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Journal of Transport Geography 14 (2006) 109–122

JOURNAL OF TRANSPORT GEOGRAPHY

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Is average daily travel time expenditure constant? In search of explanations for an increase in average travel time

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Abstract

Recent research suggests that the average time spent travelling by the Dutch population has increased over the past decades. However, different data sources show different levels of increase. This paper explores possible causes for this increase. They include a rise in incomes, which has probably resulted in an increase in both travel costs and benefits, the benefits of additional travel having increased more rapidly than costs, and possibly the increased comfort level of cars. Finally, the new opportunities offered to travellers to make better use of their travelling time, such as working in the train, might also have made a contribution.

Keywords: Travel time; Travel time budgets

1. Introduction

For the past three decades a discussion has been going on in the literature on the issue of whether people, on average, have a fairly constant travel time budget. Researchers concluding this to be the case include Szalai (1972), Zahavi (1979) and Schafer and Victor (1997), though in later work Zahavi does not reach the conclusion that such a time budget exists (Golob et al., 1981). In the past few years, the discussion has re-entered the Dutch transportation research area, with several Dutch authors doing research on this subject and discussing the hypotheses of constant travel time budgets (see, for example, Goudappel, 2001; Kraan, 1996; Muconsult, 1997, 2001; Peters et al., 2001; Rietveld, 1999; SCP, various years; van Goeverden, 1999). The theme of constant travel time budgets is important because, if present, it implies that increases in travel speeds due to such long-term developments as technological change or transportation policies result in an increase in total transport volumes. In particular, the constancy of travel time might imply that the development of faster modes would lead to longer travel distances. In addition, depending on the underlying mechanisms, constant travel time budgets may jeopardise basic assumptions in conventional travel behaviour modelling (Mokhtarian and Chen, 2004).

In this paper we will first summarise the discussions on constant travel time budgets as found in the literature (Section 2). We will follow this with an analysis of Dutch data on travel times (Section 3), suggesting that the average time spent travelling by the Dutch population might have increased in the past decades. This will be followed by an overview of possible categories of theories that may explain the constancy of time spent on travel, and the possible increase that has appeared in the Netherlands (Section 4). Our conclusions with respect to these theories are then used to categorise possible explanations for this increase (Section 5). Finally, we will discuss the results and address strategies for further research (Section 6).

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0966-6923/$ - see front matter
doi:10.1016/j.jtrangeo.2005.06.003

This paper attempts to make a contribution to a renewed discussion on travel time budgets in the context of categorising theories that might explain constancy in travel time budgets, and as an item in the overview of possible explanations for increased average travel times, and related strategies for further research.

2. A literature overview

As early as 1961 the possibility of constant travel time budgets was hypothesised by Tanner in his paper 'Factors affecting the amount of travel' (Tanner, 1961). In the 1970s empirical research was carried out by researchers such as Szalai (1972) and Zahavi (1979), suggesting that at an aggregate level (e.g. all people living in one country) the average time spent on travel is more or less the same for that group. Since then, the constant travel time budget has become a subject for discussion in the literature, with a major contribution being made in Transportation Research Part A (1981, special issue on personal travel budgets). Here we will provide a summary of the different aspects of the discussion on travel time budgets, before examining each in greater depth.

Some of the discussions are related to the question of *what* could be constant. The first and may be most important discussion is related to the theoretical aspects of constancy: can constancy in travel time budgets be based on theories? A second aspect relates to the question of who to include? Should only travellers be included, or all people? Thirdly, there is a discussion on constancy: given a certain data set, one will emphasize the consistency, while others the variation within the data set. A fourth aspect of discussion is the question of whether constancy exists over time, even if a cross-section constancy is found. Do people in a certain country spend, on average, the same amount of time on travel over time, or does constancy only appear on a cross-sectional basis (at one moment, for different geographical areas)? Fifthly, there is the discussion on the time period under consideration: are data collected for only one day or for the whole week and is the variation over time within a year included? The sixth aspect is related to what the aggregate level refers to. For example the disaggregation or aggregation could be related to the spatial unit/area (how small can this spatial unit be?) as well as to population groups. Note that with respect to the spatial unit, several studies compare countries. But will the forthcoming conclusions also be valid for a regional or urban area, or even for the neighbourhood level? With respect to population groups, please note that it is widely recognised that travel behaviour, including time spent on travel, varies between population groups—age and sex, for example. The composition of population with respect to these groups varies over time, leading to an ageing population in many Western countries. If the constancy appears at the level of population groups, it will not necessarily appear at the country level due to shifts in the breakdown between population groups and vice versa. The seventh aspect is the selection with respect to modes, purposes and the age of people. Are all modes and trip purposes included or only a selection of these? The discussion on modes focuses mainly on the inclusion of slow modes. Air travel is generally ignored. The discussion on motives focuses on the question of whether travel time budgets can be applied to a selection of purposes only, for example, home-to-work trips. With respect to age it is important to know the minimum age of those included in analyses. Eight, an important discussion is whether only travel time budgets are constant or does this hold for generalised transport cost? Here, at least monetary budgets should be included. Ninth, we elaborate on the link between travel and activity characteristics. The discussion on the quality of the data used is the final point: is the quality high enough to support the findings of the researchers? We will now focus on each of the above aspects in greater detail.

2.1. Theory

We will first focus on the constancy itself. A very important question related to the theoretical considerations is why should average travel times be constant? Several authors have stated that no sound theory for constancy exists; at least not in economics (Golob et al., 1981; Tanner, 1981; Goodwin, 1981). Goodwin stated that fixed time budgets were barely plausible, even from a psychological point of view. Following clues from Hupkes (1982), Michon (1978a,b) and Mokhtarian and Chen (2004) contributed to the debate on theory by introducing the concept of the ideal travel budget, partly referring to the research of Redmond and Mokhtarian (2001), who had found an average ideal commuting time of 16 min, and to the work of Mokhtarian and Salomon (2001). In our opinion, the concept of the ideal commuting travel budget (more than 0 min) adds to the debate, considering that people may prefer to travel to some extent more than try to reduce their travel time as much as possible. It is likely that this notion applies to travel in general, and not only to commuting. Golob et al. (1981) conclude that from an economic point of view, expenditures can be considered fixed in the short term, but become flexible in the long term when utility maximisation is applied to the expenditures themselves and not just to their allocation.

