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A Review and Discussion of the Literature on Travel Time and Money Expenditures

Authors
Chen, Cynthia
Mokhtarian, Patricia

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by

Cynthia Chen
Institute of Transportation Studies
And
Civil and Environmental Engineering
University of California, Davis 95616, USA
Fax (530) 752-6572
qzchen@ucdavis.edu

and

Patricia L. Mokhtarian
Department of Civil and Environmental Engineering
and
Institute of Transportation Studies
University of California, Davis 95616, USA
Davis, CA 95616
Tel (530) 752-7062
Fax (530) 752-7872
plmokhtarian@ucdavis.edu

Institute of Transportation Studies
One Shields Avenue
University of California
Davis, California 95616
Tel: 530-752-0247 Fax: 530-752-6572
http://www.its.ucdavis.edu/
email: itspublications@ucdavis.edu

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Cynthia Chen
Institute of Transportation Studies
and
Department of Civil and Environmental Engineering
University of California, Davis 95616, USA
(530) 752-6572 (fax)
qzchen@ucdavis.edu

and

Patricia L. Mokhtarian
Institute of Transportation Studies
and
Department of Civil and Environmental Engineering
University of California, Davis 95616, USA
(530) 752-7062 (phone), (530) 752-7872 (fax)
plmokhtarian@ucdavis.edu

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OVERVIEW SUMMARY AND DISCUSSION

I.1. Introduction

Over the last forty years of travel demand analysis, time has been a variable of central importance to our understanding of the demand for travel (Pas, 1998). A frequently-studied time-related measure is the amount of time allocated to travel. A long-standing question regarding the time allocation to travel is whether the travel time expenditure exhibits stability in time and space. One group of researchers, led by Zahavi, empirically studied this issue about 20 years ago and claimed the existence of both temporal and spatial stability of the travel time expenditure. This concept became referred to as a travel time budget[1]. They argued that average daily travel time expenditure is stable, around 1.1 hours per day per traveler[2]. Schafer (1998) used the concept of a travel time budget to forecast global travel demand.

Given a constant travel time budget, travel time saved (whether by improving the speed of travel through technology advancements such as ITS, by eliminating trips through telecommunications substitution, or by bringing desired destinations closer to the traveler) will not be allocated at all to other activities, but entirely on more travel. This is a rather extreme prediction and in any random sample, we expect the existence all of three possibilities: saved travel time may be used for more or longer activities only, or used for more travel only (possibly to access more desirable activities farther away), or used for both more or longer activities and more travel. One study found that a 10-minute reduction of commute time would increase the average total out-of-home activity duration by 1.88 minutes, average total in-home activity duration by 7.11 minutes and average total travel time by only 0.36 minutes (Kitamura et al., 1997). In that case, then, the result is counter to a constant travel time budget.

The same group of researchers who claimed the existence of a travel time budget also claimed the existence of a travel money budget. They argued that people spend a fixed percentage of their income on travel. The figure is about 10 to 11% of income for car-owning households and 3 to 5% of income for carless households (Zahavi and Ryan, 1980). Similar to the travel time budget, if a travel money budget existed, given an unchanged income level, the money saved by the ability to reduce travel will again be used for more travel instead of spending on other consumption goods and services. However, spending more money on travel may result in larger savings on other goods, for example in accepting in a longer commute to buy a cheaper house.

The issues discussed above motivated this investigation into travel time and money expenditures. This effort has two aims: to examine the constancy of travel time and money expenditure by reviewing the empirical evidence, and to explore ways of modeling an individual's time and money expenditures on travel. This report accomplishes the first aim; the second aim will be addressed in a succeeding report.

This report is organized as follows. In Section I.2, we provide an overview of the studies reviewed, including a discussion of the complexities of this cross-study comparison, and the key

[1] The word "expenditure" refers to the amount of quantitative resources spent on consuming a good or service or performing an activity (including travel); it does not imply stability. On the other hand, the word "budget" implies stability, it refers to an "allocation of time, money or generalised resources to travel which would not be influenced by policy, trends or costs" (Goodwin, 1981).

[2] An individual who makes at least one trip during the data collection period.

variables affecting travel time and money expenditures. Section I.3 offers some concluding observations. Part II of this report offers brief summaries of the individual studies reviewed. Several tables summarizing the studies reviewed are placed in the Appendix, which follows the bibliography.

I.2. Overview of Literature Reviewed

I.2.1. Progression of Research Motivations and Approaches

The research into travel time and money budgets was originally motivated by dissatisfaction with the Urban Transportation Planning System (UTPS) modeling approach. In the 1970s, the traditional four-step model used to forecast regional travel demand was increasingly viewed as inadequate for modeling changes in individuals' travel behavior. For example, a change in trip rates could well be because of changes in the transportation service levels (e.g., costs of travel), and independent of those variables considered in the conventional trip generation models (e.g., income growth, vehicle purchase, etc.). The traditional four-step model's implicit assumption of stable trip rates given certain household characteristics prevented such changes in travel behavior from being modeled accurately. In addition to the inability of traditional four-step models to handle certain behavioral changes, there was also increasing dissatisfaction with the statistical inaccuracies of these models (Gunn, 1981) and the difficulty in fitting the model to observed data (Robbins, 1978, cited in Gunn, 1981).

Around the late 1970s and early 1980s, researchers looked for the regularities in time and space that travel behavior may exhibit. It was hoped that travel time and money budgets, if they existed, could significantly improve the behavioral sensitivities of the traditional four-step modeling procedure. Zahavi (1979), who was one of the very first to raise the concept of the travel time and money budget, developed a Unified Mechanism of Travel (UMOT) process for travel demand forecasting. The UMOT concept was based on the assumption that travel time and money expenditures exhibited regularities that can be attributed to certain factors such as socio-economic characteristics of households, transportation system supply, and urban structure, and that these regularities are spatially and temporally stable. Explicitly accepting these constraints in the modeling process, as Zahavi argued, would allow transportation planners to predict behavioral changes and make policy recommendations "without going through [a] lengthy calculation process" (Zahavi and Talvitie, 1980). Chumak and Braaksma (1981) argued that the concept of a constant travel time budget can be used to check conventional forecasting results and to ensure that the conventional forecasting results reflect an equilibrium between travel demand and the supply of the transportation facilities. Additionally, Goodwin (1981) discussed how time and money budgets, if they existed, might be incorporated into various components of the traditional four-step modeling procedure. Fourteen of the 21 aggregate studies we reviewed in this report were conducted between the late 1970s and the early 1980s.

Later, with the rapid development in econometric models and computing capability, disaggregate studies more and more dominated the field in travel behavior. The research objective was still to support policy recommendations, but the interest in travel time and money budgets declined dramatically. This is probably because, even without the assumption of travel time and money budgets, one still can forecast future travel behavior and make policy recommendations. That

may be the reason why very few studies were found in the mid- and late 1980s on the stability of travel time and money expenditures.

From the late 1980s and early 1990s, activity-based research started to flourish. This was motivated by the long-recognized concept of travel as a derived demand and the recognition of history and future dependence among activities and travel within a certain period. Although the research objectives are still to forecast travel behavior and make transportation policy recommendations, the study focus has largely shifted from travel to activity. Activity-based researchers are placing a greater emphasis than ever on the behavioral aspects of observed patterns, particularly why people engage in activities distributed in space. Within this context, it is important to understand how individuals allocate time and money among activities and travel, not necessarily for the purpose of simplifying demand analysis as Zahavi first envisioned, but for the purpose of enhancing our behavioral understanding. It is hoped that an improved understanding of individuals' allocation behavior will enhance our knowledge of travel behavior, which will then allow us to construct more accurate travel demand models. All seven disaggregate studies reviewed in this report were conducted in the 1990s, and four of them are particularly in the context of an activity-analysis orientation.

I.2.2. Complexities of Cross-Study Comparisons

In cross-study comparisons, it is desirable to compare results from different studies using similar dimensions. Unfortunately, this is almost impossible to achieve as researchers conducted their studies at different times and with different objectives. Consequently, differences, sometimes significant, exist. Thus, it is important to keep the differences described below in mind while reading this report.

Modes Included. Not all studies are based on the same set of modes. In particular, modes at each end of the speed spectrum are often excluded: non-motorized modes (e.g., walking) and high-speed modes (e.g., airplanes and high-speed trains). Exclusion of any mode biases the estimation of daily travel time expenditures downward. The bias due to excluding non-motorized modes is especially severe for some European countries where the automobile is not as dominant and higher densities prevail compared to the US. For example, in Britain it was estimated that walking comprises about 30-40% of the total time spent traveling (Goodwin, 1981). As for the exclusion of high-speed modes, although the frequency of taking airplanes and high-speed trains is quite low for most people, the travel distances they cover at one time are much higher than for the more frequent trips by slower modes.

Survey Period. Due to day-to-day variations (Prendergast and Williams, 1981; Kumar and Levinson, 1995), the length of the survey period could bias the estimate of the travel expenditures. Goodwin (1981) pointed out three causes of day-to-day variation. One type is pure random day-to-day variation. The second type is systematic variation, due to the fact that not all types of trips are made every day. For example, workers may do grocery shopping once a week. The third type is the lag effect. In other words, the travel behavior we observe during the survey period may be due to time and cost effects from the unobserved previous period. In short, these day-to-day variations suggest that a minimum desirable survey period might be one week, with periods of one month or even a year desirable to capture less frequent travel (e.g., major

vacations) which may nevertheless contribute significantly to the total travel expenditure. However, the ideal of measuring all travel must be balanced against the burden on the survey respondent, and in fact survey periods almost never exceed one week, with periods of one to three days being quite common.

Survey Type. The way the question is asked may affect the response. Robinson (1997) argued that if subjects are asked to give a single answer to the total amount of time spent on activities and travel (e.g., "how much time did you spend traveling yesterday?"), the resulting answer can be very erroneous. Such questions require respondents, in a very short time, to sum up the travel times of all trips they took on the previous day. An alternative is to obtain travel time estimates via a trip diary. In the trip diary, subjects are asked to report every trip they made during a certain period. Researchers sum up the travel times of every trip respondents reported to obtain the total daily travel time expenditure. This often leads to an underestimation of the total travel times because trips with short duration tend to be forgotten by respondents. Perhaps the best alternative currently available for estimating daily travel times is via a time use survey, or activity diary (Robinson, 1997). The time use survey requires the subject to report not only travel times but also activity times, which results in fewer trips being forgotten.

Analysis Unit. Researchers used different analysis units based on different arguments. Zahavi's pioneering studies focused on travel time expenditure per traveler (those who made at least one trip during the survey period). The reason behind the use of travelers as the unit instead of all people, as Zahavi explained, was that he found that using the former measure as the basis gave stable results whereas using the latter measure did not. However, without a prior conceptual justification of the superiority of the former measure, the choice appears to be a selective acceptance of results that fit a preconception and rejection of those that did not. Chumak and Braaksma (1981) also used the trip-maker as the unit of analysis, with trip-maker defined as an individual who makes at least one mechanized trip per day.

Others (e.g., Goodwin, 1981) argued that the mean travel time expenditure per traveler will depend on the duration of the survey period, while travel time expenditure per person does not. For example, on any given day, some proportion of people may not travel, but a far smaller proportion will not have traveled in an entire week. Keeping the travel time expenditure per person constant, the daily travel time expenditure per traveler will be higher if the study period is one day than if it is one week.

Only one study (Downes and Morrell, 1981) used travel time expenditure per household, to account for interactions among household members. The argument is that tradeoffs in household responsibilities may mean that one member can travel less by having another member travel more. The travel time expenditure per household may have less variation compared to travel time expenditure per person because higher and lower travel time expenditures among household members balance out and thus provide a seemingly more stable travel time budget. However, such a measure would not provide insights into the specific nature of household tradeoffs and how they are made.

Types of Trips Included. Not all studies included all types of trips made during the study period. Some studies (e.g., Hamed and Mannering, 1993) included only post-work trips. Other

researchers (e.g., Gordon et al., 1991) only analyzed commuting times. These studies are not readily comparable to other analyses that include all types of trips (e.g., shopping, recreation etc.). However, the Hamed and Mannering study is included among the individual studies reviewed in Section 4 because of the novel (in this context) methodology it employs.

I.2.3. Methodologies Employed

The studies reviewed fall into two categories: aggregate and disaggregate. Aggregate studies analyze observations at a relatively large geographical scale (e.g., city, Transportation Analysis Zone), whereas disaggregate studies analyze observations at the household or individual level. The methodologies employed in these two types of studies differ significantly. Aggregate studies mainly employed descriptive analysis techniques; a few also used linear regressions. On the other hand, disaggregate studies employed methodologies such as structural equations modeling and survival analysis.

I.2.4. Discussion of Key Variables

I.2.4.1. Travel Time Expenditure

A number of aggregate studies beginning in the late 1970s and early 1980s explored the stability of the travel time expenditure in space and time. When these studies are compared with each other, the results do not support the concept of stability. Early studies claimed that daily travel time expenditure per traveler showed stability over time (Zahavi and Talvitie, 1980; Zahavi and Ryan, 1980; Chumak and Braaksma, 1981). Purvis (1994), however, found that the travel time expenditure per traveler showed instability over time (increased from 1965 to 1981 but decreased from 1981 to 1990) in the Bay Area. Levinson and Kumar (1995) found that daily travel time significantly increased from 1968 to 1988 in the metropolitan Washington area, using data collected for local planning purposes. Another study by the same authors (Kumar and Levinson, 1995) using the Nationwide Personal Transportation Survey (NPTS) data found a different result; specifically, they found that at the national level, the daily travel time expenditure remained unchanged between 1954 and 1990. The discrepancies between these two studies could well be because of the different geographical scales used. The NPTS data used in the latter study is at the national scale. It is quite possible that the aggregate average travel time expenditure exhibited in the latter study would appear more stable than studies using data on a smaller geographical scale (e.g., the former study). Moreover, the metropolitan Washington, D.C. area (the subject of the former study) may have unique characteristics that do not stand out in the NPTS study. In short, an apparent temporal stability at higher levels of geographic aggregation (e.g., national level) may mask instability at a finer scale (e.g., metropolitan level).

