL BACKGROUND

The theory of valuing future travel-time savings rests on a number of hypotheses about how individuals prefer to divide their time between different activities and how these preferences relate to decisions. The hypotheses generate broad rules for predicting which factors influence behavior and what general effect they have. The results can only be made specific through observing actual (or intended) behavior, which can be analyzed to reveal which actual factors are involved and how much each factor contributes to the decision.

The relevant economic theory focuses on the different mixes of activities available to the individual and the financial consequences of each distinct mix. The individual (it is supposed) allocates time between these activities to maximize personal satisfaction, or utility. Different schedules can allocate more time to one activity by saving time from others. Of course, time is never "saved" in the sense of "stored" (unlike money); it can only be transferred from one activity to another.

It is also assumed that such transfers have a money equivalent—an individual with a particular preferred schedule can derive the same overall satisfaction from a less attractive schedule if compensated by the necessary amount of money. Conversely, if circumstances place constraints on the best schedule available to the individual, it is assumed that the individual is willing to pay some amount of money to relax those constraints. (The assumptions are, of course, to be tested against actual behavior, and could be rejected in circumstances where it was found that this sort of trading did not occur.)

This is the basic notion behind a value of travel-time savings. It is seen that people often would rather pursue other

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activities than travel, and they would accordingly pay to shorten journey times. This effect can be seen in many travel markets, where speed can be purchased at a price (e.g., air versus land transportation); however, in the case of highway systems or where options are limited, the extent of the traveler's willingness to pay is unclear.

Authorities who wish to take investment or management decisions involving the expenditure of public money to achieve time savings (or avoid losses) and who wish to be guided by knowledge of travelers' willingness to pay for time savings, must resort to indirect means to establish appropriate values. This is the basic motivation behind this study (and its many predecessors).

The theoretical basis for this study is presented and worked out in some detail in the final project report (2), which applies ideas from conventional economic theory to decisions about activity patterns, including travel. The basic assumptions are as follows:

1. In dividing their time between different activities, including travel, people act consistently to maximize their satisfaction, as perceived by themselves. This is done within the limits set by available budgets of time and money. Options are evaluated and the most satisfying will be chosen.

2. In making decisions concerning travel options, such as choosing between train and car for a given journey or between different routes to the same destination, the utility of an option (for a given individual) can be approximately represented by a linear function of the time costs and the money costs associated with that option plus an "intrinsic" utility for that option regardless of journey duration or cost. It follows from this assumption that, subject to some constraints, time and money can be traded at a certain rate of exchange that will leave the individual no more or less satisfied.

3. The relative importance (utility coefficients) of travel time and cost should vary systematically between different groups of individuals and different types of travel options. In particular, the disutility of travel time should be related to the individual's external time pressures as well as to the comfort of travel by the option under consideration, and the disutility of travel cost should be closely related to available income. The intrinsic utilities of specific travel options are likely to be distributed more widely across the population.

4. A number of other ideas follow from the theoretical treatment. In particular, ideas have been developed about background variables that should be examined because they reflect systematic differences in time-cost trade-off ratios, especially for the scenarios being forecast for the Netherlands for the coming 10 to 25 years. Amounts of free time and levels of congestion and reliability emerge as important factors to consider in the study, in addition to more standard factors such as age, sex, income, occupation, household type, purpose of journey, and mode of travel.

DATA SETS ASSEMBLED

Introduction

During the more than 30 years the topic has been investigated, the classical source for estimates of travelers' rates of trading

off travel time and cost has been actual behavior, so-called revealed preferences (RPs).

Such investigations have been carried out on the basis of observations of travel behavior as interpreted through formal mathematical models based on accepted microeconomic theory. In practice, both the theory and the derived models have been highly simplified, asserting that the relative attractiveness of two travel options (be they modes, destinations, or routes) is a simple function of their travel-time differences and their cost difference. On the basis of this theory, the major problem for the typical "value-of-time" study of the 1960s and 1970s was to find a suitable observational basis, a travel-based context clearly dominated by a choice between speed and economy.

By the mid-1980s, when the Dutch value of time study was designed, research workers in the area of travel demand had already received considerable exposure to SP techniques on the basis of travelers' statements about their behavior under hypothetical choice scenarios (3,4). With respect to using SP methods to provide values of time, the results from a national study in the United Kingdom (5,6) were extremely encouraging. The assertion that these techniques could yield valid information about travelers' preferences appeared to be verified.

Given the choice of study approaches—RP or SP—the initial stages of the project involved two separate activities. On the one hand, existing RP data sets were reviewed for their potential usefulness and subjected to preliminary analyses. On the other hand, after a theoretical appraisal of the subject, purpose-designed SP experiments were developed and corresponding survey instruments were piloted. The RP stream of work will be described briefly, then the SP surveys will be described in more detail.

It was decided to use existing RP data sources, including two large household travel-demand surveys that had formed the estimation base for the Zuidvleugel study of 1977 (8,000 travelers) and the Overdraagbaarheid study of 1982 (6,000 travelers). The model systems estimated by Hague Consulting Group (then Cambridge Systematics Europe) during those studies form the basis for the Netherlands National Traffic Model (Het Landelijk Model).

