

Energy consumption due to personal mobility: The main causes at the household level

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1. SYNOPSIS

The paper illustrates the impact of social economic dynamics on household travel behaviour. Special attention will be paid to time allocation and time - money trade-offs.

2. ABSTRACT

The paper aims to illustrate what will be the likely development of mobility and consequently of direct and indirect energy consumption in Holland. We start with investigating the quality and quantity of the mobility households may be expected to demand in the nineties. This quality and quantity is largely determined by the required levels of domestic care, working and business hours, other external obligations and disposable income. In particular the trade-off between time and money is relevant here. As the value of time increases, mechanization - inter alia implying motorization - seems inevitable. Some options will be put forward that may reduce the need for mechanization or attenuate its impacts. Finally, some pitfalls will be highlighted as regards seemingly 'green' solutions' which (may) turn out to be ineffective or even counter effective in terms of reducing energy demand and/or increasing energy efficiency of the transport sector.

3. INTRODUCTION

In order to benefit from fuel efficiency improvement at the macro demand level it seems necessary to redress travel demand both in terms of mode choice and in terms of volume. However, to achieve this effectively we need a better understanding of social-economic dynamics. Time budget surveys promise to be helpful in this context. The aim of this paper is to illustrate the improvement of explanatory power of traditional economic or engineering-economic approaches through the inclusion of time allocation behaviour and time - money trade-offs. The remainder of this section will briefly introduce the phenomena at hand. The subsequent section (2) will highlight the dynamics by means of time budget data. Next we will link this information with economic and technical consumption analysis in order to illustrate likely developments, in case current trends remain unanswered by policies. The methodological aspects of this line of reasoning will be discussed in section 3, while section 4 is devoted to research and policy prospect in this context.

Economic growth is often identified as the principal force behind the steady increase of mobility, particularly car travel. However, even in comparatively mature economies or during recessions car ownership and car use only stabilize, instead to decrease. Clearly, other phenomena are important as well.

Between 1980 and 1985 every additional household in the Netherlands corresponded on average to 0.6 additional car. Yet, between 1985 and 1990 every additional household meant on average 0.9 car extra. The difference in growth rates can be partly explained by being in a different economic cycle. The difference is also related to underlying social changes at the micro level, which seem hard to revert. Moreover, the absolute levels of the growth rates suggest that in the long run every additional household means on average about 75% probability for an addition to the car stock. The following considerations apply in this context.

The Netherlands still has an increasing population (± 0.1 million annually). Furthermore, average household size decreases. Another aspect is the steady increase of employment among women. Traditionally, few married women were engaged in (full time) paid labour. If employed, the jobs constituted mostly low paid part time occupations (e.g. in a supermarket). However, for various reasons most younger women

tend to continue their job irrespective their household situation, though switching to part-time work often occurs after child birth.

Another interesting feature are the changes among the elderly. On the one hand actual retirement occurs often before the age of 65, while on the other hand life expectancy increases. In addition to this the income of the average pensioner nowadays is much better compared to 15 years ago. Moreover, he (or she) often has a car and is glad to use it for a large variety of social trips. Consequently, the elderly enjoy now a considerable time span of so-called active retirement, including travelling.

As a society wide phenomenon the shift from family oriented to individually oriented activity patterns should be mentioned. Though the underlying emancipatory developments are perhaps particularly manifest among women and elderly, there is also a general tendency to give priority to personal (i.e. individual) development. As a consequence, the diversity of activities and locations of any individual tends to increase, irrespective its household characteristics. In turn this implies a stimulus to more mobility.

The above discussion provided a brief overview of mobility developments in the Netherlands. From an energy point of view this is primarily a concern because of the predominance of the car ¹. Though technical measures play an important role in terms of reducing acidification and improving (local) air quality, energy efficiency of the car stock is improving relatively slowly. Consequently, car travel is getting an increasingly important issue in relation to the CO₂ problem. Secondly, it implies an increasing two way dependence between road traffic and the oil industry. In most European countries the transport system is almost entirely depending on imported oil.

4. EXPLANATION AND DESCRIPTION OF PRINCIPAL STIMULI REGARDING MOBILITY

4.1 An Explanation by means of activity structures and the value of time

Gradually the phenomenon of 'task combining' has become an important feature in many Dutch households (and supposedly in other OECD countries as well). This was already identified in general terms by Knulst and van Beek (1990) and it has been subject of transport oriented analysis in studies of inter alia Batenburg et al (1992) and van Beek et al (1992). To some extent it appeals to the concept of the 'harried leisure class' as described by Linder (1970), though in a more sophisticated way than just being too busy with too much material consumption. Task combining means that an adult has to fulfil at least two principal tasks. For example one combines a job with doing a lot of housework and childcare. The traditional Dutch family with children had a distinct distribution of tasks. The male partner brought in the money from a job while the female partner took care for the children and most domestic tasks. Nowadays female partners prefer to stay employed, because of more or less equal job opportunities compared to men, also in families with children. In practice this means an exchange of domestic and paid working hours between spouses, however with on balance a smaller overall budget for housework.