Zahavi and his colleagues (1980) also argued for the spatial stability of the daily travel time expenditure per traveler. This argument was supported by Hupkes (1982). But Hupkes examined the spatial stability of the daily travel expenditure per person instead of per traveler. Robinson et al. (1972) examined travel time expenditure per person per day in twelve countries. Although the highest average travel time expenditure (90 minutes) is more than twice the lowest average travel time expenditure (39 minutes), the authors concluded that the variation fell into a “remarkably narrow range.” Kitamura et al. (1992) examined the time use patterns in both the Netherlands

and California and found that Californians spent considerably more time on traveling than did the Dutch, a result that contradicts the spatial stability of travel time expenditure.

Even researchers who argued for the stability of a travel time expenditure at the aggregate level acknowledged that there was considerable variation at the disaggregate level (e.g., Zahavi and Talvitie, 1980). Analysts have attempted to relate the observed variation to a number of potential explanatory variables. We discuss some of the commonly-studied variables below. Variables representing socio-economic characteristics are presented first, followed by activity-related attributes and then area-specific attributes (density and network attributes)[3].

Age. More studies have found a significant effect of age on travel time expenditure than studies (Roth and Zahavi, 1981) that found it insignificant. Prendergast and Williams (1981) found that people of middle ages (between 21 and 64) spent more time on traveling than those who are either below school age or above retirement age. Kitamura (1992) found that people of ages between 18 and 50 traveled significantly more than those people of ages above 50. Gunn (1981) found that people of ages between 17 and 24 spent more time traveling than people of other age groups. In addition, people whose ages were below 16 or above 60 traveled significantly less than people of other age groups. All these studies examined all modes together, so these observed results are probably not due merely to the reduced "automobility" of the young and the old. In other words, the young and the old presumably not only had lower daily travel time by automobile but also had lower total daily travel time by all modes. Rutherford et al. (1996) found mixed results for the effect of age on daily travel time.

Car Ownership. A clear linkage between travel time expenditure and car ownership often appears, but the direction of such linkage is not consistent. A positive influence of car ownership on travel time expenditure has been found in many studies (van der Hoorn, 1979; Prendergast and Williams, 1981; Roth and Zahavi, 1981; Godard, 1978, cited in Gunn, 1981; Purvis, 1994; Lu and Pas, 1999). A negative relationship between car ownership and travel time expenditure was also found (Zahavi and Talvitie, 1980; Roth and Zahavi, 1981; Robinson et al., 1972). Insignificant relationships have also been found (Downes and Morrell, 1981; Bullock et al., 1974, cited in Gunn, 1981; Purvis, 1994).

The contradictory results on the relationship between car ownership and travel time expenditures are likely caused by the mix of different modes in different studies. Car ownership could well cause an increase in travel time expenditure by auto modes but a decrease in travel time expenditure by other modes. Golob (1990) found that travel time by car increases with car ownership, but travel times by public transport and non-motorized modes decrease with car ownership. Travel time expenditure by mode was also studied by other researchers (Roth and Zahavi, 1981; Prendergast and Williams, 1981; Tanner, 1981; Goodwin, 1976).

A reverse causality from travel time expenditure to future car ownership is also possible (Golob, 1990). Large amounts of time spent on car travel may cause an increase in future car ownership.

[3] Only variables found significant in more than one study are included here. Some of these results are summarized in Table 3 of the Appendix.

Similarly, large amounts of time spent on public transport may cause a switch from a slower mode to a faster mode within limits of constraints such as income.

Employment Status. The influence of employment status (employed vs. unemployed) on travel time expenditure is quite uniform. Most studies have found that employed people tend to spend more time traveling than unemployed people (van der Hoorn, 1979; Zahavi and Talvitie, 1980; Roth and Zahavi, 1981; Prendergast and Williams, 1981; Wigan and Morris, 1981; Bullock et al., 1974, cited in Gunn, 1981; Supernak, 1982; Kraan, 1996; Ma and Goulias, 1998; Lu and Pas, 1999). However, this result is moderated somewhat by interactions with gender, as discussed below.

Gender. Gender is another variable for which researchers have found contradicting results. A number of researchers have found that men spend more time traveling than women (Prendergast and Williams, 1981; Gunn, 1981; Wigan and Morris, 1981; Kitamura, et al., 1992; Levinson and Kumar, 1995; Robinson, 1997). Roth and Zahavi (1981) found no significant difference in travel time expenditure between men and women in Bogota, Columbia and yet in the same study they found men spent more time traveling than women in Singapore. The opposite relationship (women spent more time traveling than men) was found by Lu and Pas (1999). They suggested that this was due to the exclusion of many short and non-motorized trips (that were perhaps more often made by women) in many early traditional travel surveys. An insignificant relationship between gender and travel time expenditure was found by Zahavi and Talvitie (1980).

Gender by Employment Status. There may be an interactive effect between gender and employment status on travel time expenditure. Prendergast and Williams (1981) found that a combination of gender and employment increased the range between the maximum value and the minimum value significantly; the maximum average travel time expenditure, which was attained by full-time employed males, was about three times the minimum average, attained by retired women. In another study, Robinson (1997) examined travel time expenditure between the employed and the unemployed within the same gender. He found that weekly travel time was higher for employed women than for unemployed women, but weekly travel time was lower for employed men than for unemployed men. In his 1985 data set, employed women spent more time traveling than employed men.

Household Size. Zahavi and his colleagues (1980s) observed that travel time expenditure per person decreased with increasing household size, whereas travel time expenditure per traveler varied little with household size. This was one aspect of their argument for the use of travel time expenditure per traveler instead of per person. The finding on decreasing travel time expenditure per person with increasing household size was supported by Purvis (1994). In the same study, Purvis (1994) also found that daily travel time per household increased with increasing household size. Roth and Zahavi (1981) found a rather insignificant effect of household size on daily travel time expenditure per traveler.

Income. Similar to the influence of car ownership, findings on the influence of income on travel time expenditure do not agree with each other. A positive influence was found by a number of researchers (Prendergast and Williams, 1981; Tanner, 1981; Zahavi and Talvitie, 1990; Lu and Pas, 1999). Roth and Zahavi (1981) found a positive influence in Salvador, Brazil, but in the

same article, they found a negative influence in Bogota, Colombia and Santiago, Chile. Using the same data set in Bogota, Colombia, a negative influence of income level was also supported by Zahavi and Talvitie (1980). But in studies using the Singapore data in 1975, a rather independent relationship between income level and travel time expenditure was found (Zahavi and Talvitie, 1980; Roth and Zahavi, 1981).

Reasons for the conflicting results on the relationship between income and travel time expenditure may be similar to those for the conflicting results on car ownership and travel time expenditure. Researchers may have neglected to examine the relationship of income to travel time by mode. Golob (1990) used a high income dummy to examine the relationship between income and travel time by mode. He found that the high income dummy variable had a positive effect on travel time by public transport. This result seems to be quite counter-intuitive. More research is needed to explore the relationship between income and travel time expenditures by mode.

Person Group. Researchers have used a variety of variables to group people into different categories, and examine average travel time expenditure by category. Golob and McNally (1997) examined travel time expenditures on different activities by male and female household heads. In addition to the demographic variables previously discussed, at least one study used lifestyle as a basis for segmentation. Principio and Pas (1997) argued that people exhibiting similar socio-economic characteristics may not exhibit similar travel behavior due to different lifestyles adopted. Hence, they divided their sample into seven lifestyle groups using cluster analysis on time-use patterns. The *Workaholics* group (20% of the sample) spent an average of 85% of their time on work and work-related activities and spent the least time on recreation, maintenance, and social activities. The *Active Workers* group (37% of the sample) spent an average of 63% of their time on work and work-related activities, but unlike the workaholics group, they divided the rest of their time evenly among other activity categories. The *Socializers* group (6.6% of the sample) spent an average of 59% of their time socializing and devoted little time to work and school activities. The *Leisure Enthusiasts* group (7.6% of the sample) spent most of their time on recreation and leisure. The *Domestic Caretakers* group (4.5% of the sample) spent most of their time maintaining their households. The *Diverse Participants* group (18% of the sample) divided their time among a variety of activities. The *Scholars* group (6.3% of the sample) spent most of their time on school and school-related activities. Among these seven different life style groups, Principio and Pas (1997) found that the *Workaholics* group made fewer than average trips and tours and were very efficient in trip chaining. The *Active Workers* group had the highest total trip times for the two consecutive study days and they had a high number of trips and tours as well. They were also quite efficient in trip linking. The *Socializer* group made the fewest trips and tours and was inefficient in trip linking. The *Leisure* group made few trips and spent the least amount of time traveling. The *Domestic Care* group made fewer than the average number of trips and the average trip length for this group is much shorter than those of the other groups.

Activity Duration. There is an interaction between the amount of the time spent on travel and the amount of time spent on the chosen activity. In examining the travel time from work to activity, Hamed and Mannering (1993) found that travel time from work to activity is positively related to expected duration at the activity location. The same observation was made by

Kitamura et al. (1997). Ma and Goulias (1998) noted that the interaction between activity duration at the destination and travel was only pronounced for subsistence activities.

Time Spent on Other Activities (Variables: Total Time Available and Total Time on Out-of-Home Activities). Since each of us faces the same time budget, a negative relationship exists between the travel time expenditure and total amount of time spent on other activities. A related concept is the relationship between travel time expenditure and work duration (assuming that work duration is relatively fixed). Kitamura et al. (1992) found that work duration has an inverse effect on non-work travel. The more time a person spends on work, the less time he/she spends on non-work travel. In other words, travel time expenditure is proportional to total available time, defined as 24 hours minus the work duration (Kitamura et al., 1992).

There is also a linkage between the travel time expenditure and the amount of time spent on other activities. Researchers (Lu and Pas, 1999; Principio and Pas, 1997) found that travel time increases as the amount of time spent on out-of-home activities increases; decreases as the amount of time spent on in-home activities increases. Golob and McNally (1997) conducted in-depth analysis on the effect of out-of-home activity participation on travel time to the corresponding activity, as well as gender effects. They found that one hour of work activity generated about 2.8 minutes of travel to work for both men and women; one hour of maintenance activity generated about 7.8 minutes of travel to that activity for both men and women; one hour of discretionary activity generated about 5.5 minutes of travel to that activity for men and about 8.5 minutes for women. The reason behind the gender difference for travel to discretionary activities requires further analysis.

History Dependence (Variables: Duration of Previous Trips, Number of Past Activities Participated in, and Time Spent on Past Activity and Travel Participation). History dependence refers to the effect of past history on the current decision (e.g., travel time expenditure). Kitamura et al. (1997) proposed and tested the effect of history dependence on activity engagement and activity duration. They, however, did not test the effect of history dependence on travel time expenditure. This was carried out by Ma and Goulias (1998). They found that a) the longer the previous trip to a subsistence activity, or the shorter the previous trip to a leisure activity, the longer the travel time of the current trip would be; b) more time spent on past activity participation and travel on the same day or a higher number of activities in the past on the same day tended to decrease the travel time of the current trip.

Area Type. Effect of area type on travel time expenditure may be examined by simply dividing the area into urban versus suburban or large metropolitan area versus smaller cities. Van der Hoorn (1979) examined travel time expenditures in rural areas, industrialized rural areas, small towns, commuter towns, middle-sized cities, large cities, and dense urban areas such as Amsterdam in the Netherlands. He found that travel time per person per week was the highest for dense urban areas for all trip purposes except for school. Consequently, total travel time expenditure per person per week was the highest for dense urban areas. The result of high travel time expenditure for large dense urban areas was also supported by Landrock (1981) who found that people living in the London metropolitan area had significantly higher travel time expenditures than those living in other areas. Gordon et al. (1991) examined the commute times

for the top 20 cities in the US and found that commute times were higher for large cities (e.g., New York).

Not all researchers support the notion of relatively higher travel times for dense urban areas than for suburban and rural areas. Downes and Morrell (1981) examined travel time expenditures in the inner area, middle area, and outer area of Reading, Britain and found that these area types made little difference in daily travel time per person. Supernak (1982) noted that in Baltimore, Maryland, urban travel times were higher than suburban travel times while the opposite outcome was found in the Twin Cities, Minnesota.

Another way to study the effect of area type on travel time is to categorize the area by some attributes such as population density and size. Landrock (1981) studied the effects of population size and population density on the daily travel time expenditure per person in Britain. For population size, he found that except for London with an average daily travel time of 68 minutes for all persons and 88 minutes for travelers only, all other areas fell between 56 minutes and 60 minutes for all persons and between 72 minutes and 76 minutes for travelers. The high travel time expenditure in London was mainly due to the large amount of time spent on work, shopping, and social activities. With respect to population density, he found that people living in low densities had a lower daily travel time than those living at higher densities. The effect of population density on travel time expenditure seems to be significant and non-linear. The interactive effect of population size and density seems insignificant except for people living in areas of low density but high population, who tended to have higher travel times compared to those living in other areas.

Gordon et al. (1989) argued that what caused people living in large cities to have higher travel time expenditures than those living in small cities was the spatial structure, not population density. They argued that the relationship between population density and travel time expenditure is ambiguous if spatial structure is ignored. For example, as they noted, “high densities in a monocentric city imply shorter trips, and low densities mean longer trips, while in a polycentric city, low densities could mean either shorter or longer trips depending on whether workers choose homes around employment subcenters”.