Both the data design and the modeling philosophy of these studies were consistent with the requirements of value-of-time estimation. They addressed the spectrum of travel decisions faced by the traveling public and supported synthetic models that credibly reproduced individual decision making in a manner consistent with the classical microeconomic theories that had traditionally supported value-of-time research.

SP Surveys

In contrast to the RP data sets, the SP data sets were purpose-designed and drew on the experience of previous studies in a number of ways. First, the theoretical basis established for the study drew attention to the need to distinguish between different types of time-money trading behavior: (a) for different journey purposes, (b) for different income groups, (c) for travelers on different modes, (d) for different occupation groups, (e) for different personal circumstances, (f) for those with different amounts of leisure time, and (g) for different travel conditions.

The last two differentiations are somewhat novel for research of this type. Although it had previously been recognized that available free time and travel conditions were both liable to affect willingness to pay to save travel time, at the time of the project design no work had been published that was based on direct observations of these factors. Both factors, it has been argued, are relevant not only to explain present day behavior but also to inform judgments on likely trends in the future.

For the Netherlands' SP study, the questionnaire was extended to ask about the respondent's regular weekday activities, broken down into paid work, unpaid (including household) work, and travel. From the responses, estimates were formed of total average amounts of free time.

The major aspects of travel conditions recognized in the international literature are traffic congestion (for cars) and reliability (for public transportation). The Dutch study organized its car-driver data collection over a number of different sites, including several on the national highway network. Those sites were chosen to ensure a variability in average driving conditions. They were also selected on the basis of the proximity of electronic detector equipment capable of providing mean stream speeds at all times during the recruitment interviews, which were later used as the basis for the SP time-cost trading questions. In addition, direct questions were asked in the SP survey about congestion and delays during that journey.

For public transportation, no good observable proxy for reliability was found, but respondents were asked directly about their reactions to factors such as delays and departures from schedules.

In terms of journey purposes, the SP survey applied directly to travelers; for business travelers, there is considerable uncertainty about the extent to which they can provide valuations that reflect an employer's valuation of their time. Instead, business travelers were asked to evaluate time losses or gains for their own satisfaction. The results thus provide only a partial evaluation of savings or losses of business travel time, as will be discussed later.

The method of recruitment was to approach potential respondents at gas stations, parking facilities, and public transportation interchanges. The sites were selected to cover areas inside and outside the Randstad metropolitan area, which includes Amsterdam, Rotterdam, and The Hague, and thus cover both congested and less-congested areas of the country.

Travelers were asked to answer questions regarding the journey they were making at that time and whether they would be willing to participate in a postal survey. There were few refusals at this point. Those travelers willing to participate further were sent a second questionnaire by mail. The follow-up SP questionnaire was retrospective, based as much as possible on the respondents' journeys and activities when they were intercepted. The questionnaire contained four sections:

1. Questions about the journey they were making when intercepted, such as their frequency of making that type of journey; whether or not they had a fixed arrival time; whether or not they encountered delays; ticket type and fare class; possible reimbursement of travel costs; number of people traveling with the respondent; other modes used during the journey; other modes available as alternatives; and what alter-

native use any travel-time savings (or loss) would have been put toward (or taken from). These questions provided background information for analysis and served to refresh the respondents' memories of their journey.

2. Pairwise choice questions offering different combinations of time and cost savings and losses against each other. The changes in travel time and cost were described and specified to be appropriate for the respondent's mode (car, train, bus, or streetcar) and journey distance (SP time savings or losses were limited to realistic ranges—up to 5, 10, 20, or 30 min—depending on actual journey duration). Each respondent provided 12 statements of preference regarding variations in travel times and costs for their journey. (One of the 12, a "check" in which one option was both faster and cheaper than the other, was used to test respondents' understanding of the SP choice task.)

3. Questions to gain insight into the amount of the respondent's free time and its flexibility, including the amount and rigidity of paid work hours, number of hours spent doing unpaid work (e.g., housekeeping), number of hours spent traveling, and the most probable alternative uses of those hours.

4. General questions about the respondents and their households, such as the income of the household and the number of workers, adults, children, and cars.

More than 2,000 usable questionnaires were returned, a response rate of more than 60 percent. (A further 15 percent were returned, but rejected because of missing or illogical data.) No attempt was made to ensure the representativeness of the sample in terms of age, travel purpose, mode, income, and so on; this was not necessary because the objective of the study was to establish trading behavior within these sorts of groups, with the possibility of subsequent reweighting to apply to different contexts.

Thus, for example, given estimates of values of time within subgroups, typical national values can be established by weighting by the distance each subgroup travels. Alternatively, typical peak-hour highway values can be established by reference to existing survey data that give the distribution of highway users in terms of these subgroups.

RESULTS OF THE SP ANALYSIS

Analysis Approach

In this section are reported models estimated for three main travel purpose groups: Commuting, Business, and Other. The choice of this purpose split was made specifically with regard to the definitions adopted for the Netherlands National Traffic Model (Het Landelijk Model), although variables were included to detect any evidence of subtler purpose-specific effects. For Business, the experimental questionnaires asked for preferences based on the traveler's own disutilities of travel.

The data were screened to include only those who appeared to have a good understanding of the SP task and who had answered all of the most important segmentation questions such as income. Samples of 485 respondents for Commuting, 469 for Business, and 1,106 for Other purposes (mainly social, recreation, shopping, and education) were then obtained.

The estimation data contained 11 SP choice observations per respondent.