A lot of adults nowadays live in a single person household, which evidently implies the combination of tasks, though with more degrees of freedom compared to multi-person households (i.e. less obligations and time fixations). Next to more single person households, single parent households have been growing in number. Time budget surveys indicate single parents are very time conscious. Moreover, even in so-called traditional households female spouses showed a tendency to reallocate a part of their time in favour of personal development such as sports, education, etc.

All in all there is a general tendency to save on domestic obligations either to be able to do paid labour and/or to participate in activities outside the home. In other words as the volume of paid time increased and the disutility attributed to the performance of housework tasks seemed to increase, the utility to be derived from time saving devices (i.e. mechanization) increased. From an economist point of view the exchange rate between time and money (i.e. the shadow price of time) changes. This has two reasons. First, the financial budget expands while the free disposable time budget decreases and, second, the average activity pattern shows an increased number of activity switches, consequently the average duration of an activity decreases.

A decrease of average spell length constitutes a potential erosion of productivity (see Winston 1982; Perrels 1992), unless counter measures are taken (e.g. through mechanization) ².

As both paid labour and out of home activities require transport, saving time in this derived activity seems particularly attractive. This is especially relevant if total mileage per individual increases due to more destinations per day. Therefore, motorization as a special form of mechanization will be attractive to more people than ever before. The whole line of reasoning has been summarized in the flow chart below.

4.2 Empirical evidence from time budget surveys

Since 1975 a Time Budget Survey (TBO) has been held every five years. The survey requires one person out of a household to record its activities during 7 consecutive days of a week in October. For every subsequent 15 minute interval the principal activity has to be indicated. Over 100 activities are distinguished, grouped into 10 main categories. In addition to the recording of the activity the location has to be indicated (home, in place of residence, elsewhere). Travelling is distinguished by mode and motive. The latter being based on the 10 main categories (such as: job, housework, education, etc.). The number of respondents varies around 2700. During introductory and conclusive talks many background data (e.g. household size, education level, etc.) are obtained.

The impacts of changes on the labour market are highlighted in figure 2, depicting the change in paid labour time by age group and sex. The ultimate impact in terms of minutes per week has been decomposed into a budget effect and a participation effect. A positive participation effect means that more people of that group are engaged in this activity compared to a previous period. A positive budget effect means that those who participate spend more time to this activity compared to a previous period (e.g. working hours per week increased).

The youngest group shows a decline of paid labour. This can be attributed to the influence of extended education as well as to some extent to the poor labour market opportunities in the beginning of the eighties. The two next age groups together experienced a large increase of paid labour time, as regards women both in terms of participation and in terms of hours per job. One should bear in mind that these are the age groups contributing most to the labour force, so at the macro level even modest changes in participation and/or average working week are important. In the upper age category of the labour force male respondents show a significant decrease in paid labour time. They are the losers in the labour market. In relative terms the progress of elderly women in the labour force is impressive, however in numbers it is quite small.

When a household member starts to work, he or she has to reallocate time in order to perform a job. It is quite remarkable that in this reallocation process relatively few time is taken from leisure activities, while