Other measurements related to daily travel time expenditures include vehicle-miles traveled, distance traveled, mode share, and commute times. Researchers have extensively studied how different spatial designs of neighborhoods affect these measurements (e.g., Cervero, 1995, 1996; Ewing et al., 1994; Frank and Pivo, 1994; Handy, 1996a). Neo-traditional neighborhoods are sometimes referred to as transit-oriented neighborhoods (Ryan and McNally, 1995). Designed to be balanced and self-contained, these communities have mixed land uses for residential, commercial, and recreational opportunities. Streets within the community are highly inter-connected and facilitate the use of walking and bicycles. Handy (1996b) noted that studies of the impact of neo-traditional neighborhood designs on travel behavior may be divided into three categories: traditional transportation models that are used to compare between typical suburban designs and hypothetical neo-traditional neighborhood designs, aggregate level data that are used to compare between cities with different designs or different densities, and disaggregate level data that are used to test differences in individuals’ travel choices in different neighborhoods. Results from the first two types of analyses generally confirmed the initial claims that neo-

traditional neighborhoods generate fewer automobile trips and shorter trip distances, but results from the last type of analysis indicated that results often depended on factors (e.g., individual or household level characteristics) that are not accounted for in the first two types of studies.

Results showing fewer automobile trips in neo-traditional neighborhoods certainly imply a lower level of total daily travel time by automobile, although when walk and other non-motorized trips are included, the total daily travel time may not be lower compared to that in typical suburban neighborhoods. In fact, in the other studies cited above, the dominant result appears to be that total travel time is higher in high-density areas, although evidence is mixed. However, the definitive study of this issue must control for income differences: if high-density urban dwellers have lower incomes on average, then the higher travel times may be due to their use of slower modes rather than to land use effects per se. On the other hand, as noted earlier, the influence of income on travel time expenditures is also ambiguous.

Time of Day. Other things being equal, time of day is a proxy variable for how fast one can travel, which together with distance, determines travel time. Hamed and Mannering (1993) found that when departing directly from work, travel time from work to an activity tended to be higher than if departing from home. The reason, they explained, was mainly that departing from work often took place during the peak period when travel speeds were relatively low. However, they did not appear to control for potentially different distances to activities accessed from work compared to those accessed from home. In examining travel time from work to home, Hamed and Mannering (1993) found a positive effect of departing during the peak period; in other words, when departing work for home during the peak period, the travel time was likely to be higher than if departing during the off-peak period. Ma and Goulias (1998) found that a late home departure (possibly during the off-peak period) reduced the travel time expenditure.

I.2.4.2. Travel Money Expenditure

Compared to travel time expenditure, travel money expenditure is a much less visited subject. Most of the studies that examined travel money expenditure were aggregate studies. They often used descriptive analysis and simple linear regression methods to examine the stability of travel money expenditure. Zahavi and his colleagues (1980s) argued for the stability of travel money expenditure, or a travel money budget. They indicated that an average car-owning household spends about 10-11% of its income on travel while an average non-car-owning household spends about 3-5% of income on travel.

Zahavi's findings on the existence of a travel money budget were not unanimously supported by other researchers. Gunn (1981) in his review paper cited considerable evidence that contradicted Zahavi's finding of a constant travel money budget. In one data set (Annual Abstracts of Statistics), he noted that from 1950 to 1977, there was a clear upward trend in the total cost of transport as a percentage of total expenditure. Gunn (1981) went farther and noted that according to Mogridge (1977), this upward trend concealed a fairly constant share of expenditure on car transport, but not on public transport. Tanner (1961, cited in Gunn, 1981) noted that travel expenditure initially rose with income, followed by a tailing off beyond middle income groups. This result was also confirmed by Oi and Shuldiner (1962, cited in Gunn, 1981) and Morris and Wigan (1978, cited in Gunn, 1981).

Gunn (1981) also noted that the percentage of expenditure spent on transport varies at different times of the year; the transport expenditures tended to be higher in the 2nd and 3rd quarters, compared to those in the 1st and 4th quarters. Examining the percentage of travel expenditure over different days of the week, starting from Monday, it was found that the transport expenditure increased steadily and reached its peak during Friday and Saturday and then suddenly dropped to its lowest level on Sunday. Gunn (1981) concluded that there was about a 10% variation for different seasons and different days of the week.

In addition to the relationship between travel expenditures and income, Tanner (1961, cited in Gunn, 1981) also examined the travel money expenditure in areas with different densities. He found that travel expenditure in large urban areas was lower than in small urban areas, which was lower than in rural areas. Similar results were also found by Oi and Shuldiner (1962) who found that people living in small cities spent a larger proportion of their income on travel than those living in large cities, even though the expenditure on public transport was similar.

I.2.5. A Focus on the US Studies[4]

Thirteen of the reviewed studies involved US data: nine of the 21 aggregate studies, and four of the seven disaggregate studies. Findings from the US studies do not appear to differ substantially from those of non-US studies. Over the years, there have been conflicting results from different authors using different data sets. In the Bay Area, Purvis (1994) found that total travel time per day first increased from 1965 to 1981 and then dropped from 1981 to 1990 on a per person, per traveler and per household basis. Similarly, Levinson and Kumar (1995) found an increasing trend in total travel time per person per day in the Metropolitan Washington D.C. area. However, in another study by the same authors, it was found that at the national level the total travel time per person has remained the same. These conflicting results on the average probably suggest variation at the individual level, which we will discuss in more detail in the conclusion section.

In examining travel time expenditure in relation to other covariates, the US studies appeared to focus more on examining socio-economic characteristics and activity/travel pattern-related variables, compared to European studies (mostly British) that seemed to focus more on land use characteristics in addition to socio-economic characteristics. In the US, there has been a great deal of research on the effect of neo-traditional neighborhoods on various travel-related characteristics, such as vehicle-miles traveled, mode share and commute times. These studies do not usually focus on the total travel time budget, but they may render some insights into the relationship between land use patterns and total travel time expenditure. As discussed in Section I.2.4.1, European studies that examined the relationship between land use patterns and total travel time expenditure have produced contradicting results. If there were many US studies to compare, we would expect a variety of results from them as well. Likewise, findings on the socio-economic characteristics appear to contradict each other (see Section I.2.4.1).

[4] To highlight them, the title boxes for the US studies in Part II are bordered with heavy lines and bolded in Tables 1 and 2 of the Appendix.

A recent trend is to examine the total travel time expenditure in the context of an entire activity/travel pattern for a study period (e.g., a day) for the reason that travel and activities are naturally connected with each other. Relationships have been found between past participation in activities/travel and current travel time (Ma and Goulias, 1998); out-of-home activities and travel time (Lu and Pas, 1999); and total time budget and travel time (Kitamura, 1992). These recent studies were conducted not for the purpose of examining the existence of a constant travel budget, but for the purpose of both understanding travel behavior and building better and more sophisticated models than those available at the time when the constant travel budget was proposed.

I.3. Conclusion

The ultimate goal of this research effort is to develop a mathematical model of individuals' time and money allocation among activities and travel. It is thus important to explore key aspects of this allocation behavior. A foremost issue is the existence of a stable time and money budget. This question was raised more than 20 years ago and inspired many debates at the time. Review articles have also been written summarizing empirical results to that point (Gunn, 1981; Goodwin, 1981). The current literature review, conducted for this research effort, encompasses numerous additional studies but essentially confirms results that were observed 20 years ago. Here, we briefly summarize those results.

At the aggregate level, travel expenditures initially appear to have some stability. Similar travel time and money budgets may be found within a sub-population (e.g., travelers) and in certain areas. However, empirical studies that examined the existence of travel time and money budgets at different times and locations are often found to give widely different results.

At the disaggregate level, there is a high degree of variation in both travel time and money expenditures. Even proponents of a constant travel time budget acknowledge this variation, which appears in aggregate studies as well. For example, Zahavi and Talvitie (1980, p. 18), after asserting "the inescapable conclusion that travel time and money budgets exist", express the "belief that travel time and money budgets are not constant, but they are functions of several variables".

Travel time expenditure is strongly related to individual and household characteristics (e.g., income level, gender, employment status, and car ownership), attributes of activities at the destination (e.g., activity group and activity duration), and characteristics of residential areas (e.g., density, spatial structure, and level of service). Aggregate studies have exclusively examined the first and the last groups of variables. Evidence about the effect of area characteristics (e.g., density) on travel time expenditure is not as strong as the effect of individual and household characteristics. The effect of the attributes of activities at the destination has been examined exclusively in disaggregate studies, mostly by activity-based researchers.

How can a sometimes apparently stable travel time and money budget at the aggregate level arise from highly variable individual decisions? Goodwin (1981) explains it as resulting from the "interplay of offsetting causes and effects". This means that if the causes change, the seemingly

stable travel time and money expenditures may not be stable anymore. Therefore, travel time and money budgets, if observed, should be treated as alterable facts, not as inexorable behavioral laws.

The overall conclusion we draw from these studies, then, is that the claim of the definitive existence of *"constant"* travel time and money budgets in time and space is not supported. However, we do believe that individual travel time and money expenditures are behavioral phenomena that can productively be modeled as a function of the kinds of variables described above. Several directions for future research appear to be fruitful.

For example, little has been done in examining the influence of lifestyle and attitudinal variables on the travel time budget. Principio and Pas (1997) clustered their sample into seven lifestyle groups based on time use patterns with respect to activities and travel. It was observed that members in different lifestyle groups had very different travel time expenditures. This suggests possible associations between lifestyles and travel time expenditures. Attitudinal and personality variables may be other factors explaining significant differences in travel time expenditures and these areas deserve further investigation.

Goodwin (1981) noted that when time and money are added together to form a generalized expenditure, it appears to be fairly stable between different locations and over short periods of time. This was also supported by Tanner (1979; cited by Gunn, 1981) and Goodwin (1975; cited by Gunn, 1981). This implies possible trade-offs between travel money and travel time expenditure, a subject that merits additional study.

Finally, this report has focused entirely on empirically observed travel time expenditures. Mokhtarian and Salomon (forthcoming), on the other hand, hypothesized the existence of an individual's unobserved ideal travel time "budget", that varies as a function of personality, lifestyle, travel-related attitudes, stage in lifecycle, and other socio-economic and demographic variables. The observed travel time differs from the ideal due to constraints, which can operate in either direction. If current travel exceeds the desired budget, one seeks to reduce it, but if currently traveling less than desired, one seeks to increase it. Thus, rather than travel satisfaction being a monotonically decreasing function of total travel time (indicating that travel is entirely a disutility to be minimized), Mokhtarian and Salomon view satisfaction as increasing up to the desired ideal travel time, and decreasing thereafter (indicating that travel has some positive utility and that for most people there is an optimum amount of travel that is greater than zero).

While eliciting a quantitative measure of the ideal total travel time budget may be difficult using a self-administered questionnaire, it may be possible to do so in an interview context. An alternate approach was taken by Mokhtarian and Salomon, in which they surveyed respondents with respect to their relative desired travel amount: a qualitative measure of how much the individual wants to travel compared to what she is doing now (both overall, and by purpose and mode, for short-distance and long-distance travel separately). Work is currently underway to model these relative desired mobility responses as a function of the variables listed above, plus measures of observed mobility. This should provide considerable insight into circumstances under which individuals will try to reduce, maintain, or even increase their travel in order to achieve their desired budget.

PART II
SUMMARIES OF INDIVIDUAL STUDIES REVIEWED

II.1. Introduction

The following is a brief summary of individual studies reviewed. First, aggregate studies are reviewed, followed by disaggregate studies. Within each category, studies are organized chronologically. It is hoped that such an order may illustrate the progression of the state-of-the-art in researching individuals' time and monetary allocation to activities and travel. US studies are indicated by a heavy border on the title box.

II.2. Aggregate Studies

Robinson, J.; Converse, P.E.; and Szalai, A. (1972) Everyday Life in Twelve Countries. In: *The Use of Time*. A. Szalai (Ed.). Mouton, The Hague.

Study Purpose

Examine differences in time use among twelve countries.

Data & Methodology

Twelve countries participated in the data collection. A particular respondent was designated for every randomly selected household. If the designated respondent was not available for the interview, he/she could not be replaced by another member of the household. Rather, that household was dropped from the sample and another household was selected. All data was collected using both "fresh" interviews and "diary-founded" interviews. In fresh interviews, respondents were not notified that they would be asked to report all activities and trips they made on the day before the interview (24 hours from midnight to midnight). In diary-founded interviews, respondents were notified beforehand that they would be asked to report all activities and trips they made on the day before the interview. Respondents were also asked to fill out a diary in which all activities and trips were recorded. Interviewers came back on the next day to check completeness and coherence of the report, and made notes and corrections as needed to the diary filled out by the respondent.

Every respondent in the sample had to take the diary-founded interview. A fresh interview was carried out for about 10% of the sample. The interviewer conducted the fresh interview during the first meeting with the respondent and left the diary-form the respondent needed to fill out.

Although the design of the data collection called for even distribution among days of the week, disparities did arise. Not every country had exactly 1/7 of its respondents for any day of the week. For example, West German participants had more than 2/7 of the sample drawn on weekends. Disparities were corrected by weighting in the data analysis.

The data collection was carried out from September 1965 to June 1966. Winter times, summer times when vacations were common, and national holidays were intentionally avoided. The response rates for the 12 countries varied from the lowest of 60% for Belgium to the highest of 100% for Pskov (USSR) and Olomouc (Czechoslovakia).

Descriptive analyses were used in this study. Sample sizes for the 12 countries are given as follows.

Places	**Sample Size**
Belgium	2077
Kazanilk, Bulgaria	2096
Olomouc, Czechoslovakia	2192
Six cities, France	2805
100 electoral districts, Fed. Rep. Germany	1500
Osnabrück, Fed. Rep. Germany	978
Hoyerswerda, German Dem. Rep.	1650
Györ, Hungary	1994
Lima-Callao, Peru	782
Torun, Poland	2754
Forty-four cities, USA	1243
Jackson, USA	778
Pskov, USSR	2891
Kragujevac, Yugoslavia	2125
Maribor, Yugoslavia	1995

Key Results

1. The average commuting time for the twelve countries varied from the lowest of 16 minutes for Osnabrück, Fed. Rep. Germany, to the highest of 41 minutes for Kazanlik, Bulgaria. Although the highest commute time was more than twice the lowest commute time, the authors noted that average commute times "are kept within a remarkably narrow range."
2. Similarly, the total daily travel time expenditure per person varied from the lowest of 39 minutes for the 100 electoral districts of Fed. Rep. Germany to the highest of 90 minutes for Lima-Callao, Peru. The authors commented that time allocation to travel on average remained constant within a narrow range.
3. Non-car-owners spent about 6% more time traveling than car-owners.

van der Hoorn, Toon (1979) Travel Behavior and the Total Activity Pattern. *Transportation* **8**, 309-328.

