Article:

de Jong, G. and Gunn, H.F. (2001) Recent evidence on car cost and time elasticities of travel demand in Europe. Journal of Transport Economics and Policy, 35 (2). pp. 137-160. ISSN 0022-5258

Published paper

de Jong, G.; Gunn H.F. (2001) *Recent Evidence on Car Cost and Time Elasticities of Travel Demand in Europe*. Journal of Transport Economics and Policy, 35(2), pp.137-160.

Journal of Transport Economics and Policy, Volume 35, Part 2, May 2001, pp.137–160

Recent Evidence on Car Cost and Time Elasticities of Travel Demand in Europe

Gerard de Jong and Hugh Gunn

Address for correspondence: Gerard de Jong and Hugh Gunn are with RANDEurope, Newtonweg 1, 2333 CP Leiden, The Netherlands. The outcomes reported in this paper are based on the TRACE project carried out by the TRACE consortium, consisting of Hague Consulting Group (coordinator), ARPA from Italy, Heusch Boesefeldt from Germany, Stratec from Belgium and the University of Cergy-Pontoise from France, for EC-DGVII. Moshe Ben-Akiva and Joseph Berechman acted as academic advisors in this project

Abstract

Many European regions do not have traffic models that have been calibrated on data for that specific region. For such national and regional authorities that would like to have a first approximation of the travel demand impacts of changes in car cost and car travel times, the outcomes of the research project into elasticities of travel demand presented in this paper might be particularly useful. The objective of this study is not to replace detailed traffic models; if these are available we advise their use. In this paper, results are presented from a large-scale review of available evidence concerning elasticities of private car travel demand with respect to time and cost changes and from new runs with three traffic models. The focus is on countries that are member or associate member states of the European Union and on studies conducted recently (1985 and later). The car cost and car travel time elasticity outcomes presented refer to the impact on both trips and kilometres, distinguishing several modes, travel purposes, and are short versus long term.

Date of receipt of final manuscript: April 2000

Introduction

Information on time and cost elasticities is particularly useful in providing an approximate *ex ante* assessment of the probable impact on car travel demand associated with measures and policies that are being considered in the pursuit of transport or environmental policy goals. A number of national and regional authorities in Europe have traffic models available, calibrated to local circumstances, to give specific answers to questions on the effects of price and time changes. Many governmental bodies or private investors in infrastructure projects in Europe, however, do not have access to detailed traffic models. For them, a set of elasticities based on the existing literature, and model runs from other areas, can provide indicative answers to the questions about the effectiveness of policy measures. For actors that do have traffic models available, the elasticity approach can also be meaningful, because it works much faster and can be used in initial policy selection stages, with runs of the detailed network-based traffic model being carried out in a second stage on a subset of the proposed policy measures.

However, policy-makers must realise that *the* elasticity of some measure does not exist. Elasticities of travel demand vary with circumstances, which we call 'contexts' in this paper. To be useful in practice, an overview of elasticity values or an elasticity-based instrument should distinguish several, probably many, contexts and provide elasticity values for each of them. Also, assessments based on elasticities must be considered as first-order approximations in discussions on transport or related policies. When a potentially successful policy has been identified using the elasticity approach, it will often be considered necessary to conduct further detailed planning and research, in which full account can be taken of the specific and locational circumstances and characteristics.

In the course of the TRACE project, carried out by a consortium of European consultants and Universities in 1998/1999 with the financial support of the European Commission, evidence on elasticity values of car travel demand for a wide range of contexts was collected and synthesised.

The TRACE project focuses on the impact of changes in car cost and car travel time, investigating the impact of such changes both on the demand for car travel and on other travel modes, especially public transport, both in the long and short run. The project contains the following phases:

- a literature review of empirical and modelling evidence of time and cost elasticities and value of time for both short- and long-term futures;

- a review of the theoretical background of the elasticity concept (focusing on the issue of reaction time to the stimuli) and of the 'prototypical contexts' for which elasticities' values will be different;
- new runs with three existing national or regional traffic models to generate more evidence on elasticity values for different contexts;
- development of an Elasticity Handbook and a fast and user-friendly PC program TRACER to yield values for elasticities for a range of 'prototypical contexts', for an assessment of first-order impacts on car travel demand at different planning levels.