2.2. Who to include?

There is a discussion, particularly in the early literature on travel time budgets, about whether travel time is constant for everybody, or only for travellers (see, for example, Zahavi, 1979; Goodwin, 1981). Goodwin concludes that travel time per traveller is often more stable compared to travel time per person, making the former an attractive indicator. However, according to Goodwin, it does not appear to be the best primary indicator of travel expenditures. In our opinion theoretical considerations and research questions should be the primary reason to choose between 'travellers only' or 'all persons', rather than the outcomes of the data analyses. The choice made should depend on the purposes for using the constant travel time budget. In our data analyses (see Section 4) we included all persons, for reasons of data availability. This does not imply that we assume this to be the best indicator for all purposes.

2.3. What is 'constant'?

A rarely addressed question is related to the definition of constancy. If, for example, 90% of all cases in a cross-section data set have a value of ±10% compared to the average, or if a time-series data set shows an increase of 3% in a period of 15 years, is that a constancy? This, of course, is a question of interpretation. One researcher will emphasize the similarities and constancy in the data, while the other might focus more on the differences. It is important to acknowledge the general belief that there is certainly no 'law' of constancy, as in physics.

2.4. Cross-section data versus time series

The concept of constant travel time budgets suggests transferability over both space and time. The transferability over space is often reflected when comparing data from several countries, sometimes also including third world countries (see, for example, Zahavi, 1979). Though some researchers found quite stable travel time budgets based on such cross-section data sets comparing data for several countries, the results for time-series analyses do not suggest stability. Gunn (1981) reviewed the empirical evidence for constant travel time budgets and concluded that the evidence for the stability of aggregate travel behaviour from analyses of cross-sectional data had not yet been reconciled with the variations shown over time. Godard (1978) found differences of about 10% in the travel time of people in a given city over time, rejecting the hypothesis of constancy.

2.5. Time period

The importance of seasonal variation is emphasized by Gunn (1981), showing that travel expenditure in the first and fourth quarters of a year to be lower compared to the second and third quarters. Therefore time spent on travel probably also varies with the season. He showed too that a variation existed between the days of the week and concluded that an indicative variation existed of ±10% for both seasonality and day-of-week variation. Variation with respect to the day of the week is related to the fact that people plan travel patterns for the whole week. For this reason variability is less for an entire week's travel than for a single day's (Goodwin, 1975). Prendergast and Williams (1981), however, concluded that variations at the sample level in the time spent travelling on different days of the week hardly differs. Goodwin (1981) stated that proper evidence on the stability of travel budgets could only be properly assessed with data for at least a week, and possibly longer.

2.6. Disaggregation between population groups and areas

Gunn (1981) focused on differences between population groups, such as socio-economic characteristics, age, sex and 'stage in the family cycle'. He found age, income level and employment status to emerge as the most important categorisations, all producing ranges of about 20–25 min travel per day. Interactions between variables do exist. He also concluded that the effects of location were much smaller than the effects of personal or household characteristics. Besides, there is no justification for a categorisation into car ownership groups after allowance has been made for the other effects. Prendergast and Williams (1981) also concluded that significant differences exist in average travel time if a breakdown between population groups is made. Roth and Zahavi (1981) presented results for travel in developing countries and concluded that income, household size, vehicle availability, sex, age and occupation were related to travel time per person. Differences in tastes and preferences also occurred within household groups. Schwanen et al. (2002) found that gender, the number of workers in the household, age and education level have a significant impact on travel time.

One of the discussions with respect to the aggregation level refers to a possible difference between area types. Referring to Tanner (1979), Goodwin (1975) and Gunn (1981) concluded that travel times are slightly longer in areas with high residential densities, whereas this trend is reversed for money expenditure. The generalised travel expenditures for people in areas of different residential density are approximately equal. Van der Hoorn (1979) concluded higher travel times for people in larger cities in the Netherlands than for those in smaller ones. Based on empirical results, Downes and Morell (1981) also concluded that after correction for other variables, location, measured as the distance to the town centre, was found to have little effect on average travel time. Landrock (1981) found that travel time does not systematically vary with the population size of a city and with ward population density, except for higher travel times in neighbourhoods with a low population density in large cities. Schwanen (2003) found that car commute times are higher in most polycentric systems compared to monocentric systems. In addition, car commute times tend to increase with higher residential densities and with the size of daily urban systems.

2.7. Modes, motives and the selection of the population with respect to age

With respect to modes and purpose of the trip, the general conclusion is that assuming that behavioural factors tend to lead to stability in travel expenditure rates, these factors should apply to all modes and purposes combined (Kirby, 1981). Excluding modes may also cause problems with respect to modelling (Gunn, 1981). Gunn concluded that walking and cycling trips accounted for approximately 50% of all travel time in the UK, showing the importance of including these trips. However, due to data availability problems, Roth and Zahavi (1981) had limited their analyses for developing countries to motorised transport only. Goodwin (1981) concluded that mean travel time varies less when all modes, including walking and excluding non-travellers, are added up. He concluded that walking made up some 30–40% of the total time spent travelling. Finally, there is the question of the minimum age to include in surveys. Godard (1978), for example, excluded children under five in his analysis, whereas in many countries such as the Netherlands, data sets exclude children under 12. A non-consistent selection with respect to age may have an impact on cross-sectional comparisons.

2.8. Time budget versus budgets for generalised costs

Several authors have focused on the question of whether it is travel time budgets that are constant, or generalised transport costs (see, for example, Goodwin, 1981; Tanner, 1981). For theoretical reasons, Tanner (1981), for example, preferred to develop a model including generalised transport costs, and not only one for time or money.

2.9. Travel time budgets and activities

As part of a literature review, Mokhtarian and Chen (2004) emphasised the importance of activity-related characteristics. Travel time may be related to the duration of the activity, the time spent on activities other than travel and a history of dependence, referring to the effect of past history on the current decision. Hamed and Mannering (1993) and Kitamura et al. (1997) found travel time from work to the other activity to be positively related to the expected duration at the activity location. Dijst and Vidakovic (2000) concluded that the so-called travel-time ratio (the relationship between travel time for an activity and the time for the activity itself) varied depending on the purpose of the trip. Relatively speaking, people spend less time on travel to and from work than on shopping.

