TTB or Not TTB, that is the Question: A Review and Analysis of the Empirical Literature on Travel Time (and Money) Budgets

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ABSTRACT

This paper summarizes and analyzes findings from about two dozen aggregate and disaggregate studies of travel time (and sometimes money) expenditures, exploring the question of the existence of a constant travel time budget. We conclude (with prior researchers) that travel time expenditures are not constant except, perhaps, at the most aggregate level. Nevertheless, individuals' travel time expenditures do show patterns that can be partly explained by measurable characteristics**.** 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). Further research into explaining travel time and money expenditure patterns is justified. We also suggest the existence of (and advocate further research on) an unobserved *ideal* travel time budget (that is not constant but varies by individual) that individuals try to achieve.

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. The concept of a "travel time budget" (TTB) refers to the idea that individuals' average daily travel time tends to be relatively constant. The behavioral hypothesis is that people have a certain (generally non-zero) amount of time that they are willing (or may even want) to spend on travel, and that they will make adjustments to minimize departures from that budget in either direction. Proponents of a travel time budget generally go beyond the suggestion of an individual-specific budget, however, to the observation that the actual size of that budget, as an average taken at a regional or national scale, is relatively stable across time and space. At the extreme, the TTB is viewed almost as a universal constant: 1.1 – 1.3 hours (per traveler) per day, according to several studies (Bieber, et al., 1994; Zahavi and Ryan, 1980; Zahavi and Talvitie, 1980; Hupkes, 1982; Schafer and Victor, 2000; Vilhelmson, 1999).

The position of the TTB concept in the transportation planning and modeling profession is paradoxical. On the one hand, the concept has shown a stubborn persistence in the literature, despite the fact that (as has been noted by others and will be demonstrated below) the more closely it is examined, the more elusive it becomes. Clearly there is something about the TTB idea that resonates with us. One reason is the common observation that at the aggregate level, when travel speeds increase over time – whether due to improvements in technology or additions of capacity to the system – travel distances tend to increase so as to keep travel times approximately constant (Zahavi and Ryan, 1980; Hupkes, 1982; Marchetti, 1994). This links the TTB concept to the induced demand debate (e.g., Noland and Lem, 2002), with one extreme arguing that, at least from energy and air quality standpoints, it is useless at best and counterproductive at worst to add network capacity (or, presumably, to implement any operational efficiencies that increase overall speeds), since people will simply take advantage of the improvement to travel more.

On the other hand, the TTB idea appears, at least at first glance, to clash with one of the most fundamental tenets of travel behavior: that travel time is a disutility to be minimized. The travel time minimization principle underlies a great deal of policy-making as well as virtually all regional travel demand forecasting models, and is used to justify monetizing the benefits of transportation improvements on the basis (primarily) of travel time savings. But obviously, under a TTB, travel time is not minimized but is kept constant. If that is true, then, for example, the typical travel demand model is asking the wrong question. Rather than assuming the individual to be asking, "What is the least amount of travel I can do in order to accomplish a given set of activities?", the individual instead should be viewed as asking, "What is the most attractive set of activities/ destinations I can achieve, given a certain travel time budget?"[1]

[1] Essentially this observation is attributed to Zahavi by Gunn (1981) and by Michael Wegener as a participant at the European Science Foundation/National Science Foundation Social Change and Sustainable Transport (SCAST) conference at Berkeley, California, March 10-13, 1999.

Some researchers, therefore, have expressed discomfort with the TTB concept on the grounds that it conflicts with utility maximization, or with the principle that travel is a derived demand (see, e.g., Giuliano, 1997; Tanner, 1981). In and of itself, however, the TTB concept does not seem to conflict with these principles (see, e.g., Golob, et al., 1981; Goodwin, 1981; Hupkes, 1982). Even under conventional modeling assumptions, traveling greater distances is entirely predictable (has higher utility) when the greater attractiveness of the more distant destination outweighs the disutility of the additional travel required to reach it. Thus, if individuals use travel time saved (through higher speeds or greater accessibility) to visit more destinations, and/or destinations that are farther away but more attractive, they are still increasing their utility and their demand for travel is still purely derived. The TTB concept simply adds a hypothesized behavioral constraint to the form that utility is expected to take. Specifically, the utilities of alternative activities/destinations can still (as is commonly the case now) be modeled as being directly proportional to their attractiveness, and inversely proportional to the travel time (or generalized travel cost) required to reach them, subject to an escalating penalty for violating the desired TTB in either direction for an entire day's (or other unit of time) set of activities. In principle, it is simply this latter penalty function that current models lack. In practice, establishing such a penalty function is non-trivial, since eliciting data from individuals on the abstract concept of a "desired travel time budget" would present a considerable challenge.