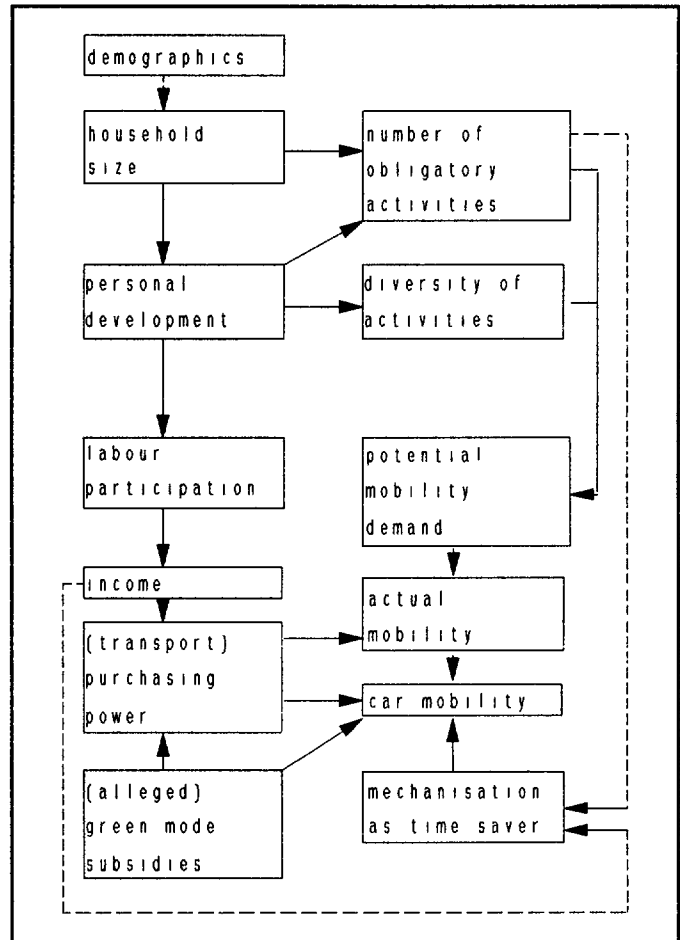


Figure 1. Causal relations between activity patterns and transportation demand

relatively much time is obtained from compressing the time budget for housework. Various estimations indicate for housewives that every extra hour spent to paid labour, 40% to 60% will be taken from the housework time budget, provided the job takes at least 12 hours a week (Perrels, 1992; Grift et al, 1991). The compression of the time budget for housework of working women may be compensated for in four ways, supposing a household intends to maintain its original level of care.

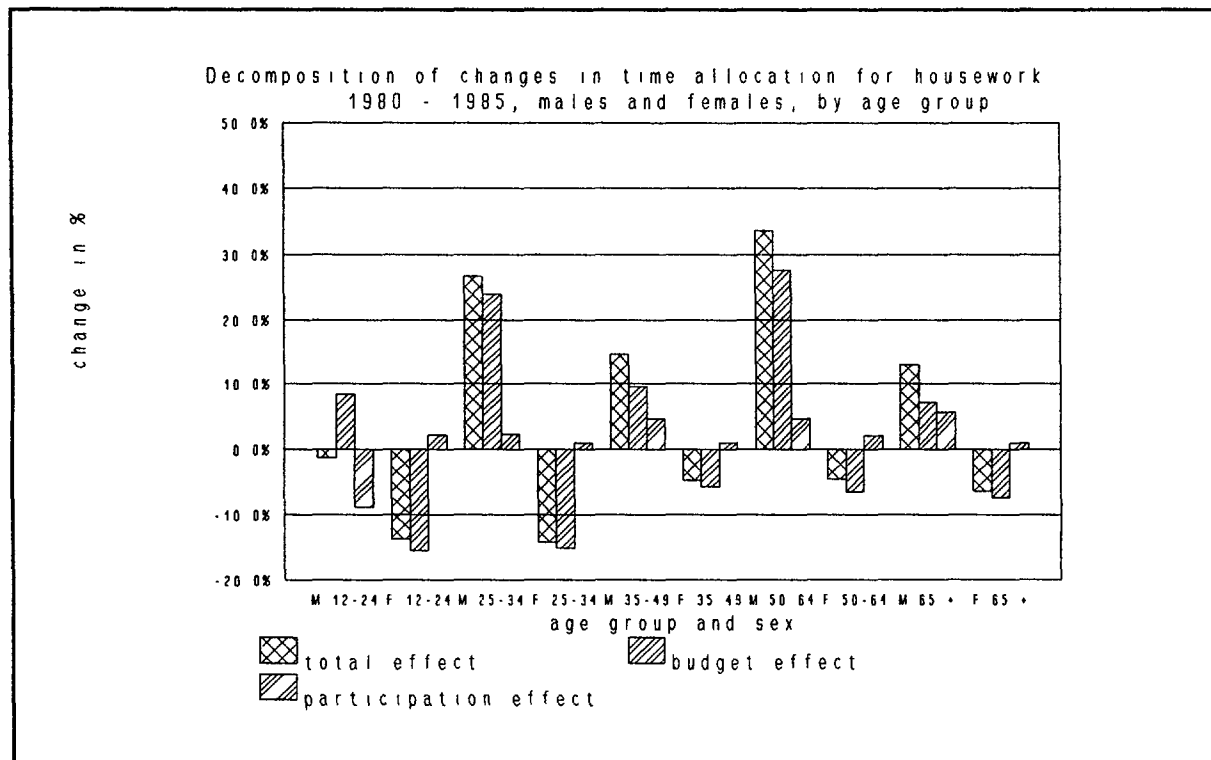


Figure 2. Changes in time allocation for paid labour 1980 - 1985 (Source: TBO80 and TBO85)

- (1) a part of the housework may be taken over by the (male) partner;
- (2) efficiency measures, e.g. cutting 'slack time';
- (3) mechanization (time saving devices);
- (4) buying ready-to-consume products/services on the market (boarding out).