Lu and Pas (1999) and Principio and Pas (1997) found that travel time increased as the amount of time spent on out-of-home activities increased. Ma and Goulias (1998) found that 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. In addition, the more time already spent that day on travel and participation in a previous activity, or the higher the number of activities already carried out on the same day tended to decrease the travel time of the current trip.

2.10. Quality of the data

Several authors have emphasized the possible impact of data quality on the outcomes. Godard (1978) notes that the quality of the data could have affected the results of his study. Zahavi (1979) restricted his work to perceived time rather than actual time. Roth and Zahavi (1981) also reflected on the poor quality and reliability of the data of their analyses. Further discussions on the relevance of data quality can be found in Zahavi (1979) and Mokhtarian and Chen (2004).

3. An overview and analysis of Dutch data

There are two data sources in the Netherlands that investigate trends in time use for transport: The National Travel Survey (OVG) and the Time Use Survey (TBO).

The OVG is a cross-sectional survey which has been conducted every year since 1978 by Statistics Netherlands (CBS). The sampling unit is the household. Sample size increased from 10,000 in the 1978–1995 period to 60,000 households from 1995 onwards. Data on travel are collected using travel diaries. The design of this survey was changed in 1985 and 1995, implying that over a longer period trends would be subject to breaches. This is a serious limitation, which can only be partially corrected. A new design was also introduced in 1999 so data from 1999 onwards are excluded from this study. The data set aims to provide a representative picture of the mobility of the Dutch population over the age of 12 years.

Fig. 1 shows the developments in time spent per day on travel for persons over 12.

The figure shows a trend breach for 1984/1985. The data used for the figure was analysed using trend regressions with a dummy variable for the period after 1984. In addition, trends for total trip making as well as for trip distances were analysed. Table 1 shows the results.

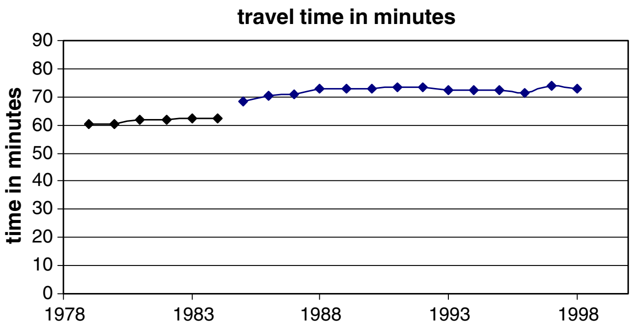

Fig. 1. Average time spent on travel per person per day. *Source:* CBS, National Travel Survey (OVG, various years).

The regressions have trend coefficients which differ significantly from zero. This implies that for all three trip making indicators positive trends could be established.

The coefficients were used to estimate expected trip indicators for 1979 and 1998, corrected for the trend breach effect. The results are displayed in Table 2.

Results indicate that the time used for travel between 1979 and 1998 did indeed increase by 7%. The mobility indicators trips and distances travelled revealed increases as well. The trends for the total number of trips between 1979 and 1999 revealed an increase of 6% in the number of trips. The trend for the number of kilometres in that period represents an increase of 31%. Hence, all travel indicators for the aggregate Dutch population over 12 years old reveal positive trends over the survey period. We have not tested differences between population segments.

To conclude, the OVG shows a small but significant increase in the average travel time per person and an almost equally strong increase in the number of trips per person.

Another data source is the Time Use Survey (data collected by the Netherlands Social and Cultural Planning Office–SCP), which presents a picture of the use of time in the Netherlands. The survey started in 1975 and has been repeated every 5 years. About 3000 respondents keep a weekly diary in which they report their actions/movements. This survey's methodology and questions are not comparable with OVG's, hence the results for the use of time for travel may be different. Specifically, time use is measured in 15-min intervals, so respondents will not register short trips. Table 3 shows the results.

According to the Time Use Survey travel time increased by about 15 min per day between 1975 and 2000. This is an increase of about 26% from 1975 to 2000. Between 1985 and 2000 this increase was 17%, which is almost double the increase in the number of trips (9%). To conclude, contrary to the OVG, according to the TBO the increase in travel time is much greater than the increase in the number of trips. The increase in the number of trips in the OVG is smaller than in the TBO, leading to the conclusion that if the data for TBO is correct, the increase in average time per trip is even bigger.

The difference between the outcomes for travel time per person of the two data sources (an increase of 7% versus 26%) can be partly explained by the shorter time period that the OVG covers (8% for 20 years implies about 10% for 25 years assuming a constant trend). Another explanation is that if the total travel time per day were to increase, it would not necessarily be shown in the same way in both data sets, as it would depend on the nature of the additional travel. If, for example, the time used for short trips tends to increase (from less than 15 min to more than 15 min, for example) it will probably be more visible in the time use data than in the travel survey data. The reason is that when short trips take clearly less than 15 min they will remain under-reported in the time use data. An increase in the travel time for all trips would imply a decreasing probability of under-reporting short trips in the Time Use Survey. This would lead to a more than proportional increase in the total reported travel time. For a further discussion of travel time data issues, see Rietveld (2002).

Both data sets have specific characteristics that may limit the validity of the conclusions. The Time Use

Table 2
Expected trip making indicators for 1979 and 1998 using the trend regression coefficients

	Predicted 1979	Predicted 1998	Change (%)
Time	60.95	65.39	7
Trips	3.23	3.43	6
Distances	26.57	34.93	31

Table 3
Time use for travel from the Dutch Time Use Survey (per person per week per day)

	1975	1980	1985	1990	1995	2000
Hours per week	6.6	6.8	7.1	7.9	8.5	8.4
Minutes per day	56.6	58.3	60.9	67.7	72.8	72.0

Source: SCP, Time Use Survey (TBO) (various years).

Table 1
Regression coefficients for time series regressions of trip making variables for 1979–1998

Travel indicator	Intercept (*t*-value)	Trend (1979 = 1)	Dummy after 1985	R^2
Time (min)	60.71 (123.99)	0.234 (3.85)	8.27 (9.77)	0.95
Trips (no)	3.11 (86.50)	0.01 (2.34)	0.267 (4.30)	0.86
Distances (km)	26.13 (81.66)	0.44 (10.01)	3.81 (6.90)	0.96

Survey data, for example, under-reports short trips. In addition, reporting and non-response errors may be present. These errors are hypothesised to have limited effects since the design of the survey did not change over the research period. OVG, on the other hand, showed a major breach in 1985, which is taken into account by performing regressions as presented before. In addition, reporting and non-response errors may not be constant in the period before and after the change in the design.