Study Purpose

Examine effect of various factors on travel time expenditures.

Data & Methodology

The data set used for this study was collected from a Netherlands survey administered in October 1975, in which about 1,100 individuals were asked to record their activities every quarter hour during the survey week. The survey had two parts:

Part 1: a. general socio-economic characteristics (for one randomly chosen respondent from the household above age 12); b. lifestyle questions; c. distribution of tasks within the household.

Part 2: for each quarter hour, the main activity in that quarter hour was filled in, and whether the activity was done in the home or outside the home.

In the survey, four special codes were used for travel modes, corresponding to the following four categories.

1. car, motor, scooter [*sic*];
2. moped;
3. bus, tram, train, ferry, taxi, boat, airplane;
4. walk, bike.

Several problems resulted from such a survey method:

1. The exact duration of the activities recorded may not be precise. Activities occupying a 15-minute period in the diaries may be only 5 minutes long, or 15 minutes long.
2. Many activities and trips could be missed because they did not take the major part of the 15-minute period.
3. The division of travel modes was coarse. For example, one cannot separate bus from airplane. Thus, estimation of travel time by a particular mode within the four broad categories is not possible.

The author reconstructed missing trips. This was done by using the information on where the activity took place and the activity codes per quarter hour. The travel modes of reconstructed trips were not known.

Descriptive analyses were used for this study.

Key Results

1. The average reported travel time expenditure per week was about 6.75 hours, or 0.96 hours a day.
2. People in car-owning households spent 45 minutes more per week (510 minutes) on traveling than people in non-car-owning households (465 minutes). For people from car-owning households, people with accessibility to cars traveled 15 minutes more per week than people without accessibility to cars.
3. The author examined travel time expenditures in rural areas, industrialized rural areas, small towns, commuter towns, middle-sized cities, large cities, and dense urban areas such as Amsterdam, Rotterdam, and the Hague. He found that travel time per person per week was the highest for dense urban areas, for all trip purposes (including work, school, culture/recreation/visits, and active recreation) except for school.
4. The author examined travel time expenditures for working men, working women, housewives, students and school children, and other people (retired and unemployed). He

found that working women and schoolchildren/students had the highest travel times. Overall, employed people spent more time traveling than the unemployed.

5. The author also examined travel time expenditures between weekday and weekend for people owning and not owning cars, for people living in areas with different densities, and for other groups of people (e.g., full-time workers, students). He found that differences existed between weekday and weekend, but the general findings discussed above for the entire week remained unchanged.

Zahavi, Yacov and Ryan, James (1980) Stability of Travel Components over Time. *Transportation Research Record* **750**, 19-26.

Study Purpose

Examine stability of travel time expenditures.

Data & Methodology

The authors used data sets from two urban areas, each collected in two different years. The Washington, D.C. survey was conducted in 1955 and 1968, with 214,905 and 332,262 households respectively; the Twin Cities survey was conducted in 1958 and 1970, with 235,473 and 325,315 households respectively. Travelers are defined as persons above 5 years old who have made at least one motorized trip during the survey day. Travel times are door-to-door times reported by respondents and speeds are derived door-to-door speeds. The authors did not indicate how travel surveys were administered to respondents and what travel-related questions were asked in the survey.

Descriptive analyses and linear regression were used for this study.

Key Results

1. "At reasonably good speeds, the daily travel time per traveler is about 1.1 hour and remains so even when speeds increase appreciably." A parallel result was reported in Zahavi and Talvitie (1980).
2. An average car-owning household spent about 10-11% of its income on travel while an average carless household spent about 3-5% of its income on travel. The authors stated that "the daily travel money expenditure, like the travel time expenditure, is related to the socioeconomic characteristics of the households." Again, a parallel result was reported in Zahavi and Talvitie (1980).

Zahavi, Yacov and Talvitie, Antti (1980) Regularities in Travel Time and Money Expenditures. *Transportation Research Record* **750**, 13-19.

Study Purpose

Examine travel money and travel time expenditures.

Data & Methodology

The authors considered several data issues to be important. First, as some trips only occur on a weekly basis, a weekly travel diary would be important. Second, the definitions of household travel time and money budgets are ambiguous. The authors preferred to study the travel money budget on a per household basis, because money can be shared by household members, and the travel time budget on a per traveler basis, because travel time cannot be easily transferred from person to person. In this paper, they analyzed both cross-sectional travel data and travel diary data[5].

The authors conducted descriptive analysis and linear regression on several data sets in this study. Findings that correspond to each data set are presented below.

Key Results

1. Using household survey data collected in Bogota, Columbia in 1972 (N = 4757 travelers), the authors found that: a) daily travel time per traveler decreased with increasing income; b) employed travelers spent more time traveling than unemployed travelers, but the differences were small; c) the difference in daily travel time expenditure between males and females was insignificant; and d) daily travel time increased as the proportion allocated to car travel increased.
2. Using travel data collected in June 1975 in Singapore (N = 4352 households), it was found that, a) income had little effect on daily travel time, and b) daily travel time for travelers from non-car-owning households was considerably higher than that for those from car-owning households.
3. Using travel diary data collected in Munich, Germany in 1976 (N is not reported), it was found that both car ownership and household size as well as their interaction had significant impacts on travel time expenditures. Directions of these impacts were not clearly stated in the paper, however. The authors argued that travel time expenditures did not vary between days.
4. Travel money expenditures, like travel time expenditures, were stable in time and space and thus could be regarded as a travel money budget.

[5] They reported results separately from cross-sectional data sets and travel diary data sets. However, they did not clarify the differences between the two.

Chumak, A. and Braaksma, J. P. (1981) Implications of the Travel-Time Budget for Urban Transportation Modeling in Canada. *Transportation Research Record* **794**, 19-27.

Study Purpose

To investigate the validity of the travel time budget concept in Canada and the practical implications of the travel time budget concept for conventional travel demand forecasting procedures.

Data & Methodology

The authors used data from home interview surveys conducted in Calgary in 1964 and 1971, in Toronto in 1964 and 1971 and in Montreal in 1971. No other information about these home interview surveys was given in the paper. More results were presented from the Calgary data than from the other data sets. Descriptive analyses were used for this study.

Key Results

1. The average daily travel time per trip maker (defined as an individual who makes at least one mechanized trip per day) was around 1.11 hour for Calgary in 1971, 1.09 for Toronto in 1964 and 1.18 for Montreal in 1971.
2. Using the Calgary data, it was shown that the average daily travel time varied by mode. It was the highest for individuals who used both transit and cars, followed by car drivers, those who only used cars and those who only used transit.
3. Using the Calgary data, it was shown that the average daily travel time was significantly higher for workers than for nonworkers.
4. Using the Calgary data, it was reported that the average daily travel time per trip maker varied little with location of residence.
5. Using the Calgary data, it was reported that trip makers in car-owning households had significantly higher daily travel time than those in carless households. However, there was little difference between households who owned one car and households who owned more than one car.
6. The average daily automobile travel time per trip maker varied in the three cities. It was the highest in Toronto, followed by Calgary and Montreal.
7. The authors concluded that the data results in Canada supported the concept of a travel time budget. In terms of practical implications for conventional transportation planning procedures, the concept of a travel time budget may be used as a check on the conventional forecasting results. The authors also hypothesized that there exists an equilibrium, such that the travel demand equals the volume that can be accommodated by the transportation facility. They suggested that the concept of a travel time budget can be used to ensure that the conventional forecasting results reflect such an equilibrium.

Downes, J. D. and Morrell, D. (1981) Variation of Travel Time Budgets and Trip Rates in Reading. *Transportation Research* **15A**, 47-53.

Study Purpose

Examine the stability of travel time expenditures and trip rates in Reading, UK.

Data & Methodology

The authors used the 1971 Reading Travel Survey, described in Prendergast and Williams (1981) to examine variation of travel time budgets in the Reading area. The authors obtained travel times per household to account for possible interactions among household members. Then the authors calculated travel times per person by averaging over the number of people in the household.

Descriptive analyses were used for this study.

Key Results

1. Household location (inner area, middle area, or outer area) had little impact on daily travel time per person.
2. There was little dependence of daily travel times per person on car ownership.

Gunn, Hugh (1981) Travel Budgets – A Review of Evidence and Modeling Implications. *Transportation Research* **15A**, 7-23.

Study Purpose

To "review the empirical evidence about the role of travel budgets as determinants of travel behavior, together with the development of the ideas about models based on travel budgets."

Data & Methodology

1. The National Travel Surveys of 1966, 1972/73, and 1975/76.
2. The County Surveyor's Trip Rate Data Bank for 1974 and 1977.
3. The Family Expenditure Surveys (1959 onwards).
4. The Reading Activity Survey (1973).
5. The annual Abstract of Statistics for various years.

Descriptive analysis and linear regression were used for the study. The author looked into two measures of travel behavior: total travel time expenditure and current travel money expenditure. Total travel time expenditure was taken to be all reported time spent on travel, including all waiting time and walk trips. Current travel money expenditure referred to the expenditure

covering the running and maintenance of a personal vehicle and other out-of-pocket costs of travel.

Key Results

Evidence from the UK:

1. The percentage of total expenditure allocated to travel by all modes increased over time.
2. Citing Mogridge (1977), it was reported that the percentage of disposable income allocated to car travel was constant. However, the percentage of disposable income allocated to public transport varied over time, presumably due to changes in levels of service and fares.
3. Travel time and money expenditures had about 10% variation across day of week and seasons.
4. Current travel money expenditure exhibited a seasonal variation, with spring and summer quarters higher than fall and winter quarters.
5. Citing Tanner (1961), it was reported that average distances traveled by people living in different types of area were very similar, but the travel money expenditures were different. Thus, people living in rural areas spent less time traveling than those living in large urban areas. Furthermore, rural households spent the least on travel and large urban households spent the most on travel.
6. Tanner (1961) also noted a pattern of current travel money expenditure with increasing income: initially rising, followed by a tailing off at high income levels.
7. Residential density did not affect travel time expenditure per person per day very much.
8. Citing Tanner (1979), a fairly steady increase has occurred over the years in total travel time expenditure and current travel money expenditure.
9. Goodwin (1976) found that travel time expenditure varied across households with different levels of car ownership (the direction of the impact was not stated in the paper). However, Bullock et al. (1974) found that car ownership had little effect on total travel time expenditure, although employment status had a substantial effect.
10. Age group, income level, and occupation type were important factors determining total travel time expenditure. Those between ages 17 and 24 spent significantly more time traveling than did people of other age groups. Those below age 16 or above age 60 spent the least amount of time traveling. Travel time expenditure increased with increasing income. Professionals spent more time traveling than non-professionals.
11. Women traveled less than men. And women living in rural areas traveled even less.
12. In general, location effects were smaller than personal and household effects.

Evidence from Other Countries:

13. Citing Morris & Wigan (1978), for Australian households, travel expenditure was directly related to household income or total expenditure. The trend was similar to that identified in the UK, initially increasing followed by a tailing off beyond middle income groups. However, Australian households spent a far larger proportion of their income on travel than British households did.

14. Citing Oi and Shuldiner (1962), a similar pattern between travel expenditure and overall expenditure was observed in the US. They also demonstrated a time trend of increase in travel money expenditure, a conclusion that was consistent with Tanner's.
15. Oi and Shuldiner (1962) concluded that residents living in small cities spent a larger proportion of their income on travel than those living in large cities, even though the expenditure on public transport was similar.
16. Citing Godard (1978), it was concluded that neither travel time expenditure between cities, nor travel time expenditure over time, can be considered stable.
17. Godard (1978) noted that "personal characteristics were more strongly correlated with travel time than were household characteristics."
18. Godard (1978) noted that travel time expenditures increased with urban size.

Landrock, John N. (1981) Spatial Stability of Average Daily Travel Times and Trip Rates within Great Britain. *Transportation Research* **15A**, 55-62.

Study Purpose

Examine stability of trip rates and travel time throughout Great Britain.

Data & Methodology

The 1975/76 National Travel Survey (NTS) was used. The NTS was carried out about every three to four years. The 1975/76 survey collected data from about 10,000 households randomly selected throughout Great Britain evenly throughout July 1975 to June 1976. All household members were asked to record a 7-day survey. However, only for the 7th day, short walk trips (walk trips over 50 yards and under 1 mile) and travel times were required to be recorded. For this study, the author only used the 7th-day data. While this was the only way walk trips could be included, the respondent fatigue that was inevitable on the seventh day of a travel diary may have resulted in trip underreporting and hence limited the generalizability of these results.

Descriptive analysis was used for the study.

Key Results

1. The average daily travel time per person fell between 56 and 60 minutes, with the exception of the London area where it was almost 68 minutes.
2. The average daily travel time for travelers fell between 72 and 76 minutes, with the exception of the London area where it was 88 minutes.
3. People living in lower population density areas had a lower daily travel time for both persons and travelers, compared to other areas.
4. The high daily travel time by London residents was mainly due to high travel times for work trips and trips with social purposes.
5. Disaggregated by population size and population density, average daily travel times per person tended to be stable except for people living in areas of low density but high population, who tended to have higher travel times.

Prendergast, Lynn S. and Williams, Robert D. (1981) Individual Travel Time Budgets. *Transportation Research* **15A**, 39-46.

Study Purpose

Examine stability of travel time expenditures.