Existing international reviews of elasticities of travel demand (for example, Goodwin, 1992; Oum *et al*., 1992) have specific limitations, which were remedied in the TRACE review:

- no car travel time elasticities have been presented;
- no elasticities for the number of car driver trips, car passenger trips, or car passenger kilometres have been presented; the focus has been on vehicle kilometres and public transport;
- some countries in Europe have been covered very well (especially the UK), for other countries coverage has been limited;
- evidence presented after 1992 is missing.

In this paper, outcomes of the TRACE literature review on elasticities will be summarised (section 2) and compared against elasticity values from new model runs (section 3). Finally, in section 4 some conclusions are drawn.

The Literature Review on Elasticities of Car Cost and Car Time

Elasticities studied in this paper

In this paper, as well as in the TRACE project, we are focusing on the following stimuli:

- impact of changes in car travel cost;
- impact of changes in car travel times.

For both we shall be studying the impact on (response):

- car driver trips and vehicle kilometrage (direct or own-price elasticities);
- car passenger trips and car passenger kilometrage;

- other modes (cross or cross-price elasticities): public transport, sometimes also slow modes.

Freight transport is not studied. Impacts of changes in public transport (for example fares, public transport travel times) are not studied either.

Main findings of the literature review on elasticities

This section contains a summary of evidence on car cost and car time elasticities of demand for car travel and public transport, collected in the TRACE project. This review is restricted to countries in Europe, and focuses on recent studies (1985 and later). For countries where only limited evidence could be found, some material dating before 1985 has been included. (The Literature Reviewed is given in the Appendix.)

Detailed numerical outcomes on elasticities can be found in TRACE Deliverable 1. In the third section of this paper, summary tables are presented in which elasticities from the literature review are compared against elasticities from new model runs. For the elasticities from the literature review, the means were calculated without weighting, as has been done by Goodwin (1992) in his review. Some more general findings are given later in this section.

In total more than 50 studies (including some national and international overview studies) were identified that contained elasticities relevant for this project. These studies cover 12 European countries. The countries for which most elasticities were found are the UK and the Netherlands. For countries in Eastern Europe only one study could be found that provides elasticities (and values of time), which deals with Belarus, Moldova, Russia, and Ukraine. For other Eastern European countries no elasticities (or values of time) were found, even though 12 institutes in these countries were contacted. Our conclusion is that it is highly probable that for most Eastern European countries no studies giving elasticities or values of time exist.

The most important distinctions within travel demand models, which are used in practice to derive elasticities, are a distinction by the choice that is modelled and one by the type of data used. Models for the following choices can be found in the literature:

- mode choice;
- departure time choice;
- destination choice;
- travel frequency choice;
- car ownership;
- residential choice.

Most evidence in the literature, however, refers to mode choice. These elasticities usually give the modal shift impact at a fixed volume of trips.

The second distinction is based on the type of data used in the model. Stated Preference (SP) data give the reactions as stated by the respondents in a survey (travellers), when confronted with hypothetical alternatives constructed by the researcher. Revealed Preference (RP) data are statistics on observed behaviour, revealing choices that have actually been made by travellers. Some researchers use the term RP data only for cross-section data on individual choices.

Comparing Elasticity Values from the Literature Review and New Model Runs

The three existing traffic models for which new runs were carried out in the TRACE project are:

- the Netherlands' National Model System (NMS);
- the Italian National Model System (which is a model for long-distance tours);
- the integrated land use/transport model for the Brussels region.

The scenarios used in the runs with the three models are basically the same. Runs were carried out, all for the base-year of the model (around 1994):

- fuel cost of the car (distance-related cost) + 10%, + 25%, + 40%;
- all travel times by car + 10%, + 25%, + 40%;
- all car parking charges + 10%, + 25%, + 40% (not in the Italian model);
- no change (to get a reference level for the calculation of elasticities).

As regards the outputs of these runs, the following modes were distinguished:

- car (passenger and driver; Brussels);
- car driver (Netherlands, Italy);
- car passenger (Netherlands);
- public transport (Netherlands, Italy, Brussels);
- slow modes (Netherlands);

and the following purposes (Netherlands, Italy):

- commuting;
- business (Netherlands: home-based and non-home-based separately);

- education;
- other;

and the following one-way trip distance classes:

- 0–5 km (Netherlands, Brussels);
- 5–30 km (Netherlands, Brussels);
- 0–30 km (Italy);
- 30–100 km (Netherlands, Italy, Brussels);
- more than 100 km (Netherlands, Italy, Brussels).