The main estimation procedure was binary logit analysis using the orthogonal segmentation approach adopted in the U.K. study. In this approach, the choices are explained as a function of the utility difference between the two alternatives, using both "main" effect coefficients and a number of additional effects which only apply to certain segments of the sample. For respondent i , choice pair j , the model is specified as

$$p_{1ij} = 1/(1 + e^{U_{ij}})$$

$$p_{2ij} = 1 - p_{1ij}$$

and

$$U_{ij} = (c_{2j} - c_{1j}) \cdot (\alpha_0 + \sum_k \alpha_k \cdot \delta_{ik}) \\ + (t_{2j} - t_{1j}) \cdot (\beta_0 + \sum_l \beta_l \cdot \delta_{il}) + \mu_{ij}$$

where

p_{1ij}, p_{2ij} = the probability of choosing Alternatives 1 and 2;

c_{1j}, c_{2j} = the travel costs for Alternatives 1 and 2;

t_{1j}, t_{2j} = the travel times for Alternatives 1 and 2;

α_0, β_0 = the main cost and time coefficients, respectively;

α_k, β_l = additional cost and time coefficients, respectively;

δ_{ik}, δ_{il} = 0/1 variables indicating membership in segments; and

μ_{ij} = the random error term.

Membership in the k segments for additional cost effects and in the l segments for additional time effects can be specified with regard to the respondent (e.g., age group), the household (e.g., income group), and the journey (e.g., mode of travel), and all additional effects are estimated simultaneously. Thus, each respondent may belong to a number of different segments. It is necessary, however, that for each type of segmentation one group be defined as the "base," for which no additional coefficient is estimated (avoiding perfect correlation with the main coefficient).

With the coefficients that result from this model specification, a value of time can be calculated for respondent i as

$$VOT_i = (\beta_0 + \sum_l \beta_l \cdot \delta_{il}) / (\alpha_0 + \sum_k \alpha_k \cdot \delta_{ik})$$

A wide variety of segmentations were tested during analysis. Although some provided interesting results, they were not directly useful. The models discussed in most detail here were those for which all variables can be used in application. In addition, as discussed in previous sections, it was required that these variables be supported by economic theory. After describing the main results, additional findings not included in the final models will be discussed.

The main models for the three purpose categories are presented in Table 1. This table can be interpreted as follows: first, the base monetary value of in-vehicle time changes by income group is given. Then, the percentage adjustments from

the base values for a number of additional segmentations are given. Because income was the segmentation used on the cost variable, the base values of time for each income group k can be presented directly as $\beta_0/(\alpha_0 + \alpha_k)$. For the additional segmentation effects on the time variable, the results are presented as percentage changes from the base value, on the basis of the fraction β_l/β_0 for Segment l .

To use the results in combination, the percentage adjustments must be added across all relevant segments for a given type of individual, and then applied to the base value for the relevant purpose and income group. For example, a commuter with a household gross income of F5,000 per month, in a one-person-one-worker household, employed full time, age 40, male, with 40 hr/week free time, and traveling by train, would have a value of in-vehicle time of F10.3/hr * (100 percent + 21.7 percent + 0 percent - 14.6 percent + 0 percent + 21.6 percent + 6.1 percent) = F10.3/hr * 134.8 percent = F13.9/hr.

Thus, when all of the segmentation variables are applied, the average VOT across an entire population may be quite different from the base values.

The main cost and time coefficients, α_0 and β_0 , were estimated precisely for all purposes, with t -statistics exceeding 10.0. All other coefficients, estimated as differences from the main coefficients, were significant except where indicated in the table. Overall, the model fit and the number of different significant effects that could be estimated indicate that the data collection approach was successful at identifying systematic effects.

From the theory, it is expected that four main types of variables systematically influence the value of a given amount of travel time:

1. Money budget constraints,
2. Time budget constraints,
3. The characteristics of the journey itself, and
4. The circumstances (personal and organizational) under which the time savings or loss occurs (i.e., the alternative uses of that time).

Each of these types of factors will be discussed in turn.

Influence of Money Budget Constraints

For this dimension, household income is expected to be the main influence, with travelers willing to pay more (or save less) for a given change in travel time as income increases.

For all three purposes, using total household monthly gross income as the segmentation variable, the results indicate that value of time increases with income, as expected. The base values for Commuting and Other are similar. The wider distribution of incomes across the segments in the Other sample allows better estimation for low incomes. The values vary less than proportionally with income for all purpose groups.

For Business, the effects are more extreme for very low and high incomes. This may be related to the respondent's profession, which in turn will be related to the type of cost constraints imposed by the employer. Although business travelers were asked to respond as if they were spending their own money, the fact that such trips are often paid for by the