In a recent study Harms (2003) presents a detailed comparison between OVG and TBO. This analysis showed that it was not possible to explain the differences in numbers between OVG and TBO to such an extent that the differences in outcomes could be fully explained. It was concluded however that the trends were similar enough to conclude that travel indicators increase over time. His conclusion matches ours.[1]

We conclude that although the two sources differ in terms of the magnitude of the increase in travel time, they are in agreement about the fact that travel time has increased in the last few decades. This suggests that the time budgets within the population are not constant, but increase over a longer time period. Moreover, since both types of data reveal trends in the same direction, we feel confident enough to draw conclusions about the increase but not about the exact level of this increase. On the other hand, it is unclear whether the conclusion based on the OVG data is accurate, that the increase in the number of trips almost equals the increase in travel time, especially since the TBO survey suggests a much stronger trend in the total time travelled per person. We suggest that the average time spent per trip also increased and that the overall increase in travel time per person cannot be explained by the increase in trips. Therefore, in Section 5 we present trends that have both a positive impact on the number of trips as well as resulting in an increase in the average travel time per trip.

4. Theoretical explanations for constant travel time budgets

We now continue by focusing on explanations for the likely increase in the average travel time in the past decades as found in the literature.

Based on an extensive literature review, including sources from economics, psychology, biology, sociology and other disciplines, Peters et al. (2001) presented three categories of explanations for constant travel time budgets.

4.1. Reductionistic explanations

Reductionistic approaches use more or less absolute explanations for human behaviour and related constant travel time budgets. Examples can be found in biology, zoology, socio-biology, experimental psychology and evolutionary psychology. For example, evolutionary psychology assumes that most human behaviour is genetically determined. This genetic background may also explain travel behaviour. The genetic structure results from a long evolutionary development. The explanations for constant travel time budgets can be found in a homeostatic regulatory system, in a need for a minimum level of exercise to stimulate muscles, and in a complex system of hormones related to the costs of travel (discomfort, stress, energy use) as well as the benefits (the access to destinations, the pleasure of cycling, driving a car or travelling by train) and to biological clocks.

4.2. Reconstructive explanations

Reconstructive approaches explain human behaviour mathematically (quantitative models) on the basis of theoretical pre-assumptions about behaviour. Examples can be found in disciplines that describe human behaviour in terms of utility (as can be found in economics, psychology and geography). The assumption is that human behaviour results from economic or rational behaviour: it is the result of choices between different options. Explanations result from an optimal balance between time for activities and related travel (Dijst, 1995; Bhat and Koppelman, 1999) and from the marginal disutility of extra travel time or additional trips compared to the marginal benefits of related activities (e.g. a job at a longer distance from home might increase the utility of working). Economics is an example of a reconstructive approach. It is well known that with a simple Cobb–Douglas utility function and a constraint for time use one can easily arrive at constant shares for the time budget implying a constant daily travel time. However, this is a rather implausible model. The point is that not only time constraints play a role, but also income constraints, and as Golob et al. (1981) have pointed out, in such a case it is impossible to arrive at constant travel time budgets. A recent study along this line is Kockelman (2001) who finds that neither from a theoretical perspective, nor from an empirical one is travel time constant for an individual.

4.3. Contextualising explanations

These approaches explain human behaviour from a historical, cultural, socio-psychological, social or geo-

[1] Note that trends as presented in this paper differ to some extent from the ones used in Harms (2003) because Harms used uncorrected travel time data, whereas we corrected for rounding errors in short trips. It is beyond the scope of this paper to fully explain the methodological differences. However, it should be noted that both trends imply significant increases for the average time use for travel per person.

graphical perspective. Using these strategies does not allow us to explain a constant travel time by individual behaviour. It is the context in which an individual functions that explains travel behaviour. Evolutionary learning processes might explain constancy or changes in travel time budgets.

These three approaches should be seen as different explanations that can be distinguished, but there is not always a sharp distinction between the approaches. For example, the geographical perspective might focus on regional changes in the housing or labour markets having impacts on large groups that can be explained by contextualising explanations. Apart from the overall impact on large groups, the impact of these changes on travel time expenditure might also be explained at an individual level using the reconstructive approach. To conclude, the effects of some changes in society on travel time expenditure might not be fully explained by one approach exclusively.

4.4. Usefulness of explanations

In our opinion the first type of explanation, the reductionistic one, gives few opportunities to explain the possible increase in travel time: the increase is in conflict with these explanations. In addition, Goudappel (2001) shows that individuals who travel more than average on week-days, also travel more at the weekend when leisure purposes are common. This implies, therefore, that individuals can be identified as relatively mobile or less mobile persons. The amount of time spent on travel is related to an individual's characteristics and attitudes towards mobility. These differences remain constant over time. In principle, the third category—contextualising explanations—might be helpful in explaining an increase in travel times, but during the 1975–2000 period changes in our society were too limited for this to explain the increase in travel time. In addition, Goudappel (2001) shows that over the 1985–1995 period the amount of travel time needed per unit of time to participate in activities increased as well. Therefore, the reconstruction strategies are the most helpful for explaining the increase in average travel time: the increase might result from (a) an increase in benefits of travel, (b) a decrease in costs, or (c) a change in the composition of the population, e.g. with respect to age and income. We will discuss these three categories of explanations in the next section.

5. Possible causes for an increase in average travel time

In this section we present *possible* causes for the increase in travel times. Further research is needed to find out if these causes really play a role (see Section 6). After presenting the possible causes, Section 5.4 presents a simple model to visualise the impact of changes in costs and utility on average travel time and links the causes as presented below to this model.

5.1. A possible increase in the utility of travel

According to the reconstructive explanations, an increase in the utility of travel results—ceteris paribus—in an increase in travel times. Possible reasons for this utility increase are presented below. Because we used data for the Netherlands to show the increase in average travel time, we also used the trends that have occurred in the Netherlands that could explain this increase. However, most—if not all—the trends also occurred in many other Western countries, implying that the geographical scope of the discussion is broader than just the Netherlands.