Outputs were provided in terms of the elasticities of the number of trips and kilometres, both for the short and the long run. The short run is defined as including mode choice effects only. The long-run elasticities include the following effects:

- mode choice (Netherlands, Italy, Brussels);
- destination choice (Netherlands, Italy);
- travel frequency choice (Italy);
- relocation of population (under 65) and of retail and service activities (Brussels).

In the segmentation used in the model runs, we tried to guarantee the maximum possible amount of consistency between the three models and to include the distinctions that are most relevant for elasticity values (for example travel purpose, distance class). Because the models use different variables and definitions, it is not possible to have precisely the same segmentation in all three models. Descriptions of the models used and detailed outcomes on the elasticities from the three models can be found in TRACE Deliverable 3.

In Tables 1 to 8 we compare the average elasticities from the literature survey against elasticities from the runs with the three models. For this comparison we excluded the elasticities from the Netherlands' National Model System from the literature, to avoid comparing it with itself. The elasticities from the three models are taken from runs in which the stimulus variable (car cost or car time) is increased by 10 per cent.

Impact of car cost on car drivers

Table 1 gives the average fuel price elasticities (at constant fuel efficiency) for the number of trips as car driver. In the NMS, car driver is a separate mode (as is car passenger). The number of car driver trips then also gives the number of car (vehicle) trips. The Italian national model also provides outcomes for car drivers. The model for Brussels assumes a fixed car occupancy rate: the elasticities for car drivers are identical to the elasticities for car drivers and car passengers together. The elasticities from the Brussels model, which is a morning peak model, are interpreted here as commuting elasticities. The other two models are for a 24-hour period.

In this table, and in the tables that follow, there are a number of empty cells in the columns for the literature and the models for Italy and Brussels. This means that for those travel purposes no elasticities are available. The NMS is—for the shorter distances—the most complete source of elasticities. For the longer distances, the Italian model could be used as the prime source.

The literature review, the NMS, and the model for Brussels give similar short-term fuel price elasticities of the number of car trips for commuting. For the other four travel purposes, the short-term elasticities from the literature and the NMS are also broadly similar.

The short-term elasticities from the Italian model (except for 'other' travel, such as shopping and visiting friends and relatives) are higher than from the other sources. This can be explained from the long-distance nature of the Italian model. This model only deals with interzonal trips, using relatively large zones (270 zones in Italy, 62 abroad). For long-distance trips, public transport (in this model including air transport) has a relatively strong competitive position, as has been found in many long-distance studies. As a result of this, the substitution effect will be larger than for short-distance travel, and the elasticities will be higher (in absolute values). Most of the trips in the Italian model are in the distance class 30–100 km; > 100 km is also an important category (even for commuting it contains 17 per cent of all trips in the model). The distance class 0–30 km is clearly the smallest of the three distance classes. For this distance class, the fuel-price elasticities for commuting (and other purposes) trips by car for the short term are around −0.2, as in the other sources. For 30–100 km, the elasticities are around −0.4.

For the long run the elasticities from the NMS for business (home-based and non-home-based) and education are lower than those from the literature, but higher for other travel purposes. For all purposes together, the NMS gives a slightly higher elasticity than the average from the literature. The Brussels model, which explicitly contains the effect of changes in residential location, gives an elasticity only slightly above the one from NMS and European literature (for commuting). The long-term trips elasticities from the Italian model are not much higher than their short-term counterparts: the frequency effect is apparently small compared to the direct mode choice effect.

The general message from Table 1 is that the differences in the elasticities of car trips are rather small: both for the short and long term they

Table 1
Fuel Price Elasticities of the Number of Car Trips

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting	−0.20	−0.11	−0.52	−0.16
Home-based business	−0.06	−0.01	−0.29	
Non-home-based business	−0.06	−0.01		
Education	−0.22	−0.10	−0.55	
Other	−0.20	−0.31	−0.16	
Total	−0.16	−0.19		
Long term:				
Commuting	−0.14	−0.15	−0.55	−0.24
Home-based business	−0.07	−0.01	−0.29	
Non-home-based business	−0.17	−0.01		
Education	−0.40	−0.18	−0.59	
Other	−0.15	−0.41	−0.16	
Total	−0.19	−0.25		

Note: All elasticity comparisons in this paper are in terms of absolute values. For instance, an elasticity of −0.3 will be said to be 'higher' than an elasticity of −0.2.

are generally close to −0.2. In the European literature and the NMS, commuting and business travel is less sensitive to changes in fuel prices than travel for other purposes.