TABLE 1 VALUES OF IN-VEHICLE TIME FROM SP ANALYSIS RESULTS

| PURPOSE GROUP: | COMMUTING | BUSINESS | OTHER |
|--|--------------------|--------------------|-------------------|
| Sample/Observations: | 485 / 5535 | 469 / 5159 | 1106 / 12166 |
| Base Values by Income (1988 f/hour) | | | |
| 0 - 1500 f/month | 7.0 * | 9.1 | 6.3 |
| 1501 - 2500 f/month | 7.0 * | 9.1 | 7.4 |
| 2501 - 4000 f/month (base) | 7.7 | 12.2 | 7.9 |
| 4001 - 6000 f/month | 10.3 | 12.7 * | 8.9 |
| 6001 - 8000 f/month | 10.4 | 14.5 | 10.4 |
| 8001 f/month or more | 12.2 | 31.4 | 12.3 |
| Additional Segment Effects: | | | |
| Household Composition | | | |
| 1 person/1 worker | +21.7% | +42.5% | +9.0% |
| 2 persons/2 workers | +14.8% | +8.3% * | +7.1% |
| 1 or more children | +20.3% | +4.6% * | +2.0%* |
| All other types (base) | --- | --- | --- |
| Personal Occupation | | | |
| House "wife" | NA | NA | -15.2% |
| Pensioner | NA | NA | -16.5% |
| Employed part-time | +29.1% | -17.6% | -4.5%* |
| All others (base) | --- | --- | --- |
| Age Group | | | |
| 20 or younger | +43.0% | +45.8% | -12.0% |
| 21 - 35 (base) | --- | --- | --- |
| 36 - 50 | -14.6% | -6.3% * | -3.1%* |
| 51 or older | -17.3% | -3.4% * | -21.8% |
| Sex | | | |
| Male (base) | --- | --- | --- |
| Female | -20.0% | -0.8% * | +3.5%* |
| Personal "Free Time" | | | |
| 64 or more hours/week (base) | --- | --- | --- |
| 50 - 63 hours/week | --- | --- | +5.5% |
| 36 - 49 hours/week | +21.6% | +16.7% | +17.2% |
| 35 or fewer hours/week | +28.0% | +33.1% | +17.2% |
| Journey (Sub)Purpose | | | |
| "Other work" | NA | -19.0% | NA |
| Education | NA | NA | +19.0% |
| Shopping/personal business | NA | NA | -9.5% |
| All others applicable (base) | --- | --- | --- |
| Journey Mode and Conditions | | | |
| Car- urban traffic (base) | --- | --- | --- |
| Car- motorway, speed > 110 kph | +9.6% * | +5.0% * | +23.8% |
| Car- motorway, speed 100-110 kph | +35.4% | +14.5% | -11.6% |
| Car- motorway, speed 90- 99 kph | +53.0% | +33.4% | -6.8%* |
| Car, motorway, speed < 90 kph | +67.8% | +33.4% | -6.8%* |
| Train | +6.1% * | -18.5% | -1.6%* |
| Bus/tram | -9.1% * | -22.1% | -25.1% |
| Average Value across the Sample | 12.7 f/hour | 19.8 f/hour | 8.1 f/hour |

Notes: --- = no parameter estimated;

* = estimate not significantly different from base group ($T < 1.8$)

employer will inevitably influence the responses. For the very high incomes, it may be that the high values are associated with business ownership or senior management (i.e., the employee is also the employer).

One might expect other variables besides income to influence cost sensitivity. Such variables include the number of people and vehicles to be maintained out of household income and the respondent's role in the household. Although such variables were tested, no significant effects were found. This may be in part because household-type and person-type variables are also important in determining time budgets, and

these time budget effects may overshadow any cost budget effects.

Another issue that may be important is the possible reimbursement of travel costs by employers or others. For the most part, this effect is expected to be reflected in the journey purpose. Although all respondents were asked to answer as if they were paying all travel costs themselves, additional analysis indicated a residual effect in the Commuting and Other purpose groups, where those whose costs were reimbursed were willing to pay more for a given time savings. Though it is not clear how this result could be applied to

exogenous data, given the imprecise concept of cost reimbursement, it may be an interesting area for further analysis.

Influence of Time Budget Constraints

Time budget effects are expected to be present at both the household and person levels. Three types of households in the sample were identified in which the members were expected to be under time pressures: (a) working adults living alone; (b) working adults living with one or more additional workers, but with no nonworking adults or children (the so-called DINKs); and (c) households with one or more children under working age.

Table 1 indicates that the effects of household type are much larger for Commuting than for Other private travel. This makes sense, as one would expect values for commuting journeys to reflect regular daily activity patterns, in which the type of household has a large influence.

There is not such an obvious explanation for the high value of time related to Business travel in one-person households. This effect may be related to the type of profession, as was the high income effect. In fact, people living alone have the highest values for all purpose groups. Though not tested here, this trend may also be related to lower money budget constraints, as these people do not have to share as much of their household income with others.

Occupation will often determine a person's role in the household and, thus, influence time constraints. For Business and Commuting, the only distinction to be made is between full- and part-time workers. Lower values for Business travel among part-time workers than among full-time workers may be related to professions with fewer time constraints or tighter cost constraints. Part-time workers have higher Commuting values, however. It is believable that part-time workers have tighter everyday constraints. In fact, it is likely that these time constraints prevent many such people from working full time.

For Other purposes—reflecting less regular travel—there is no significant difference between full- and part-time workers. House “wives” and pensioners appear to be less time constrained (have lower values of time), as one would expect. The effects for these two groups, however, are not as large as were found, for example, in the U.K. study. This may be because in the United Kingdom their time budget constraints are also reflected in the age, sex, and free time variables described below.