Among others Knulst and Schoonderwoerd (1983) and Perrels (1988) have shown that indeed individuals with more obligations tend to spend less time on meals, personal care, etc., in other words they were cutting on 'slack time' (2).

The importance of exchanging tasks with partners (1) is shown in Figure 3.

It shows a similar analysis as did Figure 2, but now for housework. In several age groups compensatory movements between males and females due to on the one hand increased female labour participation and on the other hand decreased employment of men (especially over the age of 50) can be witnessed. The interpretation of the changes for the categories under the age of 25 is less clear, both extended education and decreased employment had their impacts, though they work out in a different way. After their retirement men always report more involvement in housework tasks. On top of this there seems to be a kind of cohort-effect, newer vintages of retired men appear to be more inclined to do housework.

As regards free time (leisure, sports, meals, etc.) the changes in the overall budget are small compared to the dynamics in housework and paid labour. This experience coincides with the estimated trade-off ratios mentioned above. Of course there are changes within and between the various free time sub-categories. For

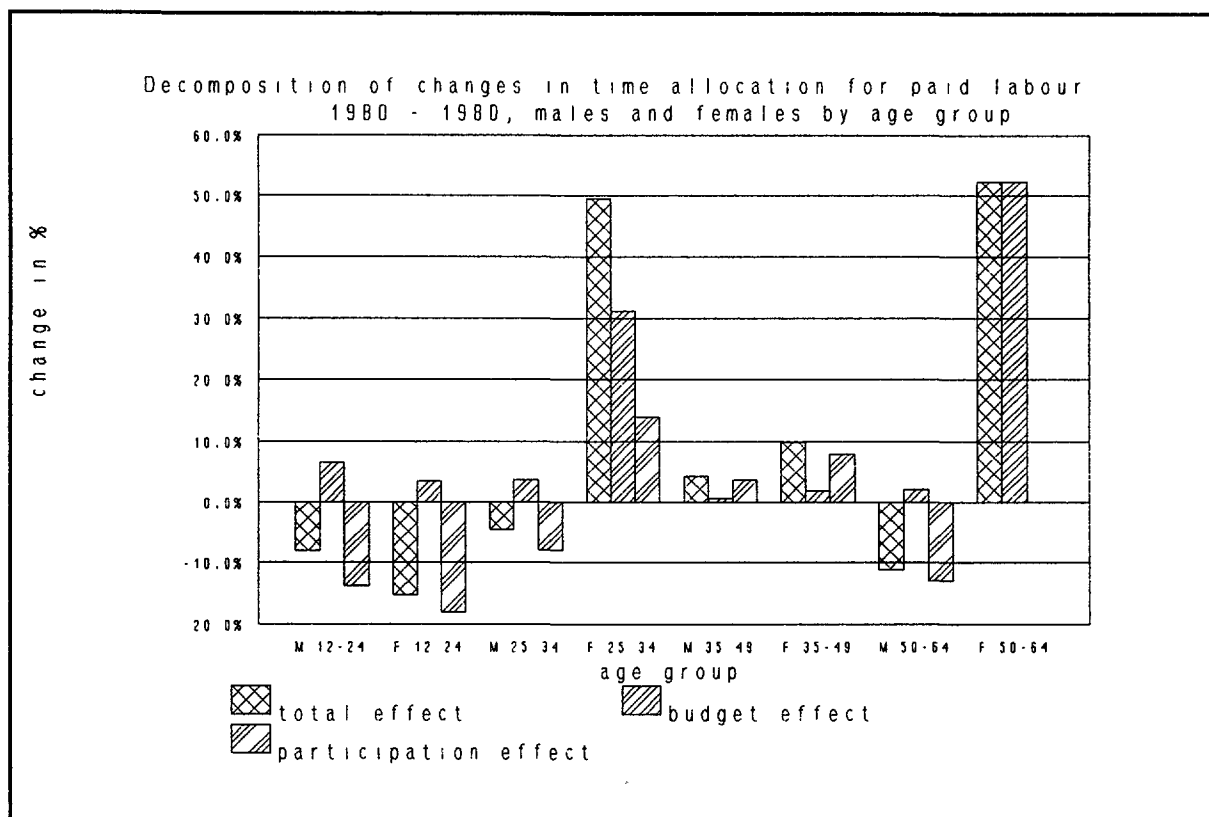


Figure 3. Changes in time allocation for housework 1980 - 1985 (source TBO80 and TBO85)

example, time spent on outdoor recreation increased for virtually all age groups and both sexes.