Data & Methodology

The authors used three travel surveys conducted in Britain in the 1970s: the 1972/73 National Travel Survey, the 1971 Reading Travel Survey and the 1973 Reading Activities Survey. The 1972/73 National Travel Survey was conducted over 12 months beginning in April 1972. Addresses throughout Britain were cluster-sampled, resulting in a sample that was fairly representative by day of week and by town sizes. Members of sampled households were asked to provide certain person and household attributes and keep a travel diary over a 7-day period. For this study, the authors used 7^{th}-day data obtained from 12,347 individuals age 16 and over.

The Reading Travel Survey was undertaken on Thursdays during October and November of 1971. Randomly sampled households were asked to provide their socio-economic and demographic information for each member age 2 and over. At the end of the survey day, respondents were asked to complete a travel record, indicating the starting and ending times of each trip, together with mode and purpose of the trip. The survey specification did however require exclusion of incidental walks (walks between modes). This resulted in a possible under-reporting of walk trips. About 9,369 individuals, drawn from 3,368 households, responded to the survey.

The Reading Activities Survey was conducted during the first three months of 1973. The sample consisted of about 348 individuals between the ages of 16 and 69. Respondents were asked to complete a questionnaire and to keep a week-long diary, recording the location and description of every activity they performed.

Descriptive analyses were used for this study.

Key Results

1. Daily travel time expenditure per person varied by day of the week, rising from Monday to Saturday and suddenly dropping on Sunday.
2. Daily travel time per person was the lowest for those below school age and those above retirement age.
3. Men spent more time traveling than women.
4. An interaction between gender and age was found for daily travel times. For ages between 21 and 64, men spent significantly more time traveling than women compared to the gender difference for other age groups.
5. Employed people spent more time traveling than unemployed people.

6. An interaction between gender and employment was found for daily travel times. Full-time employed males spent the most time traveling, about 3 times the smallest average travel time expenditure, which occurred for retired women.
7. Based on the 1972/73 National Travel Survey, daily travel time increased with increasing household income and vehicle ownership. The increase with income tapered off after an annual income of 1500 to 1999 pounds.
8. Daily travel time differed by mode, both per person and per traveler.

Roth, Gabriel J. and Zahavi, Yacov (1981) Travel Time "Budgets" in Developing Countries. *Transportation Research* **15A**, 87-95.

Study Purpose

Examine the stability of travel time expenditures.

Data & Methodology

1. A travel survey conducted in Bogota, Colombia in 1972 (N = 4757 travelers).
2. A travel survey carried out in Singapore's central business district in June 1975 (N = 4352 households).
3. A travel survey conducted in Salvador, Brazil (date and sample size not reported).
4. A travel survey conducted in Santiago, Chile (date not reported; N = 44,928 travelers).

Descriptive analyses were used for the study.

Key Results

Bogota, Colombia

1. Daily travel time per traveler decreased with increasing income and car ownership.
2. Daily travel time per traveler did not vary with household size in a systematic way.
3. Travel times of students showed greater variation than other groups.
4. Employed people spent 10-20% more time on travel than unemployed ones. The travel time expenditure for both males and females (regardless of their employment status) was about the same. Travelers who were white collar workers tended to travel less than those who were blue collar workers.
5. The minimum[6] daily travel time per traveler, at the highest income level, was about 1 hour.
6. The variation of the travel time expenditure from the mean values was fairly stable for all population segments.

Singapore

[6] The authors did not clarify whether it was a minimum among the averages for the various groups examined, or an absolute minimum.

7. Daily travel time per traveler was fairly stable over a wide range of income levels, in contrast to the results for Bogota and Salvador.
8. The daily travel time per traveler for non-car-owning households was higher than that for car-owning households.
9. Age did not have a systematic effect on daily travel time per traveler.
10. Women spent less time on travel than men, also in contrast to the results from Bogota.

Salvador, Brazil

11. Daily travel time per traveler increased with increasing income, in contrast to results from Bogota and Singapore.

Santiago, Chile

12. Daily travel time per motorized traveler decreased with increasing income and car ownership, consistent with the results for Bogota.
13. Daily travel time by bus and walking decreased with increasing income. However, daily travel time by car increased with increasing income. Results 12 and 13 suggest that the decrease in total daily travel time per traveler with increasing income was due to the substitution of the slower walk and bus modes with the faster auto mode as income rises.
14. The time allocated to walking was short and stable for all income levels.

Tanner, J. C. (1981) Expenditure of Time and Money on Travel. *Transportation Research* **15A**, 25-38.

Study Purpose

Examine the basis of the concept of constant travel time and money expenditures from both a theoretical and empirical point of view.

Data & Methodology

As in the Landrock (1981) study, the 7th-day data of the 1975/76 National Travel Survey (NTS) was used, this time to examine travel time and money expenditures by household income, density, and mode. Household incomes were divided into 11 categories. For density, four different categories were used. Travel mode was divided into three major groups: cars and motorcycles (driver and passenger), public transport (bus, rail, and taxi), and non-motorized modes (bike and walk).

Travel time per person per day by mode was calculated for each income and density group. Money expenditure was calculated for public transport from the 7th-day data. The money expenditure for non-motorized modes was zero. The money expenditure for cars and motorcycles was not reported, so it was estimated from the distances traveled and the assumption of constant cost per kilometer.

The author also developed a range of generalized expenditures based on two extreme assumptions, one with a zero value of time and the other with time valued at 100% of the average wage rate.

To examine the stability of travel time and money expenditure over time, the author also used the 1972/73 National Travel Survey.

Theoretical models were developed to estimate travel time and money expenditures. Descriptive analyses were used in empirical verifications.

Key Results

1. People living in high density areas spent more time and money on travel for both public transport and non-motorized modes than those living in low density areas. The reverse was true for private transport (cars and motorcycles).
2. Total travel time per person per day by all modes varied little with density, but rose with income.
3. Travel time spent on public transport and non-motorized modes varied little with income.
4. Travel time spent on private transport rose with income.
5. Generalized travel expenditure was independent of income.
6. Both total travel time and money expenditures and generalized expenditure increased over time.

Wigan, M. R. and Morris, J. M. (1981) The Transport Implications of Activity and Time Budget Constraints. *Transportation Research* **15A**, 63-86.

Study Purpose

Review empirical studies examining activity and travel budgets, investigate activity linkage in space and time and its implications in modeling structures.

Data & Methodology

The data set used for this study had two parts. One was taken from the 1965/66 MCTB (Melbourne, Australia) study and the other was obtained from the medium-sized city of Albury-Wodonga in a companion study.

Significant differences existed in terms of accessibility characteristics and spatial structures between the two cities. In Melbourne, only 28% of the workers lived within 3 miles of their workplace compared to 74% in Albury-Wodonga. Also, car usage was much higher in Albury-Wodonga than in Melbourne, and so was the usage of non-motorized modes.

Descriptive analyses were used for this study.

Key Results

1. Time allocation on various activities (including travel) was different between the two cities. For both cities, employed males spent the most amount of time traveling, followed by employed females, and then housewives.
2. Citing Goodwin (1976), it was reported that travel time by all modes varied little with residential density. However, travel time by walk and bus increased with residential density, and travel time by car decreased with residential density.
3. Men had longer commuting times.
4. Citing another study (OECD, 1977) in Stockholm, it was reported that for households where both adults were working, females' average daily travel times were 86 minutes without children, and 76 minutes with children. In households where only males were working, females' travel times were 75 and 73 minutes respectively. In both cases, males spent more time traveling than females and males' travel time increased with the presence of children. For student households (not precisely defined in the paper), females' average daily travel time went from 73 to 74 minutes with the presence of children, while males' more than doubled, from 88 to 180 minutes. The dramatic increase from 88 to 180 minutes could be caused by small sample sizes in the cell[7]. To the extent that the data are representative, a possible interpretation is that the presence of very young children tended to keep mothers at home and fathers away from home.
5. Citing another study (Godard, 1978), it was reported that travel time expenditures increased with vehicle ownership and with the progression of time.

Hupkes, Geurt (1982) The Law of Constant Travel Time and Trip-Rates. *Futures,* **February**, 38-46.

Study Purpose

To explain the existence of constant travel time and trip rates by a bio-psychological approach and a utility optimization approach.

Data & Methodology

Disaggregate time budget surveys in Netherlands in 1962 and 1972 were used. Descriptive analyses were used.

Key Results

1. Although passenger kilometers have significantly increased by 60% from 1962 to 1972, average trips and travel time in hours per person per year remained constant from 1962 to 1972. On a per-day basis, the data indicate 4.4 trips per person in 1962 and 4.3 trips in 1972, and 1.2 hours of travel time in both years.
2. Using the bio-psychological approach, it is suggested that people try to stabilize their average travel time per day because stress will result if they do not.
3. Using utility optimization approach, the utility of travel time has two components: the intrinsic utility obtained from travel itself and the utility derived from performing the activity

[7] Sample sizes were not reported in the study.

at the destination. At the optimal level of total utility, people prefer to consume a fixed amount of travel time per day or a fixed number of trips per day.
4. Neither the bio-psychological approach nor the utility optimization approach explains constant travel time or trip rates perfectly. They are supplementary to each other.

Supernak, Janusz (1982) Travel-Time Budgets: A Critique. *Transportation Research Record* **879**, 15-25.

Study Purpose

Examine the stability of travel time budgets.

Data & Methodology

Descriptive analysis and linear regression on data from the US metropolitan areas of Baltimore, Maryland (1977) and the Twin Cities of Minneapolis-St. Paul, Minnesota (1970) were used for this study. Analysis on the Baltimore data alone was based on travel time per person and examined all modes (including walk). The author did a comparison study between Baltimore and the Twin Cities. Due to limitations of the Twin Cities data, the comparison was based on travel time per traveler and excluded the walk mode.

Key Results

1. Employed persons spent more time traveling than unemployed persons.
2. Trip rates of homogeneous groups appeared to be more stable than travel time expenditures.

The author also made the following observations:

1. The effect of area type on travel time expenditures was not consistent. In Baltimore, urban travel times were higher than suburban travel times while the opposite case was found in the Twin Cities.
2. "Ignoring non-travelers and some transportation modes (e.g., walk) represents an undesirable simplification of any concept of travel budget."
3. There is no support for analysis based on an average traveler representing a certain family type because variation of travel behavior among family members was dramatic.
4. "Travel-time budgets, if they exist, are very different for different categories of persons."
5. Differences in travel time expenditures by area type and person category were reduced when travel time per traveler was used and the walk mode was excluded.

Kitamura, Ryuichi; Robinson, John; Golob, Thomas F.; Bradley, Mark; Leonard, John; and van der Hoorn, Toon (1992) *A Comparative Analysis of Time Use Data in the Netherlands and California.* Research Report Number UCD-ITS-RR-92-9, Institute of Transportation Studies, University of California, Davis, June.

Study Purpose

Examine differences in time allocation to daily activities (including travel) between the Netherlands and California.

Data & Methodology

Using two time-use data sets in California and the Netherlands, the authors examined differences in terms of time use between these two locales. The Dutch survey was a self-administered written survey, while the California data was collected via telephone. Each respondent in the Dutch survey was asked to complete activity reports for an entire week; each respondent in the California survey was asked to complete an activity report for only one day. The Dutch and California samples contained 2964 and 1564 respondents respectively. The response rates for these two surveys were 54% and 62% respectively.

The diary format used by the two surveys was somewhat different. The Dutch survey used a 15-minute time interval with closed activity categories. The California survey used an open interval approach with complete text reporting of activities. Only 3 location codes were used in the Dutch survey while the California survey used 46 location codes.

Despite the above differences, similarities between the two surveys existed. Both were conducted around the same time with the California survey in 1987-1988 and the Dutch survey in 1985. Both surveys used the same coding scheme as Szalai (1972).

The authors noted that slightly more trips per person were found in the California survey than in the Dutch survey. For both surveys, missing (imputed) trips constituted about 40% to 50% of all trips. Descriptive analyses and linear regression were used for this study.

Key Results

1. In general, time use was very different between California and the Netherlands.
2. Weekly travel time per person for the Dutch was lower than for the Californians.
3. Men spent more time traveling than women in both data sets.
4. People under 50 traveled more than those 50 and older in both data sets.
5. Travel time expenditure was not a constant quantity.
6. In California, Saturday was a peak travel day especially for women while travel time was more evenly dispersed in the Netherlands by comparison.
7. Non-work travel time was strongly affected by work duration.
8. Total travel time expenditure was proportional to 24 hours minus work duration.

Purvis, Chuck (1994) Changes in Regional Travel Characteristics and Travel Time Expenditures in San Francisco Bay Area: 1960-1990. *Transportation Research Record* **1466**, 99-109.

Study Purpose

Examine changes in travel characteristics in the Bay Area from 1960 to 1990.

Data & Methodology

The author used three household travel surveys conducted in the Bay Area in 1965, 1981, and 1990. The 1965 survey was a home interview (face-to-face, in-person) survey of 20,486 households regarding their weekday travel behavior. An additional 10,200 households were interviewed regarding their weekend travel behavior. The 1981 survey was a telephone interview of 6,209 households regarding weekday travel behavior and an additional 882 households regarding weekend travel behavior. The 1990 survey was a telephone interview of more than 10,800 households regarding weekday travel behavior. Among these households, 9,438 households provided single weekday travel diaries and 1,486 households provided 3-day or 5-day travel diaries. The results presented in this paper used the single-day sample.

All three surveys were administered to all members in the household age 5 years old and over. All three surveys collected basic household information, person information and trip data. Household information included household income, vehicle ownership, tenure of residence, structure type, and owner/renter tenure. Person information included age, sex, race/ethnicity, relationship to head of household, and employment status. Trip information included detailed means of transportation, origin and destination location and trip purpose, trip start time, trip finish time, and vehicle occupancy.

Descriptive analyses were used for this study.