Table 2 gives the effects of the same changes in fuel price, but now on the number of car kilometres.

In Table 2 we see a close correspondence between the elasticities from European literature and the NMS. The main exception is other travel in the long run: here the NMS is clearly more sensitive. The long-term elasticities of car kilometrage in the NMS, the Italian model, and several sources in the literature also contain a destination choice effect: if the fuel price increases, destinations located further away become less attractive. Consequently the long-term effect is bigger than the short-term (mode choice only) effect. All sources except the Italian model give a long-term elasticity for all purposes together of about −0.3. In the recent report on transport and the economy (SACTRA, 1999), several reviewers are cited who have also concluded that the fuel price elasticity of vehicle kilometres should be around −0.15 in the short run and −0.3 in the long run. In the NMS and the literature, commuting and business travel have a lower than average sensitivity. The Italian model yields elasticities for car kilometrage that are clearly higher than from the other sources. Again this has to do with the long-distance nature of this particular model (and good sub-

Table 2
Fuel Price Elasticities of the Number of Car Kilometres

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting	−0.12	−0.10	−0.79	−0.22
Home-based business	−0.02	−0.03	−1.58	
Non-home-based business	−0.02	−0.02		
Education	−0.09	−0.04	−1.09	
Other	−0.20	−0.24	−0.87	
Total	−0.16	−0.13		
Long term:				
Commuting	−0.23	−0.22	−1.22	−0.31
Home-based business	−0.20	−0.25	−1.73	
Non-home-based business	−0.26	−0.16		
Education	−0.41	−0.35	−1.41	
Other	−0.29	−0.65	−1.03	
Total	−0.26	−0.36		

stitution possibilities for long distances). For distances in the categories 0–30 km and 30–100 km, the elasticities from the Italian model are around −0.2 and −0.5 respectively. The short-term effect in this model is mode choice only; the long-term effect also includes destination and frequency choice. The mode choice effect turns out to be most important in this model, for most cases, but in terms of kilometres there is also a substantial destination choice effect.

Impact of car cost on car passengers

The NMS runs carried out for the TRACE project also provide fuel price elasticities of trips and of kilometres by car passengers (meaning other persons than the driver). These are often positive: if the fuel price increases, the car driver alternative (in many cases being: driving alone) becomes less attractive and the car passenger alternative (carpooling usually means sharing the cost) becomes more attractive. The detailed outcomes are in TRACE Deliverable 3. However, the literature and the runs with the two other models yield only limited evidence on effects on car passengers. For this reason we did not produce a table for this mode in this paper. In a model for Amsterdam developed by Daly and others, elasticities are reported for drive alone, carpool driver, and carpool passenger separately (Daly *et al.*, 1990). The Norwegian national model (Institute of Transport Economics & Hague Consulting Group, 1990) gives 0.16 as a long-term fuel price elasticity of the number of kilometres as car passenger, and the NMS 0.15.

Impact of car times on car drivers

The effects of changes in the travel time by car on the number of car trips (or car driver trips which is the same thing) are shown in Table 3.

Table 3

Car Time Elasticities of the Number of Car Trips

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting	−0.62	−0.39	−0.54	−0.23
Home-based business		−0.07	−0.29	
Non-home-based business		−0.04		
Education		−0.06	−0.66	
Other	−0.52	−0.11	−0.09	
Total	−0.60	−0.20		
Long term:				
Commuting	−0.41	−0.58	−0.56	−0.36
Home-based business	−0.30	−0.12	−0.29	
Non-home-based business	−0.12	−0.10		
Education	−0.57	−0.19	−0.70	
Other	−0.52	−0.21	−0.09	
Total	−0.29	−0.33		

The effects of some percentage change in car time is, according to most sources, greater than the effect of a change in car cost by the same percentage. In the NMS, the Italian model, and the European literature, commuting trips are more sensitive to changes in time than business trips. The Brussels model has a lower time sensitivity for commuting. The general picture from all sources is a long-term elasticity of about −0.3.

In Table 4 the impacts of car travel time on the number of car kilometres are shown.