5.1.1. Spatial trends

The utility of extra travel time might have increased due to spatial trends. Relevant trends are increases in the scale at which services are available. In health care and hospitals, for example, the number of services has decreased and the average size of the remaining services has increased (SCP, 1996). Therefore people need to travel more to reach/obtain the same service. The location of jobs related to employees has also changed, as recently-developed employment areas are quite often located on the outskirts of town. Cities and towns have increased in size, resulting in larger distances between new residential areas and town centres. Therefore, for the same utility, people often have to travel over longer distances and spend more time on travel. This trend is an incentive to travel longer rather than to travel more often.

5.1.2. Specialisation in the labour market and in employees' skills

The labour market is becoming more and more specialised. The same holds for employees. The educational level of employees has increased as well as the levels of specialised education and training required for many jobs. These trends imply that nowadays a person has to consider a much larger area when job-seeking than several decades ago. Again, the utility of travelling longer distances increases, as seen, for example, in Rietveld and van Woudenberg (2003). This trend is also mainly an incentive to travel longer rather than to travel more often.

5.1.3. Segmentation in the housing market

Higher income levels have raised people's aspirations with respect to housing (dwellings and the residential surroundings). Preferences have probably become more specific ('a pre-war house in a nice, green environment that is attractive for children'), thereby possibly increasing the household search area. This process can be further stimulated by the decreased level of social relationships at the neighbourhood or village level. The chance of people finding an attractive dwelling close to their job location has decreased, a trend that may be further strengthened by the relatively homogeneous way in which residential areas have been designed in post-war Netherlands. The increased search area for dwellings may also have increased travel times to locations of jobs, relatives, friends, etc. Again, this trend is mainly an incentive to travel longer rather than to travel more often.

5.1.4. A diversification of leisure activities

People tend to participate in more leisure activities but within the same time period. The general wish for more diversification in leisure explains this trend, but there is also the desire to participate in more expensive leisure activities, made possible by increased incomes (Batenburg and Knulst, 1993). This trend results in increased leisure-related travel time. This trend mainly is an incentive to travel more often within the same time budget, resulting in an increase in the number of trips and a reduction in the average time spent on trips.

5.1.5. Travel for fun

People travel partly for the fun of it (Mokhtarian and Salomon, 1999, 2001). Research shows the time spent on fun travel to be increasing, whether by Sunday bike, motorcycle or car (Batenburg and Knulst, 1993). This trend also probably increases the number of short trips, since the need to travel for the fun of it might be satisfied by not travelling for too long. An indication for this might be the afore-mentioned optimal commuting time of 16 min. Most people dislike longer trips.

5.1.6. Increasing labour participation of women

Traditionally the labour participation of women in the Netherlands has been quite low for a western country, e.g. in 1990 only 39% of all women had a job. Since then this percentage has rapidly increased, to 43.5% in 1995 and 51% in 1999. This value is comparable with the surrounding countries, but still lower than in the Scandinavian countries, the UK and the US. However, a higher share of working women in the Netherlands work part-time (Sofokles, 2000). The long-term trend is even more striking: between 1971 and 2003 labour participation of women aged 25–64 increased from 21% to 61% (SCP, 2004). Working women in double-earner households have much shorter travel distances than average. This is related to the fact that they work part-time and often want to be close to home and school, because of their children (Rouwendal and Rietveld, 1994). This leads us to believe that this trend mainly has an impact on the number of trips, that the share of short trips increases due to this trend.

5.1.7. Other economic developments

Like most countries, the Netherlands has become a service society. The transition from an agricultural and industrial community into a service society has resulted in an increasing need for face-to-face contact and possibly an increase in business travel. Only some of these needs can be fulfilled by ICT. In addition, the increasing trend for *outsourcing* of non-core business will probably result in the spatial separation of core activities and suppliers, and therefore in an increase in related mobility. The result might be both an increase in the number of trips as well as in total travel time.

5.2. The changing costs of travel

The second category of possible explanations for the increase of average travel time might be the changing costs of travel. In this section we will present explanations of this type.

5.2.1. The increase in the share of car kilometres on motorways

The motorway is relatively safe and comfortable. In the Netherlands the chance per kilometre of getting killed in a road accident on a motorway is only between 33% and 11% of the chance of getting killed on other categories of roads outside the built-up area (Koornstra, 1998). The share of car kilometres in the motorway network has increased during the past decades at the expense of the share of kilometres in the built-up area (CBS, 2001). The impact on the average travel time per person per day is difficult to predict because it has two effects, each with a different sign. On the one hand, generalised transport costs per km will have decreased due to the higher safety and comfort level, resulting in more travel. On the other, generalised transport costs *per hour* have increased because the speed on a motorway is much higher than average, resulting in an increase in monetary costs per hour of travel. It is also difficult to draw conclusions on the impact on the number of trips. A small increase due to the decrease in generalised transport costs is possible.

5.2.2. A reduction in the improvements of the road network

Over the past two decades, the improvements in the road network in many countries such as Great Britain, have been limited compared to previous decades (V&W, 1999a; CEMT, 1999). We not only refer to new motorways and other major roads outside the built-up areas but also to major roads within the built-up areas. However, car use and ownership has continued to increase during the past decades. In addition, travelling longer distances has probably also increased for several reasons, as presented above. The improvements in road infrastructure have not been able to cope with the increased level of car use, with a resulting rise in congestion (see CEMT, 1999). For certain combinations of origins and destinations, travel times have probably increased. Travel times increase slowly and rather smoothly, so people might get used to the increases, accept them and do not therefore consider changing jobs, residential locations or destinations. The main impact, therefore, is probably an increase in travel times, not in the number of trips.

This trend in increased travel times for certain combinations and destinations seems to conflict with the overall increase in the speed of travel on the road network, but in reality it does not. Despite the increase in congestion, the speed on the motorways is still much higher than on other roads. In the Netherlands, time loss due to congestion is yearly about 10% of total travel time on the main roads. This means that—assuming an average travelling speed of 100 km/h without congestion—the average travel speed including congestion is 90 km/h which is still much higher than the average for all roads. Therefore the increase in the share of kilometres on the main road network has resulted in an increase in the average speed for all car kilometres on the whole road network, despite the sharp increase in congestion in the past two decades (Van Wee and van den Brink, 1999).