Key Results

1. The author examined total travel time expenditure per mobile person, per traveler, per mobile household, and per traveling household. Here, the term mobile was used to "denote persons or households who reported travel – by any means of transportation, including walking or bicycling – during their assigned travel day". The term traveler was "used to denote persons or households who reported motorized travel (vehicle driver, vehicle passenger, or transit passenger) during the assigned travel day." The author found that overall, total travel time expenditure per weekday increased from 1965 to 1981 (from 0.86 to 1.07 hours per person), but decreased (to 1.03 hours) from 1981 to 1990. From the entire period of 1965 to 1990, average daily travel time expenditure increased by 20% for all persons, 14% for mobile persons, 9% for travelers, 1% for mobile households, and 5% for traveling households.
2. For a given year, daily travel time per person was stable for all levels of car ownership, but daily travel time per household increased with increasing car ownership.
3. For a given year, daily travel time per person decreased with increasing household size, but daily travel time per household increased with increasing household size.

Kumar, Ajay and Levinson, David (1995) Temporal Variations on Allocation of Time. *Transportation Research Record* **1493**, 118-127.

Study Purpose

Examine time allocation to activities by day of the week and month of the year.

Data & Methodology

The 1990-1991 Nationwide Personal Transportation Survey (NPTS) was used for this study. The NPTS was a telephone interview of 21,817 households and 47,499 persons making almost 150,000 trips. The survey collected data on household demographics, income, vehicle availability, all trips made on the survey day, long trips made over a 2-week period, and traffic accidents within the past 5 years. Trip-related characteristics included departure time, distance, duration of the trip, trip purpose and mode, day of the week, and month of the year. The survey was conducted between March 1990 and March 1991. Because any single household in the sample was only surveyed for one day, comparison across days and months would generally be confounded by differences between households. To assess some long-term trends in activity patterns in the US, the authors also used results from the 1954 data reported by de Grazia (1990) and the 1966 data reported by Szalai (1972) and Robinson (1977).

Descriptive analyses were used in this study.

Key Results

1. From 1954-1965/66, there was an increase in travel time on weekdays and Saturday. Then, a decrease took place from 1965/66 to 1990/91. The travel time budget was back to about 1.1 hour per day, its level in 1954.
2. Daily travel time did not vary much by month of the year. There was a slight increase in May and July.
3. Daily travel time did not vary much by day of the week. Travel time slightly increased over the weekend. Monday exhibited the lowest daily travel time while Saturday and Sunday exhibited the highest daily travel times.

Levinson, David and Kumar, Ajay (1995) Activity, Travel, and the Allocation of Time. *APA Journal* **Autumn**, 458-470.

Study Purpose

Examine time allocation to daily activities.

Data & Methodology

The principal data source for this study was the detailed household travel survey conducted by the Metropolitan Washington Council of Governments (MWCOG) for 1968 and 1987-1988. The 1968 sample consisted of a sample of more than 23,000 households, making 150,000 trips. The 1968 survey excluded non-motorized nonwork trips. The 1987-1988 sample contained 7,400 households and 55,000 trips. For both studies, each household was assigned a travel diary day and all members of the household reported trips they made on that day. Trip-related information included locations of origin and destination of each trip, trip starting and ending times, and trip

modes. In addition to trip data, both surveys collected information on household and personal characteristics including age, sex, vehicle ownership, and household size. The author only included adults ages 18-65 for this study, which used descriptive analysis.

Key Results

1. Individuals who worked at home made more (albeit shorter) trips than a typical worker did. Overall, they traveled about half an hour less per day than did typical workers.
2. Overall, the total daily travel time expenditure had increased significantly, by 26 minutes for working men (from 85 to 101 minutes) and 14 minutes for working women (from 79 to 93 minutes). This dramatic increase was partly due to the exclusion of non-motorized nonwork trips in the 1968 survey.
3. The authors divided the sample into those who work outside home, those who work at home, and nonworkers. Each of these three categories was further divided into male and female. For all cases, men spent more time traveling than women did. People who worked outside home spent more time traveling than nonworkers, who traveled more than people who worked at home.

Rutherford, G. Scott; McCormack, Edward; and Wilkinson, Martina (1996) Travel Impacts of Urban Form: Implications from an Analysis of Two Seattle Area Travel Diaries. *Proceedings of the TMIP Urban Design, Telecommuting and Travel Forecasting Conference,* October 27-30, 1996. Williamsburg, Virginia, 95-166.

Study Purpose

Examine the transportation implications of mixed land use patterns.

Data & Methodology

Two data sets were used for this study. One was a two-day travel diary and demographic survey of 900 households in three Greater Seattle area neighborhoods (Kirkland, Wallingford, and Queen Anne) collected by the Washington State Transportation Commission's Innovations Unit in November and December of 1991. The other was a data set collected by the Puget Sound Regional Council, from September to November of 1989.

Descriptive analyses were used in this study.

Key Results

1. Total daily travel time expenditures per person were similar for five counties, with the lowest being 86.2 minutes and highest being 93.8 minutes.
2. Total daily travel expenditures varied by age. The variation, however, did not seem to be systematic across counties. For example, in one county (Queen Anne), people age 18-24 had the highest travel time expenditure of 111 minutes, while in another county (Kirkland), people of the same age group had the lowest travel time expenditure of 81 minutes.

Principio, Shari L. and Pas, Eric I. (1997) The Sociodemographics and Travel Behavior of Life Style Groups Identified by Time Use Patterns. Paper Presented at the 76th Annual Meeting of the Transportation Research Board, Washington, D.C.

Study Purpose

Examine the role of life style variables in identifying different time use patterns.

Data & Methodology

The data used for this study was the 1994/95 Triangle Travel Behavior Survey (TTBS). The survey was conducted from November 1994 through April 1995, excluding the holiday periods of Thanksgiving, Christmas, and New Year. The survey was designed to be an activity diary survey. All respondents age 5 and older were asked to record all activities (including travel) in chronological order. Each household was assigned two consecutive days. All seven days of the week were covered in the entire survey. Saturday and Sunday pairs were excluded.

The TTBS survey consisted of three samples: one stratified by residential density, one obtained by random digit dialing, and an enrichment sample designed to yield information about transit use. Only the first two samples were used for this study. A total of 2,316 households were sampled and 1,778 households completed the survey. The sample used for this study consisted of the 1,167 households whose diary days were both weekdays.

The survey collected information on all out-of-home activities and those in-home activities which could have taken place in another location. Activities that were conducted at home were all coded as home activities.

Cluster analysis and descriptive analyses were used.

Key Results

1. Cluster analysis identified seven different lifestyle groups in the sample: the workaholics (20% of the sample), the active workers (37% of the sample), the socializer (6.6% of the sample), the leisure enthusiasts (7.6% of the sample), the domestic caretakers (4.5% of the sample), the diverse participants (18% of the sample), and the scholars (6.3% of the sample). The total travel time for the two days was the highest for active workers, followed by diverse participants, scholars, workaholics, socializers, domestic caretakers, and leisure enthusiasts.
2. The workaholics group made fewer trips and tours than average and chained trips efficiently.
3. The active workers group had the highest total travel times for the two days; they had a high number of trips and tours and were efficient in trip linking.
4. The socializer group made the fewest trips and tours and was inefficient in trip linking.
5. The leisure group made very few trips and spent the least amount of time traveling for the two days. The leisure group tended to be retired people.

6. The domestic care group made fewer trips than average and the average trip length was much shorter than for the other groups. Like the leisure group, the domestic care group tended to be retired people.

Robinson, John (1997) *Time for Life. The Surprising Ways Americans Use their Time.* The Pennsylvania State University Press, University Park, Pennsylvania.

Study Purpose

Americans' use of time.

Data & Methodology

The Americans' use of time project consisted of three time use studies in 1965, 1975, and 1985 respectively. The 1965 study interviewed about 2,000 adults ages 18 to 65, who were asked to keep complete diaries of their activities for a single day. Data was collected between November 1, 1965 and spring of 1966. Of the total sample, 1,244 adults were part of the national urban sample and another 788 adults came from the city of Jackson, Michigan and its suburbs. The field procedures used a "tomorrow" approach. This meant that the interviewer contacted the respondent on the first day, conducted a "warm-up" interview on the first day and left the diary for the respondent to enter the next day's activities. On the day after the next day, the interviewer came back and picked up the diary. This ensured that the diary was filled out correctly and contained no missing information.

The 1975 data was based on a survey collected between October and November 1975. Both spouses in a given household were interviewed. The original respondents who were interviewed in 1975 were re-interviewed by telephone three times during 1976: in February, May and September by telephone. For this study, only the first-wave respondents (about 2,406 respondents) were used. The 1975 study employed the same open-ended diary approach as that in 1965.

The 1985 study collected single-day diary data for more than 5,300 respondents ages 12 years and older. The 1985 study employed the same open-ended diary approach as those in 1965 and 1975. The data was collected throughout the entire year from January to December, 1985. The 1985 survey was administered via three types of samples: mail-back, telephone and personal interview, each having 3,340, 1,210, and 808 respondents respectively.

A number of mechanisms were implemented to ensure comparability across the three studies done in 1965, 1975, and 1985. First, only people between 18 and 64 were selected for this study that compares these three surveys. Second, as the 1965 study excluded rural residents, researchers examined whether there were significant differences in behavior between the urban and rural respondents of the other two studies. No significant differences were found. Third, Multiple Classification Analysis (MCA) was used to ensure other things were equal when comparing the studies across three decades. The MCA technique may be viewed as a stepwise regression. The MCA technique creates a new dependent variable by subtracting the predicted

dependent variable from its observed value. This new dependent variable (i.e., the residual) can be used to examine the remaining variability, especially if the distribution of the dependent variable is not normal.

As diary data was not available for a week, but only for a single day, the author constructed a "synthetic week" to obtain time expenditures on activities and travel. This was done by adding up times from an equal number of diaries from Monday to Sunday. Descriptive analyses were used.

Key Results

1. Employed women spent 8.5, 9.0, and 10.9 hours per week on traveling in 1965, 1975, and 1985 while unemployed women spent 7.5, 7.4, and 7.9 hours per week on traveling for the same years. From these numbers, it was noted that employed women's travel time expenditure increased significantly over the years and employed women spent more time traveling than unemployed women.
2. Employed men spent 10.6, 10.3, and 9.5 hours per week traveling in 1965, 1975, and 1985 while unemployed men spent 12.5, 11.0, and 11.0 hours per week traveling for the same years. From these numbers, it was noted that for both employed and unemployed men, the travel time expenditure decreased over the years and unemployed men traveled more than employed men.
3. Overall, men (both employed and unemployed) still spent more time traveling than women (both employed and unemployed), but in 1985 alone employed women spent more time traveling than employed men.

II.3. Disaggregate Studies

Golob, T. (1990) The Dynamics of Household Travel Time Expenditures and Car Ownership Decisions. *Transportation Research* **24A**, 443-463.

Study Purpose

Examine contemporary and longitudinal relationships between car ownership and travel time by modes (car, public transport, and non-motorized modes).

Data & Methodology

The data source was the Dutch National Panel data. Starting in 1984 with biannual and annual intervals, sampled respondents ages 11 years old and over were asked to complete weekly travel diaries, and personal and household questions. Travel modes were grouped into three categories: car (driver and passenger), public transport (bus, tram, subway and train), and non-motorized modes (bicycle and walk). Travel times by mode are computed as household weekly totals calculated from the diaries, correcting missing information.

The authors used waves 3, 5, 7, and 9 of the panel, collected in the spring of 1985, 1986, 1987, and 1988. Instead of using a pure-stayer sample, the author used a pooled wave-pair sample[8] consisting of 2,119 separate households from 1985 to 1988.

Structural equations modeling was applied in this study.

Key Results

Direct Effects:

1. Car travel time increased with car ownership and travel time by public transport at the same point in time.
2. Travel time by public transport decreased by car ownership at the same point in time.
3. Travel time by non-motorized mode decreased by car travel time and car ownership at the same point in time. There was a slight positive influence of travel time by public transport on travel time by non-motorized mode at the same point in time.
4. There was a lagged positive influence of car travel time on future car ownership.

Total Effects:

Note: the author did not discuss the total effects among endogenous variables, only the total effects of exogenous variables on endogenous variables at the second point in time.

5. Car ownership at the second point in time increased with number of drivers in the household both at the same point in time and in the previous year. The high income dummy had both contemporaneous and lagged effects (both positive), but the low income dummy had only a negative contemporaneous effect. Households located in rural areas had higher car ownership than those living in the cities.
6. Car travel time at the second point in time increased with the number of drivers in the household both at the same point in time and in the previous wave. Number of workers, number of adults, and number of children ages 12 to 17 at the second point in time had positive effects. As for the effect of residential location, households living in rural areas had the highest travel time, followed by households living in suburban cities, households living in the largest cities, and then households living in either nonsuburban medium-sized cities or in suburbs without rail service.
7. Travel time by public transport at the second point in time was influenced negatively by number of adults and drivers in the household in the previous year. There was also a contemporaneous effect of number of drivers. Residential location also played an important role. Households living in large cities had the highest travel time by public transport, followed by those living in medium-sized cities, suburbs and rural areas. The high income dummy had both a contemporaneous and positive effect and a negative lagged effect.

[8] This term was not defined in the paper, but was in this report taken to be the set of households appearing in two consecutive waves, with the analysis treating the first observation for each household as “wave 1” regardless of calendar year, and the second observation as “wave 2”.

8. Travel time by non-motorized mode at the second point in time was positively influenced by number of adults and number of children who were between 12 and 17 at the same point in time. Number of drivers had a negative effect on travel time by non-motorized modes both at the same point in time and in the previous year. The high income dummy had a negative influence both at the same point in time and in the previous wave while the low income dummy had a positive influence both at the same point in time and in the previous wave.

Hamed, Mohammad M. and Mannering, Fred L. (1993) Modeling Travelers' Postwork Activity Involvement: Toward a New Methodology. *Transportation Science* **27(4)**, 381-394.

Study Purpose

To model activity participation after work.