A person's age and sex will also influence activities and time constraints inside and outside the home. Both Commuting and Business values decrease with age, although the only large differences are for workers under age 21, who represent small proportions of the sample. This age group, consisting mostly of students, has a slightly lower value for Other purposes than the base age group (21 to 35). For the older groups, the values for Other purposes decrease with age, perhaps reflecting a less busy life-style. These values apply specifically to in-vehicle time, so the lower values could also indicate that older people find sitting in vehicles less disagreeable or boring than do younger people.

After the aforementioned factors have been accounted for, males and females do not have significantly different values for Business and Other purposes. Females have somewhat

lower values than males for Commuting. This does not mean, however, that female commuters have lower values overall. In fact, this effect may counteract somewhat the higher values found for single workers, DINK households, and part-time workers—all of which include a higher-than-average number of female workers.

There may be other factors determining people's time constraints that are not fully captured by the standard segmentations considered thus far. As a more direct way of getting at such factors, people were asked directly how many hours per week they spent on paid work, unpaid work (including work in the household), and weekday travel. These hours were subtracted from the number of hours in a full week (168), and another 8 hr/day was subtracted for sleeping. What remained was labeled free time. So a person with 35 hr/week paid work, 14 hr/week unpaid work, and 3 hr/weekday travel time would have about $[7*(24 - 8)] - 35 - 14 - (5*3) = 48$ hr/week free time.

Such an estimate not only gives an additional indicator of present time constraints but also, by making assumptions about future trends in hours spent on paid and unpaid work, this variable (together with the income variable) can be used to adjust values of time to correspond to future economic scenarios.

Table 1 indicates that the free time segmentation gives significant results, even after the other household- and person-type variables have been accounted for. For Commuting and Business, respondents appear to value travel-time changes more highly as the amount of free time decreases. The cutoff points used here are 49 hr/week and 35 hr/week. The magnitude of the effects are similar for both purposes. For Other private purposes, usually reflecting less frequent travel, free time has less influence, although the effect is still significant below 49 hr/week.

Influence of Characteristics of the Journey

In addition to differences between respondents, there may also be differences due to the specific journeys they were making. The purpose of the journey is an important aspect. The Business and Other models were estimated by using subsamples that contain more than one journey purpose category. To determine whether the subpurposes yield different values of time, additional segmentation coefficients were included.

In particular, for Business a variable was introduced to test whether or not the traditional businessman had higher or lower willingness to pay than those merely traveling to a nonfixed workplace. The latter category, labeled “other work,” includes trips usually made by people with nonfixed workplaces (sales representatives, construction workers, etc.) or by people running errands for their work. Although this distinction is difficult to make accurately in all cases, some systematic difference has been captured in a significantly lower value for “other work” journeys than for “employer's business.”

Similarly, variables were included to detect any variation in willingness to pay for travel-time savings within the Other purposes; the subpurposes “education” and “shopping—personal business” were separately identified. The analysis indicated significantly higher values related to education journeys and

somewhat lower values for shopping—personal business. These results conform to expectations—regular education journeys are often time constrained in the same way as commuting journeys, and such constraints are less common for shopping trips. No significant differences were found among the remaining purposes, which include social visits, recreation, and a small number of other miscellaneous journeys. It is worth noting that these three purpose groups—education, shopping—personal business, and social-recreation-other—are also separated in the Landelijk Model forecasting system, in combination with which these results will eventually be applied.

Other characteristics of the journey relate specifically to in-vehicle time. These are the mode used and the travel conditions for that mode. A large proportion of the sample consisted of highway car drivers. They were intercepted at times and places for which the average speed during the date and hours of recruitment was known. Travel time is expected to become more unpleasant as traffic flows increase and average speeds decrease. For Commuting and Business journeys, this is clearly the case. The effect is greatest for Commuting, where congestion is most likely to be perceived as a persistent problem.

The speeds used to determine the variables in Table 1 are 1-hr average traffic speeds, so that although these speeds do not reflect what one might consider “real” congestion levels, they do indicate traffic conditions in which delays could occur.

For Other purposes, it appears that journeys using the highway during off-peak hours (highest speeds) have higher values of time than those who use the highway during more congested periods. This is contrary to the results for Commuting and Business. One explanation may be that many non-work-related journeys can just as easily be made outside peak hours, so that those people who nevertheless travel in congested conditions may be less sensitive to travel-time losses than those who travel off-peak.

The base segment for all purposes is made up of motorists who were intercepted in city centers and may not have used the highway at all. Although this distinction is not accurate in all cases, the results indicate a generally higher value of time savings for interurban traffic than for urban traffic. This effect may arise because travel times for urban journeys tend to be shorter or because significant time savings for city trips may be seen as unrealistic.

The final results in Table 1 reflect values for in-vehicle time in trains and in buses and streetcars in contrast to car in-vehicle time. The differences between train and car for Commuting and Other are not statistically significant. For Business, train in-vehicle time changes are valued less than for car. This may be because useful work can be done on the train or may be related to the profession of the traveler.

Bus and streetcar in-vehicle time values are lower than those for car in all three models. For Commuting, the difference is not significant, and for Business the effect is similar to train and applies to a very small sample. The most important result is for Other purposes, for which the majority of bus and streetcar journeys in the Netherlands are made.