Evidence concerning mechanization (3) is a complicated matter, as the probability to buy household appliances is related to household size, income, employment of housewife, dwelling type and degree of urbanization (not all these variables are relevant for all appliances). Moreover, a further complication is added by allowing for buying ready-to-consume services (boarding out) (4) as a third alternative. Instead of discussing mechanization in general we will focus directly on impacts of changed activity patterns on mobility, in particular car travel. The Figures 4 and 5 summarize the main developments.

Figure 4 allows a comparison of travel behaviour in 1975 and 1985 for the average respondent of the time budget surveys. Total travel time per week for all modes together (car+bike+transit) increased from about 370 minutes per week to about 410 minutes per week (+11%). Ignoring a possible small impact from congestion, average travel time per mode may be translated in mileage. Given this assumption virtually the entire increase in mobility is concentrated in the use of cars. Public transit seemed even to loose slightly.

If we take a closer look at the breakdown by motive, we observe that especially free time motives boosted car use from 1975 to 1985, though the other motives contributed to the growth as well. Public transport seems to loose in particular in the commuting market, while gaining slightly in education related trips. After 1985 more specific transit promoting policies have been developed, which indeed boosted rail travel by students also for non-school bound trips. However, as shown here for the period 75 - 85, hardly any progress has been made among typical car commuters in recent years. So, despite the efforts modal preferences in commuting remain largely unaffected. Travelling by bike remains stable. Commuting by bike reduced, while shopping by bike increased. The latter development has some positive elements as regards environmental policies concerning inner cities.

Figure 5 compares travel behaviour in 1980 and 1985, decomposed by age group and sex. First the figure

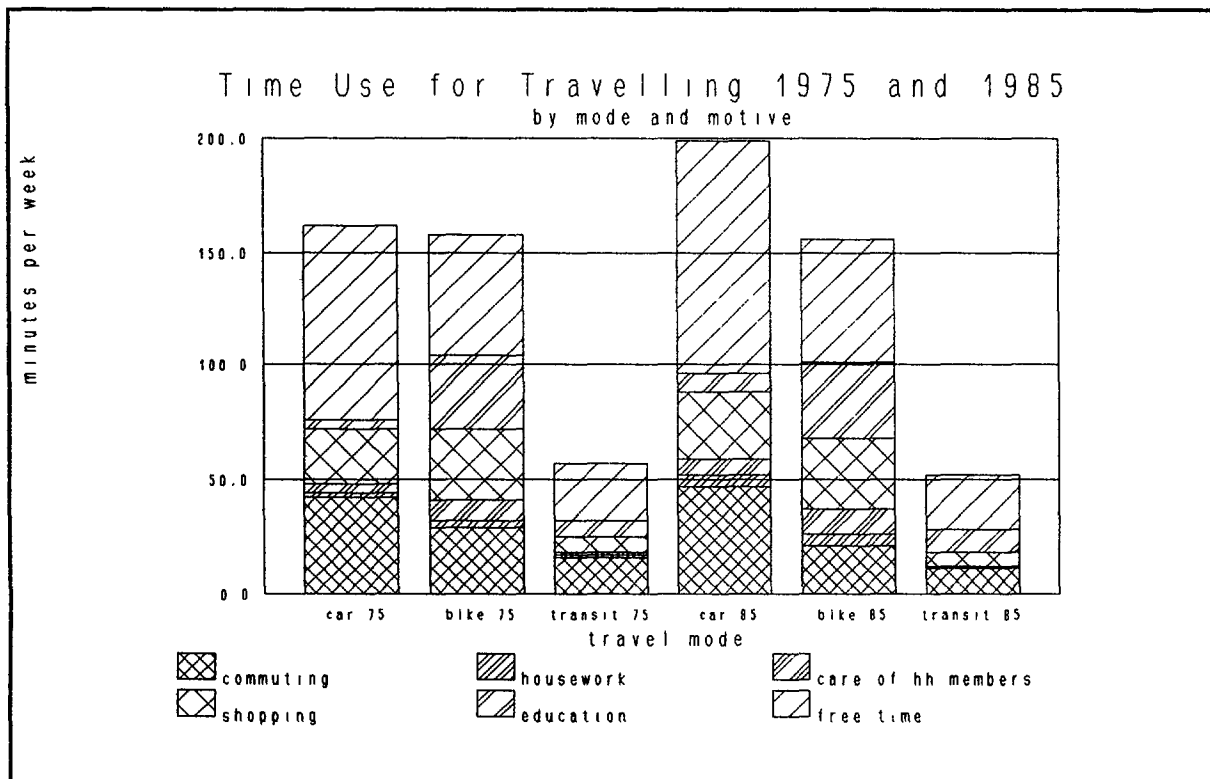


Figure 4. Time allocation for traveling 1975 - 1985 by mode and motive (Source: Knulst and van Beek)