5.2.3. The role of the bicycle

The bicycle's share decreases rapidly for distances longer than 5 km and certainly 10 km. For example, only a few people cycle to work if the home-to-work distance is more than 10 km. The disutility of cycling probably increases more than proportionally for longer distances, which might be explained by physiological factors. Given the trend towards longer distances and the increased level of car ownership, more people can reach further destinations by changing their modal choice from bicycle to car. But once they use the car, the more than proportional disutility after 5–10 km no longer exists, or exists but to a lesser extent. This is especially true for longer car distances, when the share of kilometres on the relatively comfortable and safe motorway increases. The overall effect may be a moderate disutility of longer travel times. We do not expect a significant impact on the number of trips.

5.2.4. The increased comfort level of cars

Nowadays cars are much more comfortable than some decades ago. Bennis et al. (1991) developed a quality index for cars. Between 1962 and 1990 the index for 'comparable cars' increased by 30%, which resulted in a decrease in the disutility of car travel. Besides, many people consider travelling by car to be more comfortable than travelling by public transport or bicycle. The increased level of car ownership makes comfortable travel by car available to more people. Besides, cars have become much safer, also leading to a decrease in the disutility of travel (see also below). Finally, the reliability of cars has improved, making them more attractive. In short, the better quality of cars has resulted in a decrease in their disutility. This trend might result in longer travel times for those who already used the car, due to the decrease in generalised transport costs. For those who switch modes, e.g. from bicycle to car, the impact on travel times is more difficult to establish. If this trend has an effect on the number of trips it is probably positive, due to the decreased generalised transport costs: the decrease in travel time and discomfort might more than compensate for the increase in monetary costs because using a car is more expensive than using a bicycle.

5.2.5. Improved road safety

The risk of getting killed in a road accident has decreased rapidly. Despite the current increase in mobility, the number of people killed in road traffic is only one-third of the level in the early 1970s (CBS, 1995). This is not only caused by the increased safety of cars, as mentioned before, but also by improvements in road infrastructure and health care (including the time an ambulance needs to reach the location of a road accident and to return to a hospital). Safer travel means a lower travel disutility. We expect both the number of trips and the travel time to be positively influenced by this trend.

5.2.6. Increased possibilities for combining travel with other activities

The possibility of combining travel with other activities has increased. For example, one can work in a train with a portable computer (laptop). People can also make phone calls in trains and cars using cell phones. The increased possibility of combining travel with other activities has resulted in a decreased disutility in travel time. Besides, because now people can phone in case of unexpected delays and let other people know about their delay, the disutility related to a low level of reliability of travel times may also be reduced. The reliability of travel times seems to be an important issue and recently received attention in transport literature (see, for example, Bates et al., 2001; Lam and Small, 2001). The result will very likely be an increase in travel time rather than in the number of trips.

5.3. Changes in the population

5.3.1. Changes in the share of 'homogeneous groups of people'

Average travel time will not be the same for 'homogeneous' (e.g. similar age, income and household) groups of people, so that a change in the breakdown of population may lead to a change in the average time spent on travel. Goudappel (2001) applied a breakdown of the population with respect to one variable (gender, age, household structure, number of cars in the household, education, employment situation and urbanisation) using TBO data. The results show that the increase in travel time for each disaggregated group is more or less the same as for the whole population. Theoretically it is possible that a breakdown based on more than one variable will give other results, but this is not very likely. Our tentative conclusion is that changes in the population with respect to variables such as age and education do not explain the increase in average travel times of the whole Dutch population.

5.3.2. More people combining different tasks

Another change that may be relevant with respect to the population is an increase in the proportion of people combining such tasks as taking care of the children and working. As Section 5.1 has shown, the labour participation of women has increased greatly in the past decades. This trend also has an impact on the share of people combining tasks since many of these women have children and a partner who works, often full-time. It is possible that the increase in the share of people combining tasks leads to an increase in average travel time. However, research by Batenburg and Knulst (1993) shows that this increase did not significantly contribute to the increase in average travel time. However, it is very likely that this trend has increased the number of trips. And because travel time is not affected by this trend, it might have reduced the travel time per trip.

5.3.3. A decrease in household size

The average household size has decreased since the 1960s. This decrease may have led to an increase in mobility because the time needed per person for household-related tasks, such as shopping, increases (Batenburg and Knulst, 1993). Because many of these trips are relatively short (both in time and distance), the impact on the number of trips is probably bigger than on travel time.

5.4. An analysis of changes in costs and utility

The impact of changes in costs and utility on average travel time as discussed in Sections 5.1–5.3 can be visualised in a simple model. In this section we first present the model and then continue by linking the trends discussed in the previous sections to this model.

The model shows the choices of persons when there are changes in costs and utility of travel on the one hand, and the resulting travel time on the other. We assume that a person can choose from three modes: walking, cycling and driving (a car) and then start the model by analysing the costs. Fig. 2 illustrates the travel times for trips for each mode.

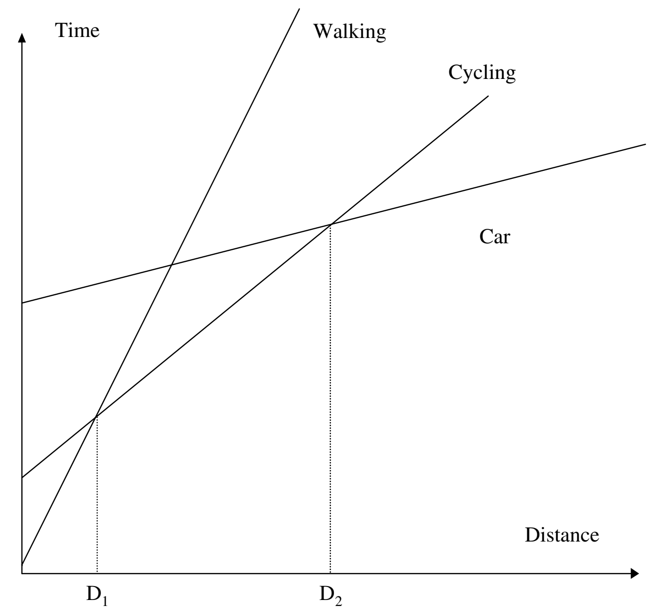

Fig. 2. Travel times per mode and the linear relationship between travel distance and travel time.