Data & Methodology

The authors used trip diary data obtained from the Puget Sound Council of Governments (PSCOG) for travelers located in the four-county region of Seattle, Washington. Each traveler was asked to report every activity he/she conducted on the survey day as well as associated attributes. These attributes included activity type, trip origin, destination, starting and ending times, travel mode and travel time to activities, and home and activity duration. In addition to the information on each activity, travelers also reported information on the number of activities conducted all day, home-stay and work duration, home and work location, age, and gender. Household socio-economic data such as number of household members, income, number of vehicles, number of employed people, and number of children were also provided by respondents. A total of 370 completed diaries were used for this study.

A utility maximization framework (discrete choice modeling, duration models) was used in this study.

Key Results

1. Number of years lived in the neighborhood had a negative effect on travel time from work to home.
2. Departure time from work during peak period had a positive effect on travel time from work to home.
3. Travel time from work to an activity and back home was positively related to the duration of that activity.
4. People experienced greater travel time if pursuing an activity immediately after work than if pursuing an activity directly from home.
5. Travel time to and from activities was also affected by the type of activity being pursued. Travel time to a free-time discretionary activity was less than that to other activities (shopping, personal business).
6. Travel time to personal business activities was greater than for other activity types.

Kraan, Mariëtte. (1996) *Time to Travel? A Model for the Allocation of Time and Money*. Unpublished Ph.D. Dissertation. University of Twente. The Netherlands.

Study Purpose

To analyze how travel relates to the total activity pattern. A model of time allocation to activities and travel is developed.

Data & Methodology

The study used the Time Budget Survey ("TijdsBestedingsOnderzoek", TBO), which was carried out every five years in October. The sample size was approximately 3,000 respondents. Households throughout the Netherlands were randomly selected and household members age 12 or older were asked to fill out the survey. A geographically weighted sampling scheme was used such that more respondents were sampled in large cities.

Respondents were asked to fill in an activity every 15 minutes. If there was more than one activity within the 15-minute interval, respondents were asked to record the activity with the longest duration. Information on characteristics of households was also collected. Information at the household level included household size, household income, distance to public transportation stations, car ownership, and public transport season passes. Information at the individual level included age, gender, employment status, working hours and commuting distance.

A utility maximization framework was used to develop a model of time and money allocation to various activities.

Key Results

1. The sample was divided into six groups according to employment status: full-timers, part-timers, students, housewives, unemployed, and pensioners. Single students (a subgroup within the group of students) and single workers (including both full-timers and part-timers) were also examined for their time allocation. It was found that travel time expenditures varied significantly among different groups.
2. People with full time obligatory activities spent a great amount of time traveling to these obligatory activities.
3. People with a large maintenance task (part-timers and housewives) and also the unemployed spent a large amount of time traveling for those activities (e.g., shopping). Students (both singles and those in large households) and pensioners, to a lesser extent, did so as well.
4. No significant difference was found among housewives, part-timers and the unemployed in terms of travel time spent for maintenance activities.
5. No significant difference was found among students, single workers and full-timers in terms of travel time spent for maintenance activities.
6. Part-timers, housewives, students in large households and full-timers spent less time traveling for leisure activities than others.
7. Similarly, no significant difference was found among unemployed, single workers, and pensioners in terms of travel time spent for leisure activities.

8. Among all groups, single students spent the most time traveling for leisure activities, a significant difference from other groups of the population.

Golob, Tom F. and McNally, Michael G. (1997) A Model of Activity Participation and Travel Interactions between Household Heads. *Transportation Research B* **31(3)**, 177-194.

Study Purpose

Examine the interaction of activity participation and travel for household heads.

Data & Methodology

This study utilized the revealed preference component of the 1994 Activity and Travel Survey in Portland, Oregan. The revealed preference data included a two-day activity diary recording all activities including travel, and all in-home activities with a duration of more than 30 minutes for all individuals in the household. Socio-economic data on the household and its members was also included. The data set consisted of 2,230 households with 5,120 individuals. For this study, 1,318 married or unmarried adult couples (18 years or older) living in the same residence were analyzed using structural equation systems.

Key Results

Direct Effects:

1. Duration of work and maintenance had the same effect on commute travel time for males and females. About 22.6 minutes of travel was involved for every 8 hours of out-of-home work activity and about 7.8 minutes of travel was involved for every hour of out-of-home maintenance activity.
2. Duration of discretionary activities had a stronger positive effect for women than for men. Every hour of out-of-home discretionary activity entailed about 5.5 minutes of travel for males but 8.5 minutes of travel for females.
3. A negative effect existed between maintenance travel and work activity for males; that is, longer times spent on maintenance travel tended to be associated with shorter work times for males.
4. A negative effect existed between female work activity and female maintenance travel.
5. A negative effect existed between discretionary travel and discretionary activity for females.
6. A positive effect existed between male work activities and female maintenance travel; that is, when the male in the household spent a longer time on work, the female tended to spend more time on maintenance travel.
7. A negative effect existed between male travel for work activities and female duration of participation in discretionary activities.

Total Effects:

8. Male work travel was positively influenced by male work activity, and negatively influenced by male maintenance activity and maintenance travel.
9. Female work travel was positively influenced by female work activity.
10. Male maintenance travel was negatively influenced by male work activity and positively influenced by male maintenance activity.
11. Female maintenance travel was positively influenced by male work activity and female maintenance activity, and negatively influenced by female work activity, male maintenance activity and male maintenance travel.
12. Male discretionary travel was positively influenced by male and female discretionary activities and male maintenance travel, and negatively influenced by male and female work activity, male and female maintenance activity, and male work travel.
13. Female discretionary travel was positively influenced by male maintenance activity, female discretionary activity, and male maintenance travel, and negatively influenced by male and female work activity, female maintenance activity, and male work travel.
14. Exogenous variables played significant roles in the amount of travel made for different purposes by males and females. These variables included number of children 0-5, number of children 6-11, number of children 12-21 without a driver's license, number of children 12-21 with a driver's license, number of workers, number of vehicles, household vehicles per driver, and dummy variables for household in current home one year or less, household renting, male head with a driver's license, female head with a driver's license, and male head younger than 26.

Kitamura, Ryuichi; Fujii, Satoshi; and Pas, E. (1997) Time-use Data, Analysis and Modeling: toward the Next Generation of Transportation Planning Methodologies. *Transport Policy* **4(4)**, 225-235.

Study Purpose

This paper argued that the activity-based approach must be the central thesis for transportation planning methodologies. In addition time-use data can be used for policy evaluations. Two examples of policy evaluation using time-use data were given in the paper.

Data and Methodology

The authors cited one study (Fujii et al., 1997) in which the researchers examined how saved commuting time was allocated to other activities and travel. They used a data set collected in 1994 in the Osaka-Kobe metropolitan area as part of an evaluation of the impact of the new Wangan (Bayshore) Line of the Hanshin Expressway system. Questionnaires were mailed out to randomly-selected households and household members who were at least 16 years old were asked to complete the questionnaires and mail them back. The final data set contained 594 households, or 1,257 individuals. Structural equation systems were used for the study by Fujii et al. (1997).

Key Results

1. The estimated model indicated that a 10-minute reduction of commute time would increase average total out-of-home activity duration by 1.88 minutes, average total in-home activity duration by 7.11 minutes, and average total travel time by 0.36 minutes. The number of home-based trip chains after returning home from work would increase about 30%, from 0.03 to 0.04. The reduction in commute time probably facilitates early arrival at home from work, which may encourage participation in activities outside of home again, a finding by Hamed and Mannering (1993).
2. The above results did not support the concept of a constant travel time budget. Over 70% of the time saved was applied to in-home activities and about 19% of the time saved was applied to out-of-home activities. Only a small amount of the time saved was again used for travel.

Ma, June and Goulias, Konstadinos (1998) Forecasting Home Departure Time, Daily Time Budget, Activity Duration, and Travel Time Using Panel Data. Paper Presented at the 77th Annual Meeting of the Transportation Research Board, Washington, D.C.

Study Purpose

The authors were interested in developing a model to forecast how a person allocates his/her daily time. More specifically, given the total daily budget that a person is willing to spend on out-of-home activities and temporary in-home stays[9], the developed model predicts time allocation to different kinds of out-of-home activities, temporary in-home stays and travel.

Data Methodology

The authors used the data set from the Puget Sound Transportation Panel (PSTP). The first day of the 4th-wave data was used for this study, consisting of 5,500 individual activities or trips. The authors employed a sequential process to estimate starting times and durations of all out-of-home activities and travel. Accelerated Failure Time (AFT) modeling was used for this study.

Key Results

Note: the travel time indicated below is the travel time of the current trip.

1. Activity duration was significantly related to travel time only when a person traveled to participate in a subsistence activity. This result is in contrast to that found by Hamed and Mannering (1993). The authors argued that the difference resulted from different data and model structure.
2. "People who are employed, work five days per week and live far away from their workplace tend to travel longer for work-related activities than others do."
3. "Late home departure time, more time spent on past activity participation and travel on the same day, or higher number of activities in the past on the same day tend to decrease the travel time [of the current trip]."

[9] All time at home between the first and last trip of the day is considered temporary in-home time.

4. "The longer the previous trip to a subsistence activity, or the shorter the previous trip to a leisure activity, the longer the travel time [of the current trip] is."

Lu, Xuedong and Pas, Eric I. (1999) Socio-demographics, Activity Participation and Travel Behavior. *Transportation Research* **33A**, 1-18.

Study Purpose

Examine the role of socio-demographics and activity participation in travel behavior.

Data & Methodology

The authors used the data from the Oregon–Southwest Washington Activity and Travel Survey of 1994/95. The survey was conducted through a telephone interview. All respondents in the sampled households were asked to report in a two-day diary all of their out-of-home activities (including travel) and all in-home activities whose duration was longer than 30 minutes. Pairs of days were staggered to include all seven days of the week across the sample. In addition to activity and travel information, characteristics of the household and its members were also collected.

The survey was conducted in the spring of 1994 and the fall and winter of 1995. Only the spring 1994 portion of the data was used for this study. The spring 1994 sample consisted of 2,230 households, of which about 2,514 individuals age 16 and older were used for this study.

Structural equation systems were used.

Key Results

Direct Effects:

1. Socio-demographics had a significant effect on daily total travel time. Namely, women spent more time traveling than men. Employed people spent more time traveling than did unemployed people. People with more vehicles spent more time traveling than non-car-owning people did. Number of workers and number of children in the household decreased the amount of time spent on traveling. Household income had a positive effect on daily total travel time.
2. Daily total travel time increased as the amount of time spent on out-of-home activities increased.

Total Effects:

3. A negative association exists between total daily travel time and the amount of time spent on in-home activities.
4. Total daily travel time increases as the amount of time spent on maintenance and other out-of-home activities increases.
5. Total daily travel time is positively related to age, income, and number of workers and is negatively related to number of vehicles and number of children.

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APPENDIX

SUMMARY OF STUDIES REVIEWED

Table 1: Aggregate Studies
(In Chronological Order by Date of Publication)*

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Robinson, J.; Converse, P. E.; and Szalai, A. (1972)	Activity diary	1 day	All days	2077 people	9/1965-6/1966	Belgium	All modes
	Activity diary	1 day	All days	2096 people	9/1965-6/1966	Kazanilk, Bulgaria	All modes
	Activity diary	1 day	All days	2192 people	9/1965-6/1966	Olomouc, Czechoslov-akia	All modes
	Activity diary	1 day	All days	2805 people	9/1965-6/1966	Six cities, France	All modes
	Activity diary	1 day	All days	1500 people	9/1965-6/1966	100 electoral districts, Fed. Rep. Germany	All modes
	Activity diary	1 day	All days	978 people	9/1965-6/1966	Osnabrück, Fed. Rep. Germany	All modes
	Activity diary	1 day	All days	1650 people	9/1965-6/1966	Hoyerswer-da, German Dem. Rep.	All modes
	Activity diary	1 day	All days	1994 people	9/1965-6/1966	Györ, Hungary	All modes
	Activity diary	1 day	All days	782 people	9/1965-6/1966	Lima-Callao, Peru	All modes
	Activity diary	1 day	All days	2754 people	9/1965-6/1966	Torun, Poland	All modes
	Activity diary	**1 day**	**All days**	**1243 people**	**9/1965-6/1966**	**Forty-four cities, USA**	**All modes**

* To highlight them, the US studies are in bold.