Lower values of time for public transportation users were also found in the U.K. national study. One explanation is that driving a car requires more concentration and is thus more disagreeable, and that people will be willing to pay more to avoid it. This explanation is compatible with the car conges-

tion effects described above. Another possible explanation is that the effect is due to “self-selection”—urban travelers who are pressed for time (and have a choice) go by car, whereas those who are less time conscious go by bus or streetcar. This phenomenon is most likely to occur in the off-peak hours, when travel times between modes differ the most. The perceived unreliability of obtaining consistent travel-time savings in buses and streetcars may also play a role.

Influence of Alternative Uses of Time Saved or Lost

The theory suggests that this feature should show itself mainly in a difference in willingness to pay between travel purposes, which ordinarily differ in both the time of day of the trip and the rigidity of the traveler’s timetable. Person- and household-type differences were also expected to be related to time budgets and the attractiveness of alternative uses of time. Although the effects mentioned above were expected to be the most important and useful, the survey was designed to provide additional insight into the circumstances surrounding particular trips.

Respondents were asked what the alternative use of any time saved or lost during their journey would have been and whether such changes would have been useful or inconvenient. Not surprisingly, those who considered time changes useful (disruptful) were most willing to pay to obtain (avoid) them—even after all of the effects in Table 1 were taken into account. Similarly, those who considered paid work to be the alternative use of travel time were most willing to pay for time savings, whereas those who indicated free time as the alternative were least willing to pay. The same result occurred for avoiding time losses for all purpose groups. It is possible that such results reflect journey-specific time pressures that are not fully captured by the free time variable. It is not evident, however, how variables based on such self-reported conjectures could be applied in practice.

Respondents were also asked about any in-vehicle delays during their journey and how frequently they expected such delays to occur. Those who were late due to delays valued time changes most highly (again, after the estimated effects were controlled for), as did those who expected delays most frequently for a journey such as they were making. Those who had to transfer to another mode during their journey also appeared relatively time sensitive, reflecting greater inconvenience due to delays. Finally, those traveling during the weekend and off-peak periods indicated somewhat less residual time-sensitivity than peak travelers, possibly reflecting the lower frequency of delays or less urgent alternative uses of time.

Another interesting result attributable to the value of alternative uses of time was that the value of a given time loss was considerably higher than the value of the same amount of time saved, and that a longer time saving or loss was valued more highly per minute than a shorter one. These effects were particularly evident for commuters, who valued time losses about three times as high per minute as savings. That the direction and magnitude of time changes influence the value placed on them came as little surprise; this effect has been found in other studies using similar techniques. It is likely, however, that such effects reflect short-term behavior—

rigidities of schedules (work hours, family activities, meetings outside the home, etc.) can mean that substantial increases in travel time cause disruption in the short term (i.e., until the schedules are rearranged). Further, the same sort of rigidities can mean that small time savings from travel cannot be used effectively in the short run.

In the longer term, such effects are less relevant—a person might be no better off after a gradual travel-time increase of 10 min than after a sudden increase of 15 min and a subsequent 5-min decrease. The results indicate, however, that the inconvenience during the transition period may vary according to the phasing of travel-time savings or losses, and suggest that investments or policies that avoid unexpected travel-time losses should be evaluated with higher values of time than those that improve “steady state” travel times.

For models applied to long-term policy evaluation, it was decided to use average values, incorporating time losses and savings in a single coefficient. The experimental design that was used was balanced between time savings and losses, and the general pattern of time valuations (e.g., variation with income and purpose) was similar for losses and savings.

Applying the Results

To apply these models, one must start with the base value for the travel purpose of interest and add all segmentation effects applicable to the person type, household type, and travel conditions of interest, as explained previously. This approach means that the models are best applied on a disaggregate level. When the models are applied separately to each respondent in the estimation samples, the sample mean values of time given at the bottom of Table 1 result: F12.7/hr for Commuting, F19.8/hr for Business, and F8.1/hr for Other purposes. Highway drivers and public transportation users, however, were purposely oversampled, so a “true” mean (e.g., an average value over a nationally representative trip survey) may lie closer to values for urban car drivers.

When the models are applied to a sample of individuals, averages can be taken within certain subsamples to examine the variation along variables of specific interest. Figure 1, for example, shows average values for the three purpose groups for different income bands. Just as for the base values by

income in Table 1, the average values increase with income, but less than proportionally.

The distribution of values of time across the estimation sample after applying the models is shown in Figure 2. The general pattern for the three purpose groups is the same, but the Business model has an extended distribution at the high end, mainly due to the large high-income effect in the Business model. In application, of course, the distribution of values, as well as the means, will depend on the specific mode, route, time period, and population of travelers under study. One may also wish to adjust the models after comparing the average values with those given by RP evidence (see the following section).

Comparison of RP and SP Analysis Results

Approximate comparisons of the SP results quoted earlier with the analysis results obtained from the RP data are presented here. A more detailed report on the RP data analysis is given in the final project report (2). The figures given here are indicative only. The results highlight the great internal variability in individual-level values of time savings: a full comparison of average figures over different data sets thus requires an explicit reweighting of different traveler groups and contexts.

Similarly, other reported studies (e.g., the U.K. value of time study) can best be compared through a complete reweighting. This function of reweighting is addressed in the following section and is necessary to deriving forecast values for different traveler groups in different future year scenarios (in which, for example, income distributions, leisure time availability, and traffic conditions may vary from those of the base year). For the purposes of this section, some approximate “average” results have been estimated to illustrate broad comparability.