Firstly, we assume constant speeds compared to distance. Because using a car means walking from one's home to the car (parking place), getting into it and starting it, the car is less attractive for very short distances. The same holds for the bicycle, but to a lesser extent. However, in practice, travel speeds are not constant. For people walking or cycling, the average speed will decrease as distance increases because they need time to rest. For the car, average speed will increase because the share of the motorway increases as distance increases. Note that only during very long trips (after a few hours) does a car driver have to rest. We have not assumed rest stops for car users in this article. Fig. 3 illustrates the travel times.

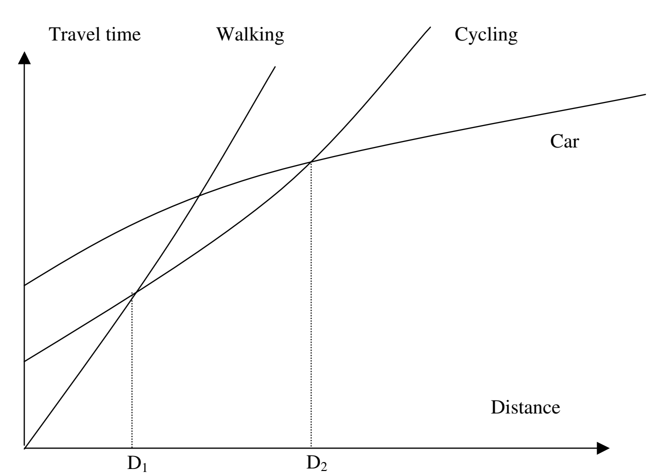

Fig. 3. Travel times per mode assuming non-constant speeds.

If the person's choice was only to be based on distance, the market areas per mode would be defined by D_1 and D_2.

Generalised transport costs not only depend on travel time and the valuation of it. The car is more comfortable than the bicycle, especially in bad weather and for longer trips. Many people like cycling for a short period, e.g. 10 min, but not for one hour. Social and physical safety also has an impact on generalised transport costs just as monetary costs do (e.g. fuel and parking costs, and toll). Fig. 4 illustrates the possible level of generalised transport costs as a function of travel for different travel times. It is clear that the areas for each mode, as defined by E_1 and E_2, will differ from the areas defined by D_1 and D_2, as presented in Fig. 3. The result is that an increase in distance does not necessarily result in an increase in travel time. To illustrate this we assume the shift from bicycle to car. Based on only travel time, this shift may occur at a distance of—for example—3 km. A person who dislikes cycling may switch at 1.5 km, while someone who likes cycling will switch only at 5 km. In other words: if the distance increases from 4.5 to 5.5 km the latter will switch from bike to car. Although the distance increases, travel time decreases. This example shows that discontinuities might occur: for example, longer distances can be combined with shorter travel times. The more generalised transport costs are dominated by travel time to lower this effect. Note that this effect only occurs due to a shift in modes. (We do not consider a decrease in car travel time here as a result of a change in the route after an increase in distance, for example, due to choosing the relatively fast motorway for longer trips.)

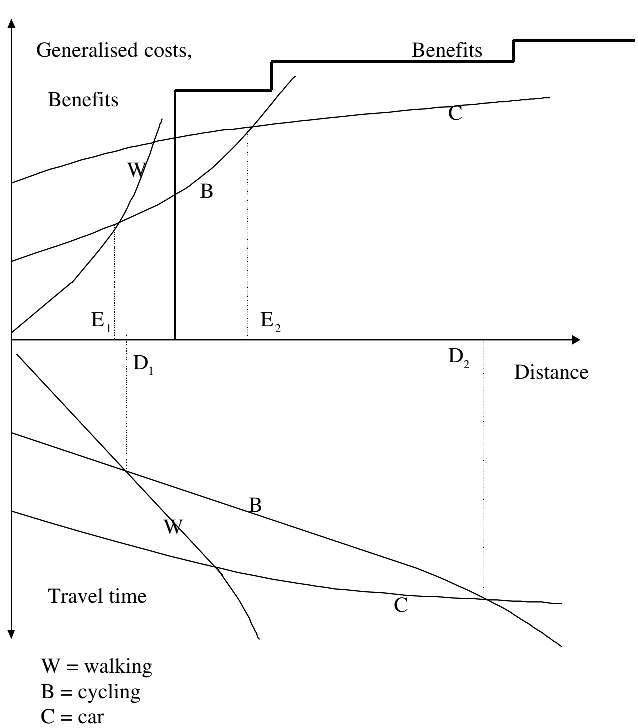

Fig. 4. Generalised costs, benefits and travel time per mode, by distance.

A change of mode may also result in an increase in travel time. Consider an individual who dislikes cycling. An increase of travel distance from 1.4 to 1.6 km results in a shift from bicycle to car and to an increase in travel time. The same often occurs if a person shifts from car to public transport.

Not only costs, but also benefits play a role. Let us assume the trip to a shop for daily needs. Consider a person who lives within cycling distance from an average quality shop and more remote with respect to higher quality shops. The line showing the benefits is the step line, as presented in Fig. 4. Note that shops of lower quality at longer distances are not relevant and therefore excluded from Fig. 4. The curve of benefits can be found by sorting shops by distance and then excluding shops of lower or equal quality compared to shops which are closer. The preferred shop is the one with the largest difference in costs and benefits. The utility of visiting this shop is expressed as the vertical difference between both the cost and the benefit curves. In the case of Fig. 4, it is the shop that is accessible by bike. For all possible locations, the costs may well exceed the benefits, in which case the person will not make the trip. It is clear that the form of the benefits curve will depend on specific circumstances: the location of the household and the location of services in the surroundings. Nevertheless, the model can be used in qualitative terms to demonstrate the effects of changes in benefits and costs on travel times. The above discussion took place in terms of travel distance for a given trip purpose. It did not address the theme of determining the average number of trips per day. This may obviously also be an important determinant of change in daily travel time. However, it is not difficult to see that the same framework can be used to analyse the trade-off between staying at home and making a trip. The point is that staying at home can be considered as a base-line alternative, with a certain utility level that has to be compared with the net benefit of making a trip of a certain distance as can be inferred from Fig. 4. A trip is only made when the net benefit of a trip is higher than the utility of staying at home. Thus, changes in the costs and benefits of trips do not only lead to changes in the distance of trips, but also to probabilities that trips of a certain type are made at all. An additional point is of course that probabilities that trips are made are also determined by the baseline utility of staying at home. This may change for example due to socio-cultural developments such as the trend for women to work. Since opportunities for working from home are still limited such a trend would imply an increase in the probability to make commuting trips, hence increasing the average trip frequency. We conclude therefore that the analytical framework adopted in this simple model not only allows the analysis of trip distances, but also of trip frequencies, and hence of daily travel time.