shows that in terms of total travel time younger persons are the most mobile, however if we separate car mobility we observe that people in the age 25 to 50 (the working population) have the highest mobility in terms of mileage. Furthermore, the figure shows that women in some age groups have become more mobile by car between 1980 and 1985. This corresponds with our expectations based on the changes in female activity schemes. Yet, the category of women in the age group 25 - 34 reports no increased car use, although their total mobility increased substantially. However, their male counterparts in the same age group did increase car use. In part this may be explained by increased task combination among male partners (see figure 2), resulting from increased labour participation of women. Provided that the first half of the eighties was an economically less favourable period, possibly many two earner families hesitated about purchasing a second car. During the second half of the eighties the share of double and triple car owning households has risen from 11.8% in 1985 to 13.8% in 1990. Apart from the generally improved economic situation, the job status and consequently payment of female employees has steadily increased. Retired persons report a very strong increase of mobility, which concentrates almost exclusively in the use of cars. As regards young men, their weakened labour market position seems to relate to reduced travel, especially by car.

According to the graphs discussed above increased female labour participation, a growing importance of more individualistic activity schemes - irrespective household type and, a far more active retired population (which grows substantially) indeed show good correspondence with mobility increases and mode choices. Of course, this relation can (and will) also be analyzed by means of statistical methods, but the discussion above is accessible to a larger audience. Batenburg and Knulst (1993) conducted a similar analysis based on the same time budget data (including 1990). They arrive preponderantly at the same conclusions as presented here. According to the results of an OLS based multiple regression lifestyle indicators such as 'belonging to one or two-person household' (-> household formation), 'task combination' (-> female labour participation) and, 'diversity of leisure activities' (-> personal development) are significant explanatory variables in addition to conventional variables such as age, income, education level and, car ownership. The fourth so-called lifestyle indicator 'employed married women' was less significant.