Thus, the apparent paradox of the TTB concept may be due simply to a failure to make the models realistic enough, rather than to an actual contradiction of the basic principles on which the models are based. Nevertheless, if the TTB is a fundamental principle of its own, it should be important for the models – on which many policy and investment decisions are based – to reflect that principle. Not surprisingly, several researchers have addressed ways of incorporating the TTB concept into some travel behavior models (Golob, et al., 1981; Goodwin, 1981; Gunn, 1981), and some have actually operationalized such models. The original proponent of the TTB, Yacov Zahavi (1979), developed a "Unified Mechanism of Travel (UMOT)" process for travel demand forecasting based on a TTB. Much more recently, researchers at MIT have used the concept to predict future worldwide mobility as incomes rise and slower modes are replaced by faster modes (Schafer, 1998, 2000; Schafer and Victor, 2000).

In view of the elemental nature of the TTB concept, the profound implications for modeling and policy/planning depending on whether it is valid or not, and the ambiguous status it currently holds in our thinking, it is worthwhile to undertake a review of the current body of evidence on the subject, and evaluate what it tells us. That is the primary purpose of this paper. Although much less attention has been devoted to travel money budgets, we also review the evidence on that subject[2]. Throughout this paper, we attempt to distinguish between "budget" and "expenditure". Following Goodwin (1981, p. 97), the word "expenditure" simply 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

[2] The same group of researchers who proposed the existence of a travel time budget also proposed the existence of a travel money budget. They argued that people spend a fixed percentage of their income on travel: about 10 to 11% of income for car-owning households and 3 to 5% of income for carless households (Zahavi and Ryan, 1980).

hand, the word “budget” implies stability, referring to an “allocation of time, money or generalised resources to travel which would not be influenced by policy, trends or costs.”

The paper is organized as follows. In Section 2, we provide an overview of the studies reviewed, including a discussion of the complexities of this cross-study comparison. In Section 3, we present a number of variables related to travel time and money expenditures in various studies, and summarize the nature of those relationships. Tables 1-3 summarize the studies reviewed; a brief synopsis of each individual study is available in Chen and Mokhtarian (1999). Section 4 offers some concluding observations. This paper focuses on empirical descriptive results with respect to travel time and money expenditures. In a companion paper (Chen and Mokhtarian, 2002), we focus on ways of modeling an individual’s time and money expenditures on travel. We review disaggregate methodological approaches found in the literature, together with key results, and develop a new utility maximization model of travel time and money expenditures.

2. OVERVIEW OF LITERATURE REVIEWED

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, for which “no lengthy calibration process to observed data is required” (Zahavi and Talvitie, 1980, p. 18). 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 detail for this paper were conducted between the late 1970s and the early 1980s.

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 may have been because disaggregate models themselves were considered to be an important improvement in forecasting capability, even without the additional assumption of travel time and money budgets. With improved computer capabilities, the motivation to simplify computation procedures was no longer as strong. Probably for these reasons, 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 formally reviewed in this paper were conducted in the 1990s, and four of them are particularly in the context of an activity-analysis orientation.

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.

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.

Goodwin (1981), on the other hand, 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. However, the Hamed and Mannering study is included here because of the novel (in this context) methodology it employs. A recent study (Vilhelmson, 1999), not formally reviewed here, models the time spent in traveling to activities that are flexible in time and space[3].