The approximate overall results are shown in Table 2 and Figure 3. Table 2 indicates the following:

1. For Commuting by car, the RP results were similar to the SP results for congested highway conditions; this may be appropriate because the RP sample consisted mostly of longer-distance urban commuters. For Commuting by train, the RP and SP results are comparable, given the measurement errors.

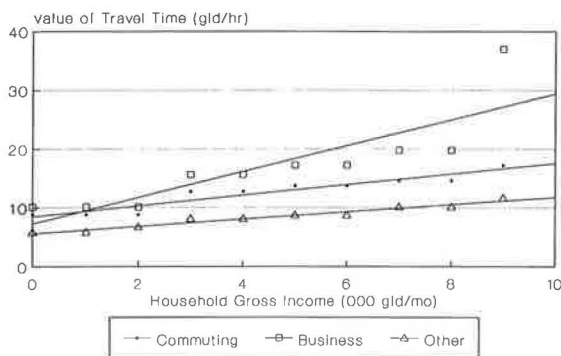


FIGURE 1 Trends in values of time with income (sample averages after applying models).

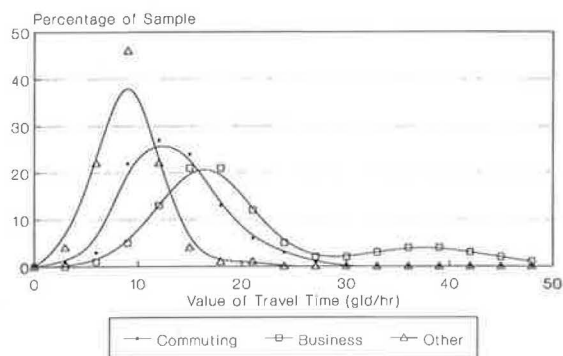


FIGURE 2 Distribution of sample values of time (sample values after applying models).

TABLE 2 COMPARISON OF RP AND SP RESULTS

| | Commuting | | Business | | Other | |
|---------------------|-----------|----|----------|----|-------|----|
| | RP | SP | RP | SP | RP | SP |
| Car ("uncongested") | 21 | 13 | 37 | 21 | 7 | 11 |
| Car ("congested") | | 19 | | 22 | | 9 |
| Train | 14 | 11 | 23 | 14 | 7 | 8 |
| Bus/Tram | NA | 9 | NA | 11 | NA | 6 |

Note: All values are in 1988 guilders per hour.

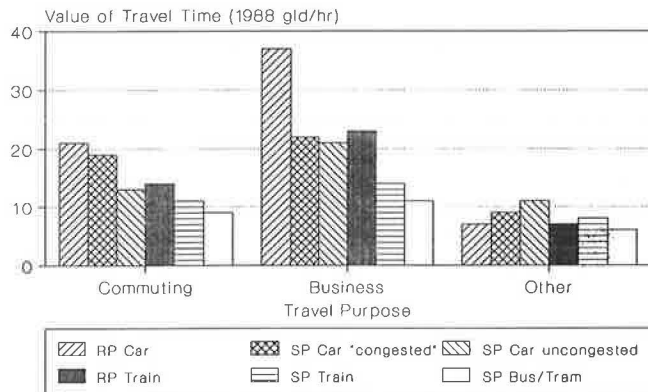


FIGURE 3 Comparison of RP and SP results (approximate average values).

2. For Business travel, the RP values are about 65 percent higher than the SP values for both car and train (though the RP estimates may contain large errors). Some discrepancy was expected because the RP values incorporate the willingness to pay of both employer and employee whereas the SP values are based on the employee's preferences only. The SP values thus require adjustment to include the employer's value, as discussed in the next section.

3. For Other private travel, all results fall within a fairly small band around F7/hr or F8/hr.

4. For all purposes, the RP mode-choice sample includes only travelers with a car available. The RP samples will thus tend to overrepresent higher incomes, which could contribute to the higher values found.

It has been concluded that the SP results are comparable overall with the independent evidence of the RP models. However, the evidence of the latter is much weaker in terms of statistical significance than had been hoped at the outset of the study, given the quantity of data available.

Finally, the similarity to the published U.K. results are noted: for the middle income band and using an approximate inflation factor to 1988 to 1.2 and a conversion rate of pounds to guilders of 3.6, Table 8.2 of *The Value of Travel Time Savings* (6), gives overall values for all nonbusiness purposes of F11/hr for car travelers, F14/hr for rail passengers, and F7/hr for bus passengers—all similar to the results presented here.

CONCLUSIONS AND RECOMMENDATIONS

Main Conclusions

This paper has summarized the planning, design, and execution of a program of research in the Netherlands into travelers' willingness to pay for travel-time savings. The purpose was to assemble a body of evidence to inform a later decision on the appropriate values to use in appraising potential transportation investments.

The study was not intended to be comprehensive; in particular, many issues associated with a full evaluation of business travel-time savings and losses were excluded.

The principal intentions of the study were (a) to reappraise the practice of valuing travel-time savings in the Netherlands and to provide current estimates of these values and (b) to examine existing methods of forecasting future values and to improve them where possible.

To fulfill these intentions, a number of secondary objectives had to be met. First, a theoretical economic framework was required to develop ideas about factors affecting values of time and the ways in which they would affect levels in future years. By building on ideas in the literature, a theoretical representation appropriate for both workers and nonworkers has been created.