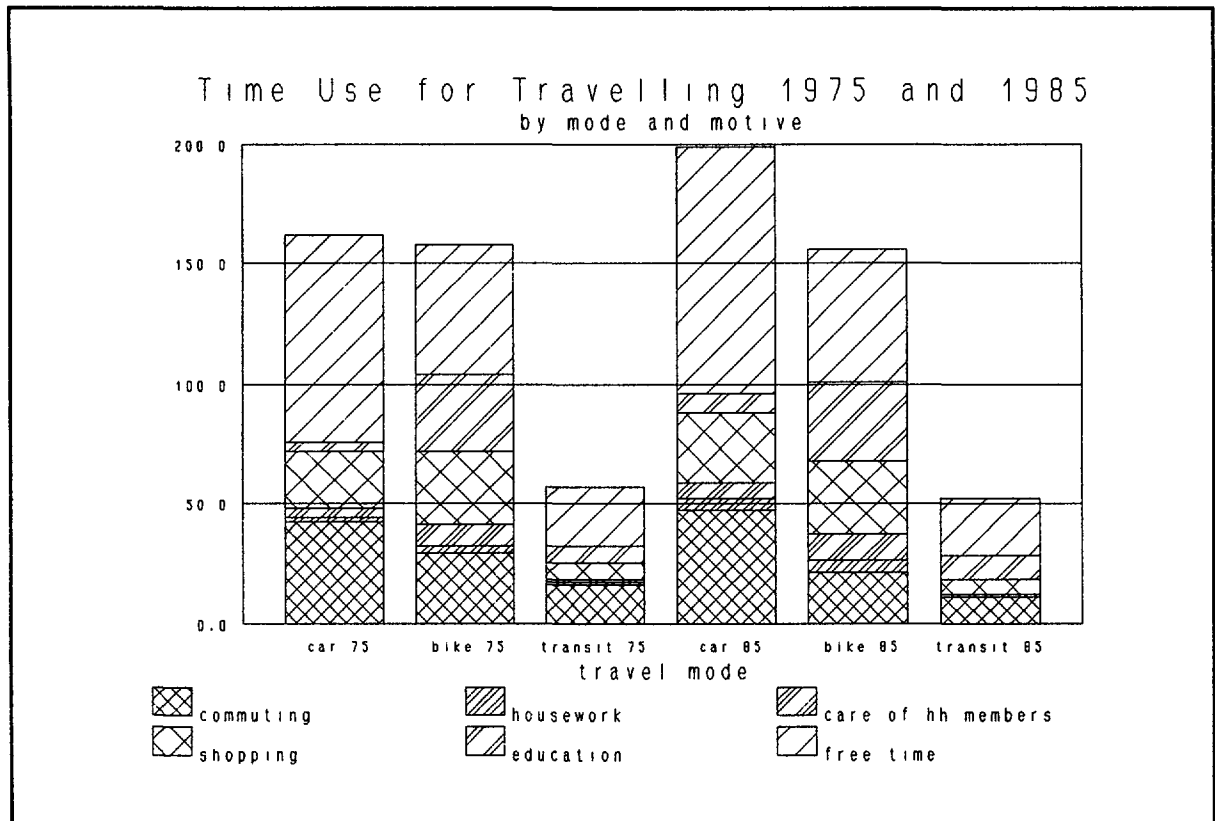


Figure 5. Comparison of weekly travel time 1980 and 1985

Apparently, most of the variance was already explained by other variables such as 'task combination'. As regards the shadow price of time, we are currently conducting statistical analysis at ECN concerning money - time trade-offs in households in relation to mechanization and energy consumption.

5. CONNECTIONS WITH SO-CALLED TRADITIONAL ECONOMIC ANALYSIS

5.1 How to merge methodologies

Mainstream economic analysis of future travel behaviour would supposedly concentrate on price- and income-elasticities of travel behaviour. The previous chapter illustrated that this approach excludes certain stimuli for mobility. Of course, these limitations do not render traditional economic analysis of travel behaviour useless. First, the overall framework of the approach remains valuable. Moreover, purchasing power (income) remains an important variable regarding transport, because increased purchasing power enables people to engage in more activities, which - in part - will require additional trips. For instance, the growth of leisure related mobility is closely related with higher incomes.

In order to arrive at sensible forecasts of travel demand a kind of three step procedure is needed, rooted in micro economic and micro simulation approaches. First, establish the expected mobility level given certain household characteristics, such as age of household members, household size, number of employed persons, location, education level, etc.

Beyond a certain annual mileage car ownership becomes attractive. However, actual car ownership will also depend on income, household size, age, etc. Therefore in the second stage a car ownership probability model can be specified, which uses the expected mobility as a kind of threshold value. If necessary, further refinements may be added regarding car (and engine) type in relation to (fuel)prices, income and fiscal

measures (for example the FACTS model by NEI(1989)). Once car ownership per household type has been simulated, actual travel behaviour in terms of modal split of the annual mileage of a household can be analyzed. Clearly, the ownership of a car is an important conditioning variable in mode choice. In such an approach traditional economic elasticities with respect to prices and income and other parameters reflecting the value of time and the influence of spatial organisation are merged into one analytical system. Clearly, this scheme still leaves out considerations such as convenience and security. The first two steps have been experimented by inter alia De Jong (1989) with reasonable success, though with important limitations on the modelled car stock (excluding lease cars, etc.). Yet, to our knowledge no operational model including all three stages is currently available. The necessity of methodological innovation will be highlighted in the next section.

5.2 Some simple experiments

The following simplified exercise will illustrate what may be missed by relying on purely economic indicators such as prices and income. First, the actual percentage increase of mobility in the age group 25 - 49 between 1980 and 1985 will be given. Subsequently, this figure will be approximated by using income and price elasticities. Finally the remaining gap is suggested to be partly attributable to the changed shadow value of time.

Between 1980 and 1985 mobility per person in the age group 25 - 49 rose by $\pm 12\%$. The total volume of paid labour hours in this age group increased with approximately 15%. In terms of disposable real income this meant an increase of 5% to 6%. Summer 1985 fuel prices started to drop to the 1980 level, however from 1981 to 1984 prices were much higher. Also some other components of transport costs rose (such as , but in varying degrees. Therefore we use a real price increase of variable car costs of about 7%. In the Netherlands the medium term elasticities of mileage with respect to income and variable car costs are rated at about 1 and -0.25^3 respectively. Given the observed changes in prices and income the elasticities would yield an increase of mileage of about 4,5%. Actually the increase of mobility in the selected age group is about 12%. The remaining 'unexplained' 7,5% increase may be - at least partly - attributed to an increase of the shadow price of time (presumably differentiated by activity type) in this age group.

The following happened regarding reallocation of time. Average time spent to paid labour increased $\pm 15\%$, while time for housework decreased 10% and free time slightly reduced (-0.5% including sleep, meals and personal care). Assuming the households wish to maintain their original level of care, the output of domestic production per hour has to grow by 10% in order to achieve a time saving of 10%. So, even with constant income the shadow price of housework time has risen. Additionally, purchasing power has increased due to extended labour participation which allows for specific time saving investments. The latter may be particular attractive as the value of various components of housework time not only depends on the total available time budget but also on the timing and sequence of activities as well as external bounds such as opening times of shops and public facilities (see also end of section 2.1). In other words the premium on a time saving opportunity that enables you to reach the shop before closing time can be substantial. In principle it is possible to infer the shadow price of time by means of various analytical tools. On the one hand scheduling models including nested discrete choice techniques can be applied (Perrels 1992). On the other hand various authors have attempted to establish empirical bid-rent curves for the use of time based on interviews (inter alia Quah, 1987).