2.3. Methodologies Employed

Basic information about the studies reviewed is summarized in Tables 1 and 2. The studies 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. The analysis methodologies themselves are the focus of a companion paper (Chen and Mokhtarian, 2002).

3. THE RELATIONSHIPS OF KEY VARIABLES TO TRAVEL TIME AND MONEY EXPENDITURE

3.1. Travel Time Expenditure

A number of aggregate studies beginning in the late 1970s and early 1980s explored the stability of travel time expenditures 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

[3] The same study tabulates average total daily travel time for Swedish adults ages 20-64 (based on large-sample nationwide surveys), for several time points from 1978 to 1995. The result shows stability (about 80 minutes or 1-1/3 hours per day) from 1978 to 1991, with decreases in 1994 (to 74 minutes/day) and 1995 (to 69 minutes/day). The decrease is attributed to the shift to faster modes of travel (auto), and to underestimation due to a shift in survey administration mode from personal interview to telephone.

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 (p. 117) 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 socioeconomic characteristics are presented first, followed by activity-related attributes and then area-specific attributes (density and network attributes). Only variables found significant in more than one study are included here. The results are summarized in Table 3.

3.1.1 Socioeconomic Characteristics

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, et al. (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. 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 contradictory 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 of 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, p. 461) used income dummy variables to examine the relationship between income and travel time by mode for members of the Dutch National Mobility Panel. He found that the high income dummy had a positive contemporaneous effect on travel time by public transport, “indicating that public transport is a superior economic good”, but a negative lagged effect “as a consequence of adjustments in car ownership”. More research is needed to explore the complex 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.

3.1.2 Activity-Related Characteristics

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). Using structural equations modeling, another 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).

Other 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, and 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.

3.1.3. Area-Specific Characteristics

Area Type. The 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) reasoned 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 (p. 140), "In a monocentric city high densities imply shorter trips, and low densities mean longer trips. In a policentric city, low densities could mean either shorter or longer trips depending upon whether workers choose homes around employment subcenters … or whether cross-commuting across metropolitan areas is common."

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.

3.2. 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.

More recently, Osula and Adebisi (2001) modeled travel money expenditures in Nigeria, and found that the appropriate functional form was not stable across a significant energy policy change. They concluded (p. 269) that "'travel budget' is as yet not usable as a term for travel expenditures in Nigeria."

4. CONCLUSIONS

The question of the existence of a stable time and money budget 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; Hupkes, 1982). The current literature review 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 examine 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 that for 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, p. 104) 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 travel time expenditures. 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 (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 paper has focused almost entirely on empirically observed travel time expenditures. In the Introduction, however, we implied that an *unobserved*, *desired* travel time budget is a logical behavioral construct that could underpin the observed regularities in expenditures. Hints of such a construct appear in Hupkes (1982) and Michon (1978, cited by Hupkes, 1982). The concept is further articulated by Mokhtarian and Salomon (2001). They hypothesize the existence of an unobserved ideal travel time budget, which 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). For them, an important aspect of the ideal travel time budget is that travel is to some extent desired for its own sake, not merely as a means for conducting a desired activity at another destination (also see Mokhtarian, et al., 2001). However, this is not essential: even if the demand for travel is purely derived, it would still be reasonable for individuals to have a mental target for a desired amount of time to spend on reaching desired destinations.

The research challenge is to capture the effect on travel and activity behavior of such a mental target (assuming it exists). 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. And it may be possible to elicit partial measures even in a questionnaire. In particular, because of the regularity, frequency and importance of the commute trip, responses to a question about the ideal commute time can be considered reasonably informative. Redmond and Mokhtarian (2001) analyzed the responses to such a question for 1,300 San Francisco Bay Area workers, and found an average ideal commute time of about 16 minutes.

An alternate approach was also taken by Mokhtarian and her colleagues, 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). Modeling those relative desired mobility responses as a function of the personal characteristics listed above, plus measures of observed mobility, is providing considerable insight into circumstances under which individuals will try to reduce, maintain, or even increase their travel in order to achieve their desired budget (Choo, et al., 2001). A great deal more could be learned, however, about the nature of these ideal travel time budgets and their role in individual decision-making.

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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

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

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.