We now continue by linking the trends as presented in Section 5 to this model.

Spatial trends, such as increases in the scale of services, imply that nearby services have disappeared. The supply curve only becomes positive at longer distances. It is clear that this will result in longer trips (outside the rare exceptions due to longer travel times after switching modes) and longer travel times. *Specialisation on the labour market and of the skills of employees* also leads to a decrease of opportunities at shorter distances. The curve of benefits will shift to the right. The same holds for the *segmentation in the housing market*. The developments with respect to leisure and the trends in the economy (transition to services, more outsourcing) result in the same pattern: an increase in the utility of travel and therefore an increase in travel time. The increase in travel time due to the increase in travel-for-fun as well as the increase in labour participation of women are evident.

Factors related to the costs, as presented in Section 5.2, the role of the bicycle, the increased comfort level and safety of cars, and the increased possibilities for combining travel with other activities will result in lower costs. The reduction in generalised transport costs increases the chance that people will choose more remote opportunities. Besides, trips with higher costs than benefits (for all opportunities and related distances) will not be made without the reduction of generalised transport costs. However, due to the decrease in these costs, benefits could exceed the costs, resulting in more trips and therefore more time for travel.

We conclude that the model presented in Fig. 4 offers possibilities to analyse changes in the costs and benefits of trips, and in the resulting travel time.

An important trend deserving more attention is the increase in incomes. This trend has a complex impact on Fig. 4. Firstly, an increase in income leads to an increase in car ownership and car use, making longer trips relatively more attractive. These longer trips do not necessarily result in more travel time because, generally speaking, the car is faster than the bicycle or public transport. On the other hand, people with higher incomes attach higher value to time (Gunn, 2001). On average they also have more expensive cars, resulting in higher monetary costs. Higher incomes therefore have an upward effect on the cost curve. This upward effect is not the same for all distances.

On average the optimal travel distance, and so travel time, will decrease due to the increase in generalised transport costs. On the other hand, the benefits of opportunities will also vary with income. People with higher incomes will be prepared to pay more for the same opportunities. Therefore not only will the cost curve show an upward trend due to higher incomes, but so will the benefit curve. It is difficult to say beforehand what the impact on the optimal travel time and distance will be. For situations where the benefits increase more than the generalised transport costs, an increase in travel times will be the result. In the opposite case a decrease will occur. Here is an example of the first possibility. Assume that the value of time increases proportionally to income and monetary costs increase less than proportionally. In this case the generalised transport costs increase less than proportionally with income. If the preference for variety increases proportionally with income, the benefit curve will increase more than the curve of the generalised transport costs. Longer travel distances will result and very likely also longer travel times. It is also relevant that cars are more comfortable as incomes rise, resulting in a lower value for time. People with higher incomes can therefore decrease the disutility of travel and make the increase in the cost curve less by shifting to more comfortable cars. We conclude that the effect of an increase in incomes on travel time will depend on many factors, and can be both positive and negative.

One relevant aspect has been excluded so far. Due to an increase in the utility of travel and the related increase in travel time, time will get scarcer and therefore increase in value. Fig. 4 assumes only separate trips without paying attention to the impact on the time budget for other activities. Including relationships between trips will make final changes in travel times less than Fig. 4 assumes.

6. Discussion and suggestions for further research

The literature 'findings' above suggest the possible increase in travel time to be mainly the result of the increased utility trips in general and of longer trips in particular in terms of travel time, as well as of changes in the transport system. Changes in the population probably play an insignificant role. We suggest that the benefits of more and longer trips have increased in the last few decades and the costs of travel have decreased, the result being an increase in the average travel time of the Dutch population. The overall impact is very likely an increase in the number of trips, but an even bigger increase in the average travel time per person. We also suggest that the following points be considered in future research into travel time budgets.

1. Research into the subjects as discussed in this article, including possible important aspects:
    - Spatial trends,
    - Specialisation on the labour market,
    - The reduction in the speed of improvements in the road network,

- The increase in the comfort and safety level of cars,
- The increase in possibilities of combining travel with other activities,
- The increase in the share that motorways have in travel time and kilometres,
- Changes in the positive utility for travel (travel for the fun of it!).

In addition, we think research into the complex interactions between the trends and their impact on both the number of trips and travel time is recommended.

2. Research into ‘utility based’ indicators for accessibility (e.g. Geurs and Ritsema van Eck, 2001). These indicators pay explicit attention to the utility of travel for the individual. They assume a decreasing marginal utility of additional opportunities. For example, the expected difference between one and two supermarkets within 2 min’ walking distance is larger than the expected difference between 5 and 6 supermarkets at this distance. Using these indicators, it is possible to find out if changes in the land use and the transport system, and in the population or the preferences of the population, will result in changes in the choice of opportunities, travel distances and travel times.
3. Panel data research focusing on the issue of whether people get used to slowly increasing travel times between certain combinations of origins and destinations. Results from psychology assuming that people are less sensitive to gradual but steady changes than to discontinuous changes that are equal in magnitude can be used here. Another subject for panel data research may be changes in lifestyle, leading to the increased utility of visiting new places.
4. Research into the effect of the increase of ICT use on travel behaviour, both with respect to travel time and to changes in activity patterns.
5. Historical research into travel behaviour in the past century and the impact of the factors as described in this article. Along similar lines, cross-national studies will also shed light on the present theme.

Acknowledgement

The authors thank Cees van Goeverden for processing and providing the OVG data, and two anonymous referees for their comments on the draft of this article.

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