The overall levels of the travel time elasticities given in Table 4 are in line with the reviewers cited in SACTRA (1999), who conclude that the long-run travel time elasticity of traffic is a factor of two or more times the fuel price elasticity.

The impact of car time on car kilometres, according to the NMS, is much greater in the long run than in the short run: the former includes

Table 4
Car Time Elasticities of the Number of Car Kilometres

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting		−0.64	−0.87	−0.31
Home-based business		−0.05	−1.36	
Non-home-based business		−0.03		
Education		−0.05	−1.35	
Other		−0.19	−0.55	
Total	−0.20	−0.35		
Long term:				
Commuting	−0.63	−2.00	−1.38	−0.49
Home-based business	−0.61	−0.15	−1.49	
Non-home-based business	−0.53	−1.20		
Education	−0.76	−0.95	−1.73	
Other	−0.85	−0.86	−0.64	
Total	−0.74	−1.34		

destination choice effects, which in the NMS can be very substantial. The long-term elasticities from the literature, especially for commuting, non-home-based business, and all purposes together, are lower than those from the NMS. A possible reason for this could be the greater supply of attractive destinations in a densely populated country such as the Netherlands; smaller elasticities in the literature come especially from Scandinavia, which has a much lower population density. Another possible explanation for relatively high long-term elasticities in the NMS is that this model is multinomial logit. Some models in the literature (such as that for Stockholm) are nested logit, in which the substitution rate between alternatives within the same nest (for example, modes to the same destination) can be greater than between alternatives in different nests. Other elasticities in the literature (such as in the UK) are based on stated preference surveys into the reactions to congestion.

The Italian long-term elasticities are of the same order of magnitude as those from the NMS, but for the short run the Italian ones are higher. This again will be partly due to the long-distance nature of the Italian model: in the Italian model the mode choice effects are bigger than in the NMS, in the Dutch model the destination choice effects are bigger than in Italy.

A detailed comparison (segment by segment) was carried out with regard to the differences in direct elasticity outcomes for the NMS (looking at commuting only) and the Brussels model. The short-run fuel price elasticities of the number of car trips are very similar in both models for most segments. An exception is that for trips going from the periphery to the Brussels region. The Brussels model (morning peak; these are mostly people living in the suburbs going to work) has a higher elasticity (−0.2 - −0.3) than the NMS for suburban to urban trips (−0.12 - −0.17). Because of this, the overall short-run fuel price elasticity of car trips (−0.16, see Table 1) in the Brussels model is slightly higher than in the NMS (−0.11). In the long run, the difference between the NMS and the Brussels fuel price elasticity of car trips is somewhat bigger, because of the additional land use impact in the Brussels model. For car kilometres (Table 2) this latter difference is reduced because the NMS now contains a bigger destination choice impact.

For the short-run car time elasticity of car trips (Table 3), the outcomes for periphery to Brussels are similar to the ones in the NMS for suburban to urban. For other segments the NMS elasticities are usually higher. This will be partly due to the higher distances in the NMS, but within similar distance classes, the time elasticities in the NMS are also higher than for Brussels. The NMS has higher time elasticities than the Brussels model in all distance classes and especially in the class 30–100 km (possibly for the NMS the trips within this class are typically longer than for Brussels). The differences are also larger for segments with low quality public transport, which reduces the Brussels elasticities more than the NMS elasticities. In the long run the differences in the car time elasticities of car trips between both models are usually smaller (see also Table 3), because of the added land use effects in the Brussels model. For kilometres, the NMS gives considerably larger time elasticities (which include a large destination choice effect) than the Brussels model.

The difference between the short-run elasticities of the NMS and the Brussels model cannot be due to land use effects, because in runs with the Brussels model these are only included in the long-run elasticities. It is also unlikely that congestion is the most important factor explaining the differences. The Brussels model (short and long run) takes into account that congestion will reduce the initial cost and time elasticities (because the initial reduction in demand will reduce congestion and travel times). The full NMS also contains this congestion feedback effect, but this was not used in the runs for TRACE. This effect should work in the same direction for both cost and time, but we observe that for cost the Brussels model has a higher elasticity and for time the NMS has a higher elasticity.