In fact the valuation of time, or rather the valuation of travel time savings, is a well known component in transport studies (notably CBA's). Yet, sofar the concept of the (shadow) value of time has hardly been integrated in travel demand analysis in general.

6. PROSPECTS FOR RESEARCH AND POLICY

The Dutch Ministry of Transportation gradually recognizes that the growth of car mobility may be higher than the policy goal of 35% growth between 1990 and 2010. The current growth rate ($\pm 2,7\%$) implies an

increase of 70% up to 2010⁴. On the other hand the improvement of fuel efficiency of the car stock has been 1.2% annually from 1980 to 1991. Consequently, the growth of aggregate car mileage should remain below that level in order to achieve a reduction of aggregate fuel demand. As a systematic rise of the rate of fuel efficiency improvement is unlikely, a continuous policy effort is required to keep aggregate mileage below this growth rate.

It has been discussed in the previous sections that in addition to and in connection with income some other factors stimulate car ownership and use as well. Repeated large price rises of cars and motor fuel in order to compensate for higher incomes seems unfeasible for various reasons (political, economic, etc.). So, energy price policies are unlikely to become the dominant instrument. This leaves unaffected the possibilities to use it as a complementary instrument reinforcing impacts initiated by other changes. A potentially forceful alternative is the promotion of (labour) time policies. Recent surveys of trade unions indicated that a substantial (and increasing) share of the work force would prefer part time jobs. This trend is closely related to the increasing numbers of two earner households. However, these are in particular the ones who are likely to choose for the mechanization option. For these households more (free) time is usually more precious than more income (see also Hochchild 1990). By promoting part time work among two earner families two goals are achieved. First, the prospective increase of their incomes is limited and consequently investing in for example two cars is less easy. Second, their time budget for domestic obligations can be extended, which together with the lower or stabilized income reduces the shadow price of housework time. Or just simply, one has less money and more time to spend to achieve a certain level of care. For example, this may induce a household to shop three times a week by bike instead of one time a week by car. In fact this kind of measures aim to guide (notably young) couples to choose a lifestyle trajectory that involves less material consumption.

Currently, the government tries to attract travellers to public transport by issuing subsidized annual travel cards to specific groups such as students and military men. As regards students one of the motives was a learning effect, which should result in a reduced inclination among employed fresh academics to buy a car. To date the measure shows signs of being counter effective. First, students have become very mobile as their marginal travel costs are zero. As such they adjust to a lifestyle which takes spatial flexibility for granted. Second, the original commuters are almost literally crowded out at several lines, thereby returning to their cars.

Comparable counter effective results may be encountered due to an ill-considered introduction of electric cars. Promoting electric vehicles as the green urban alternative could result in a substitution from public transport and bicycles to electric cars, instead of a substitution from traditional cars. Admitting only electric cars into the inner city area might contribute to the intended substitution. However, considering comparable measures in the past years, there is a serious risk of relocation of typical inner city activities such as offices and shops. According to such a scenario we would end up with an empty transit system causing extreme losses, while new centres along the urban fringe take in all the car ridden customers. This example is not meant to play down the role of technology in the quest for a solution of transport problems. It is a serious reminder to opt for a balanced approach including economic, technological and social considerations and in accordance with the local conditions instead of relying on one aspect in particular.

ENDNOTES

1. Please note that for national transport air travel is negligible. Clearly, considering long distance (i.e. international) transport air travel is a point of concern.
2. One should distinguish the utility derived from performing an activity (performance utility) from the utility derived from the accomplishment of a task (goal utility). see also Winston (1982).
3. The range of estimated values for price elasticities of variable car costs (or fuel costs) with respect to mileage is large even for one country.
4. An official white paper on environmental policy (The National Environmental Policy Plan - NMP) has formulated a reduction in the growth of the use of private cars in the period 1990-2010. The unrestricted increase was estimated at 73%, the official policy goal is to restrain the growth to

35%. Mobility and car traffic are well monitored. Since 1990 several policies have been put in place to promote public transport and to reduce the fiscal premium on commuting by car. From 1985 to 1990 car traffic grew on average 3.7 % annually. In 1990 it increased by 2.7%, while it even reduced (!) by 0.8% in 1991. However, in 1992 growth has resumed already with 2.8% due to the reasons mentioned in the text.

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