Table 1: Aggregate Studies (Continued)
(In Chronological Order by Date of Publication)

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Robinson, J.; Converse, P. E.; and Szalai, A. (1972)	**Activity diary**	**1 day**	**All days**	**778 people**	**9/1965-6/1966**	**Jackson, USA**	**All modes**
	Activity diary	1 day	All days	2891 people	9/1965-6/1966	Pskov, USSR	All modes
	Activity diary	1 day	All days	2125 people	9/1965-6/1966	Kragujevac, Yugoslavia	All modes
	Activity diary	1 day	All days	1995 people	9/1965-6/1966	Maribor, Yugoslavia	All modes
van der Hoorn, T. (1979)	Activity diary	A week	All days	1100 people	10/1975	Netherlands	1. car, motor, scooter [*sic*]; 2. moped; 3. bus, tram, train, ferry, taxi, boat, airplane; 4. walk, bike
Zahavi, Y. & Talvitie, A. (1980); **Zahavi, Y. & Ryan, J. (1980)**	**Travel survey**	**NR**	**NR**	**450,680 hhlds (1955); 547,224 hhlds (1968)**	**1955, 1968**	**Washington, D.C**	**NR**
	Travel survey	**NR**	**NR**	**366,511 hhlds (1958); 433,460 hhlds (1970)**	**1958, 1970**	**Twin Cities, Minnesota**	**NR**
Zahavi, Y. & Talvitie, A. (1980)	Travel survey	NR	NR	4757 travelers	1972	Bogota, Colombia	NR
	Travel survey	NR	NR	4352 hhlds.	6/1975	Singapore	Includes walking
	Trip diary	3 days	Weekdays	NR	1976	Munich, Germany	NR

Table 1: Aggregate Studies (Continued)
(In Chronological Order by Date of Publication)

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Chumak, A. & Braaksma, J. P. (1981)	Travel survey	NR	NR	NR	1964, 1971	Calgary (1964, 1971), Montreal (1971), Toronto (1964, 1971)	Includes cars and transit
Downes, J. D. & Morrell, D. (1981)	Trip diary	1 day	Thursday	3288 households	1971	Reading, Britain	All modes but exclusion of incidental walks between modes; travel by commercial drivers is also excluded
Gunn, H. F. (1981)	Trip diary (National Travel Surveys)	NR	NR	NR	1966	Britain	NR
	Trip diary	7 day period (only 7th day data used here)	NR	12,347 people	1972-3	Britain	All modes
	Trip diary	Both 7 days and 1 day (only 7th day data used here)	NR	10,000 households	1975/ 1976	Britain	Only on the 7th day, short walk stages (over 50 yards and under 1 mile) and travel time were recorded
	NR (The County Surveyor's Trip Rate Data Bank)	NR	NR	NR	1974 and 1977	Britain	NR
	NR (The Family Expenditure Surveys)	NR	NR	NR	1959 onwards	Britain	NR

Table 1: Aggregate Studies (Continued)
(In Chronological Order by Date of Publication)

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Gunn, H. F. (1981)	Activity diary	7 days	NR	348 people	1-3/ 1973	Reading	All modes
	NR (The Annual Abstract of Statistics)	NR	NR	NR	For various years	Britain	NR
Landrock, J. N. (1981)	Trip diary	Both 7 days and 1 day (only 7th day data used here)	NR	10,000 households	1975/ 1976	Britain	Only on the 7th day, short walk stages (over 50 yards and under 1 mile) and travel time were recorded
Prendergast, L. S. & Williams, R. T. (1981)	Trip diary	7 day period (only 7th day data used here)	NR	12,347 people	1972-3	Britain	All modes
	Trip diary	1 day	Thursday	9,369 people from 3,368 hhlds.	10-11/ 1971	Reading	Incidental walk trips and screenline counts are excluded
	Activity diary	7 days	NR	348 people	1-3/ 1973	Reading	All modes
Roth, G. & Zahavi, Y. (1981)	Travel survey	NR	NR	NR	NR	Salvador, Brazil	NR
	Travel survey	NR	NR	44,928 travelers	NR	Santiago, Chile	NR
Tanner, J. C. (1981)	Trip diary	Both 7 days and 1 day	NR	10,000 households	1975/ 1976	Britain	Only on the 7th day, short walk stages (over 50 yards and under 1 mile) and travel time were recorded
Wigan, M. R. & Morris, J. M. (1981)	Time-use diary	NR	NR	NR	1965-1966	Melbourne and Albury-Wodonga, Australia	NR

Table 1: Aggregate Studies (Continued)
(In Chronological Order by Date of Publication)

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Hupkes, G. (1982)	Travel survey	NR	NR	NR	1962	Netherlands	Motorcar, motor bike, bike, moped, walk, rail, public transport, taxi, airplane
	Travel survey	NR	NR	NR	1972	Netherlands	Same as above
Supernak, J. (1982)	**Travel survey**	**NR**	**NR**	**NR**	**1970**	**Baltimore**	**NR**
	Travel survey	**NR**	**NR**	**NR**	**1977**	**Twin Cities**	**NR**
Kitamura, R.; Robinson, J.; Golob, T.; Bradley, M.; Leonard, J.; & van der Hoorn, T. (1992)	**Time use survey**	**1 day**	**NR**	**1564 people**	**1987-1988**	**California, USA**	**All modes**
	Time use survey	**7 days**	**NR**	**2,964 people**	**1985**	**Netherlands**	**All modes**
Purvis, C. (1994)	**Travel survey**	**NR**	**Both weekday and weekend**	**20,486 hhlds (weekday); 10,200 hhlds (weekend)**	**1965**	**San Francisco Bay Area**	**NR**
	Travel survey	**NR**	**Both weekday and weekend**	**6,209 hhlds (weekday); 882 hhlds (weekend)**	**1981**	**San Francisco Bay Area**	**NR**
	Trip diary	**1 day; 3 days; 5 days (only 1-day sample used here)**	**Weekday**	**9,438 hhlds (1-day); 1,486 hhlds (3-day and 5-day)**	**1990**	**San Francisco Bay Area**	**NR**
Kumar, A. & Levinson, D. (1995)	**Trip diary**	**1 day**	**Both weekday and weekends**	**47,499 people from 21,817 hhlds**	**3/1990 - 3/1991**	**USA**	**All modes**

Table 1: Aggregate Studies (Continued)
(In Chronological Order by Date of Publication)

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Levinson, D. & Kumar, A. (1995)	Trip diary	1 day	NR	23,000 hhlds	1968	Washington, D.C.	Excluded nonmotorized nonwork trips
	Trip diary	1 day	NR	7,400 hhlds	1987-1988	Washington, D.C.	All modes
Rutherford, G. S.; McCormack, E.; and Wilkinson, M. (1996)	Trip diary	2 days	NR	900 hhlds	11,12/ 1991	Kirkland, Wallingford, and Queen Anne in Greater Seattle Area	All modes
	Trip diary	NR	NR	NR	9-11/ 1989	Puget Sound Washington Area	All modes
Principio, S. L.; Pas, E. I. (1997)	Activity diary	2 days (only those assigned both weekdays used here)	Both weekdays and weekends	1,778 households (only 1,167 hhlds. used here)	1994/ 95	Research Triangle Region, North Carolina	All modes
Robinson, J. (1997)	Time use survey	1 day	NR	5,300 people	1985	USA	All modes

Table 2: Disaggregate Studies
(In Chronological Order by Date of Publication)*

Authors	Survey Type	Survey Period	Day of Week	Sample Size	Year	Location	Modes
Golob, T. (1990)	Trip diary	7 days	NR	1334 hhlds	1985-1986	Netherlands	Car (driver and passenger), public transport (bus, tram, subway, and train), non-motorized modes (bike and walk)
	Trip diary	7 days	NR	1,393 hhlds	1986-1987	Netherlands	Same as above
	Trip diary	7 days	NR	1,689 hhlds	1987-1988	Netherlands	Same as above
Hamed, M. & Mannering, F. (1993)	**Trip diary**	**1 day**	**Weekday**	**370 people**	**NR**	**Seattle, Washington**	**All modes**
Kraan, M. (1996)	Time-use diary	7 days	NR	3,000 people	Every 5 years since 10/1975	Netherlands	All modes
Golob, T. & McNally, M. (1997)	**Activity diary**	**2 days**	**NR**	**5,120 people fr. 2,230 hhlds (only 1,292 couples used here)**	**1994**	**Portland, Oregon**	**All modes**
Kitamura, R.; Fujii, S.; and Pas, E. (1997)	Activity diary	1 day	NR	1,257 people fr. 594 hhlds	1994	Osaka-Kobe metropolitan area, Japan	All modes
Ma, J. & Goulias, K. (1998)	**Panel data**	**NR (only the 1st day of the 4th wave used)**	**NR**	**1,621 people**	**NR**	**Puget Sound, Washington Area**	**All modes**
Lu, X. & Pas, E. (1999)	**Activity diary**	**2 days**	**NR**	**2,514 people fr. 2,230 hhlds used here**	**1994**	**Portland, Oregan Metro. Area**	**All modes**

* To highlight them, the US studies are in bold.

Table 3: Key Variables and their Relationship to Travel Time Expenditure

Variable	Relation[1]	Reviewed Studies[2]
Activity Duration at the Destination	+	Hamed and Mannering (1993)[d]; Ma and Goulias (1998)[h]; Kitamura et al. (1997)
Activity Type	S	Hamed and Mannering (1993)[d]
Area Type	S	van der Hoorn (1979)[a]; Chumak and Braaksma (1981)[c]; Downes and Morrell (1981)[b]; Landrock (1981)[bc]; Tanner (1961)[b]; Supernak (1982)[b]; Kitamura et al. (1992)[a]; Rutherford et al. (1996)[b]
Density	0	Tanner (1981)[b]; Goodwin (1976)[b]; Gunn (1981)[b]
	+	van der Hoorn (1979)[a]
Age (Groups)	C	Prendergast and Williams (1981)[bc]; Gunn (1981)[b]; Kitamura et al. (1992)[a]; Rutherford et al. (1996)[b]
	0	Roth and Zahavi (1981)
Car Ownership	+	van der Hoorn (1979)[a]; Chumak and Braaksma (1981)[c]; Roth and Zahavi (1981)[c]; Prendergast and Williams (1981)[bc]; Godard (1978)[b]; Purvis (1994)[e]; Lu and Pas (1999)[b]
	-	Zahavi and Talvitie (1980)[c]; Roth and Zahavi (1981)[c]
	0	Downes and Morrell (1981)[b]; Bullock et al. (1974)[b]; Purvis (1994)[b]
	?	Zahavi and Talvitie (1980)[c]; Goodwin (1976)[b]
Day of the Week	S	van der Hoorn (1979)[a]; Zahavi and Talvitie (1980)[c]; Prendergast and Williams (1981)[bc]; Kumar and Levinson (1995)[b]
Departure Time from Work (= 1 during Peak)	+	Hamed and Mannering (1993)[d]
Duration of Previous Trip to Different Activities	C	Ma and Goulias (1998)[h]
Employment Status	S	van der Hoorn (1979)[a]; Zahavi and Talvitie (1980)[c]; Chumak and Braaksma (1981)[c]; Roth and Zahavi (1981)[c]; Prendergast and Williams (1981)[bc]; Wigan and Morris (1981)[b]; Bullock et al. (1974)[b]; Supernak (1982)[b]; Robinson (1997)[a]; Ma and Goulias (1998)[h]; Lu and Pas (1999)[b]
Gender	S	Zahavi and Talvitie (1980)[c]; Roth and Zahavi (1981)[c]; Prendergast and Williams (1981)[bc]; Gunn (1981)[b]; Kitamura et al. (1992)[a]; Wigan and Morris (1981)[d]; Levinson and Kumar (1995)[b]; Robinson (1997)[a]; Lu and Pas (1999)[b]

Table 3: Key Variables and their Relationship to Travel Time Expenditure (Continued)

Variable	Relation	Reviewed Studies
Gender × Age	S	Prendergast and Williams (1981)[bc]
Gender × Area Type	S	Gunn (1981)[b]
Gender × Employment	S	Prendergast and Williams (1981)[bc]; Robinson (1997)[a]
Gender × Marital Status	S	Prendergast and Williams (1981)[bc]
Household Size	?	Zahavi and Talvitie (1980)[c]
	-	Purvis (1994)[b]
	+	Purvis (1994)[e]
	0	Roth and Zahavi (1981)[c]
Household Size × Car Ownership	?	Zahavi and Talvitie (1980)[c]
Income	+	Zahavi and Talvitie (1980)[c]; Roth and Zahavi (1981)[c]; Prendergast and Williams (1981)[bc]; Tanner (1981)[b]; Lu and Pas (1999)[b]
	-	Roth and Zahavi (1981)[c]
	S	Gunn (1981)[b]
	0	Zahavi and Talvitie (1980)[c]; Roth and Zahavi (1981)[c]
Late Home Departure Time	-	Ma and Goulias (1998)[h]
Mode	S	Chumak and Braaksma (1981)[c]; Roth and Zahavi (1981)[c]; Prendergast and Williams (1981)[bc]; Tanner (1981)[b]; Goodwin (1976)[b]; Golob (1990)[b]
Month of the Year	S	Kumar and Levinson (1995)[b]
Number of Activities Participated in Previously on the Same Day	-	Ma and Goulias (1998)[h]
Number of Workers	+	Lu and Pas (1999)[b];
Number of Children	+	Lu and Pas (1999)[b];

Table 3: Key Variables and their Relationship to Travel Time Expenditure (Continued)

Variable	Relation[1]	Reviewed Studies[2]
Occupation Type	S	Gunn (1981)[b];
Occupation Type × Age	S	Gunn (1981)[b];
Person Group	S	van der Hoorn (1979)[a]; Roth and Zahavi (1981)[c]; OECD (1977)[b]; Levinson and Kumar (1995)[b]; Kraan (1996)[a]; Golob and McNally (1997)[f]; Principio and Pas (1997)[g];
Population Density	+	Landrock (1981)[bc];
Population Size × Population Density	0	Landrock (1981)[bc];
Tenure in Residence	+	Hamed and Mannering (1993)[d];
Time	+	Godard (1978)[b]; Gunn (1981)[b]; Tanner (1961)[b]; Purvis (1994)[bce]; Levinson and Kumar (1995)[b];
	-	Purvis (1994)[bce];
	0	Kumar and Levinson (1995)
Time of Day	-	Ma and Goulias (1998)[h];
	If peak	Hamed and Mannering (1993)[d];
Time in Past Activity Participation and Travel on the Same Day	-	Ma and Goulias (1998)[h];
Total Time Available (24 hours)	-	Kitamura et al. (1992)[a];
Total Time on Out-of-home Activities	+	Lu and Pas (1999)[b];
Urban Size	+	Godard (1978)[b];

[1] "+" means positive relationship between the variable and travel time expenditure; "-" means negative relationship between the variable and travel time expenditure; "0" means insignificant relationship between the variable and travel time expenditure; "?" means that the direction of the relationship is not clear; "C" means that although the variable is ordinal and a significant relationship has been found, one cannot summarize the effect simply by "+" or "-". For the variable of age, one may find that people in their 20s and early 30s travel the most and people of other ages have less travel time to different extents; "S" means that the relationship is significant but the studied variable is a nominal categorical variable, so that the direction of the relationship cannot be summarized with a "+" or "-". [2] Superscript "a" is travel time per person per week; "b" is travel time per person per day; "c" is travel time per traveler per day; "d" is daily commute time per person; "e" is travel time per household per day; "f" is total two-day travel time to out-of-home activities (by different activity types); "g" is two-day total travel time per person; "h" is travel time of the current trip per person.