Second, it was necessary to develop and apply research survey tools, SP experiments, to provide the quantity and quality of data needed to measure the effects that theoretical considerations suggested should influence willingness to pay.

Third, the methods had to be validated, which involved statistical comparisons of the results with overall indications of average willingness to pay drawn from observations of actual behavior. This in turn required the analysis of existing travel surveys (RP data) to find well-defined trading contexts containing such indications.

The principal conclusions were as follows:

1. Existing practice in the use of simple average values of time may lead to biased estimates of the traveling population's total willingness to pay. Many systematic effects, consistent with theory and a priori reasoning, have been found in the data. Trends that involve not only income but also many other characteristics of the traveler and the context and conditions of travel have been found in subgroups of travelers.

2. Neither theory nor data support the conventional assumptions that values of time are proportional to income levels or that they will develop proportionately to income in future years. A forecasting procedure involving a reweighting of subgroup values has been suggested, and a source of suitable information has been identified in the Netherlands National Traffic Model.

In addition, two areas for further research have been identified: (a) for travelers' own valuations of time savings and (b) for employers' valuations of business travel-time savings. These are discussed below.

Travelers' Valuations of Travel-Time Savings

The results indicate that there is no single value of travel-time savings that is appropriate for all occasions and contexts, nor

are there simple rules (e.g., 30 percent of the wage rate) that accurately reflect travelers' willingness to pay and how this will vary over time. Simple logic, elaborated within the framework of economic theory, suggests many probable dimensions of variability, and experiment confirms that this is consistent with travelers' judgments of the value of time savings.

Two consequences follow from this finding. First, better estimates of overall willingness to pay may require the introduction of more detail into standard evaluation procedures; the same total time saving may have a different worth depending on the context and types of traveler to whom it is made available. Second, much more effort will be required to generate future values of time savings. The existing convention—merely to adjust (scale) for real income growth—is believed not reasonable. This problem should be approached by estimating how the distribution of the population by income categories has changed and then calculating a new weighted average value from the new distribution.

However, the implication is not merely that the treatment of income growth should be more detailed, but that many other effects are important in determining future values of time, and these also need detailed treatment.

In particular, it appears that the different time pressures associated with amounts of free time, occupational status, household composition, and age group of the traveler have a systematic effect on willingness to pay for time savings. During the 25-year horizon typically considered for major investments, the division of the traveling population between these categories will shift, in some cases substantially [see Gunn et al. (1) for a review of the demographic developments expected for the year 2010 and the impact these are expected to have on travel patterns]. Further, the conditions under which travel takes place (in particular, congestion on the roads) are important.

The question of the appropriate level of detail at which to conduct forecasting and evaluation exercises has many dimensions. For evaluation, it has been argued that applying simple average values of time regardless of context and traveler mix may lead to biased estimates of willingness to pay. The extent of this bias will depend on the scheme-to-scheme, policy-to-policy variation in traveler types (income, trip purpose, and so on) and travel contexts (degree of congestion, etc). To avoid this bias, overall willingness to pay must be calculated separately for each application, taking into account all of the dimensions of variability.

For many applications, the effort involved in applying these models to an appropriate exogenous sample of individuals will not be justifiable; the uncertainties in other factors (financial costs, passenger demand, or political considerations separate from time savings and money costs) may outweigh any bias in using average time-savings valuations. In such cases, some simple overall averages (e.g., by mode and by journey purpose) should be available to provide guidelines for minor investment decisions, and the detailed results generated in this project should be processed to provide these averages.

The processing will involve a reweighting of the values of time of the separate subgroups of travelers involved. For past years, this can be done with the aid of the Dutch National Travel Survey data; for the future, information similar to the survey must be synthesized to perform a corresponding reweighting. Such synthetic information already exists in the

Netherlands National Traffic Model and offers a suitable basis for reexpansion.

Thus, for sketch planning, conventional average values will be produced. For evaluations at a national and regional level, however, the new disaggregated information about willingness to pay among the traveling population comes at a time when the applied forecasting methods themselves are based on detailed simulations of travelers, the choices they face, and how the choices are made.

In principle, the simulations can retain the information necessary to characterize the traveler in terms of the factors that determine willingness to pay for time savings. Both the Netherlands National Traffic Model and the associated disaggregate regional models that have been developed have these features. Thus, in addition to forecasts of numbers of trips and kilometers, the model systems could produce disaggregated forecasts of the time spent on travel and its monetary value.

Employers' Valuations of Business Travel Time

This study has focused on the business traveler's personal utility or disutility from travel, omitting the net costs or benefits to the employer. Estimating these net costs or benefits is a notoriously difficult task. At least two approaches have been advanced: first, direct contact with employers can be made and their best judgments about a series of hypothetical travel arrangements (different mixes of time and money) analyzed to infer the rate at which they value the time of the traveling employee (7). A second approach involves adjusting the marginal productivity of the traveling worker for any use that can be made of travel time (8). This approach requires direct evidence from travelers about their use of the time spent traveling (available from the SP surveys mounted in this study) and some estimates or assumptions about marginal productivity (usually taken as the wage rate plus additional costs of employing an individual). Initial estimates of the value of the time savings to the employer using this approach correspond closely to the discrepancy between the RP and SP business values presented earlier.

Further investigation into these areas is under way.

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