The most important reason for the differences in the impact of times and cost on car trips in the short run in both model systems seems to be the relative importance of travel time and travel cost in the mode choice models. The Brussels model for mode choice (included in path choice) uses generalised transport cost as one of the explanatory variables. Within this generalised cost are transport cost and time, using value-of-time measures from stated preference research. For middle and high income commuters the car VOT is 4.95 €/hour, for low income commuters it is 3.06 €/hour (see Deliverable 3 of this project). This is lower than the 6.3 €/hour found in the Dutch national VOT study of 1990 for car drivers commuting. Many European studies found a value for commuting of about 5 €/hour (see the next section of this paper). In the NMS, the relative importance of time versus cost is on average even greater (although this should not be called the value of time, because of the logarithmic cost specification and tax deduction facilities for commuter traffic). Consequently in the short run (mode choice only), car trips in the NMS are more sensitive to time changes than in the Brussels model, whereas they are less sensitive to cost changes than in the Brussels model.

Impact of car times on car passengers
The NMS runs for TRACE also provide car time elasticities for trips and kilometres of car passengers (not being the drivers). Contrary to the car cost elasticities on passengers, these are negative: if the car travel time increases, the car passenger alternative becomes less attractive. Car cost can be shared among the occupants of the car; an increase in travel time applies to each of the occupants. The NMS elasticities are in TRACE Deliverable 3. The other models and the literature did not give information that can be compared to the NMS elasticities; therefore we do not present a table for this mode.

Impact of car cost on public transport
In Table 5 we give the cross elasticities for the impact of the fuel price (for cars only) in the number of trips by public transport.

These elasticities in general turn out to be rather small (for the long-run total: around 0.1). In the model for Brussels the cross-elasticities are somewhat higher: in this predominantly urban study area there are more substitution possibilities than in a country-wide study. The high elasticities from the Italian model are related to the large share of long-distance trips, which has been mentioned when discussing the direct elasticities.

Table 6 shows the effect of the fuel price on the number of kilometres travelled by public transport.

Table 5
Fuel Price Elasticities of the Number of Public Transport Trips

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting		0.18	0.22	0.38
Home-based business	0.17	0.18	1.07	
Non-home-based business	0.17	0.05		
Education		0.01	0.17	
Other	0.48	0.25	0.50	
Total	0.33	0.17		
Long term:				
Commuting	0.12	0.16	0.22	0.37
Home-based business	0.03	0.06	1.68	
Non-home-based business		0.04		
Education	0.14	0.01	0.14	
Other	0.07	0.18	0.50	
Total	0.07	1.13		

Table 6
Fuel Price Elasticities of the Number of Traveller Kilometres by Public Transport

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting		0.18	0.37	
Home-based business		0.27	2.59	
Non-home-based business		0.13		
Education		0.01	0.35	
Other		0.26	1.76	
Total	0.07	0.17		
Long term:				
Commuting	0.26	0.18	0.14	
Home-based business		0.06	2.38	
Non-home-based business		0.05		
Education		0.01	0.07	
Other		0.19	1.57	
Total	0.10	0.14		

The NMS elasticities in Table 6 for the total are in line with the means from the European literature. Again, the Italian cross-elasticities are generally higher than the others.

Impact of car times on public transport

The effects of car travel time on public transport passenger trips are shown in Table 7. As with the direct elasticities, the cross-elasticities for changes in time exceed the cross-elasticities for changes in cost (for the same percentage change in the stimulus variable). In the model for Brussels, the total number of trips (all modes) decreases in the very long run, because of relocation. As a result, the long-run effect here is smaller than the short-run (mode choice only) effect. The NMS elasticities for all purposes together, both for the short and long-run, are higher than the averages from the European literature. For the short run, this is largely due to the outcomes of a study for countries in the former Soviet Union, where there is relatively little car traffic. The Italian model elasticities are reasonably similar to the Dutch ones, except that commuting is less sensitive in the Italian model.

Table 7
Car Time Elasticities of the Number of Public Transport Trips

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting		1.91	0.23	0.58
Home-based business		1.45	1.15	
Non-home-based business		1.38		
Education		0.03	0.21	
Other	0.73	0.52	0.30	
Total	0.27	0.95		
Long term:				
Commuting	0.22	1.07	0.23	0.46
Home-based business		1.06	1.15	
Non-home-based business		0.99		
Education		0.03	0.18	
Other		0.23	0.30	
Total	0.15	0.51		

Finally, Table 8 shows the effects on the number of public transport kilometres travelled.

Table 8
Car Time Elasticities of the Number of Traveller Kilometres by Public Transport

Term/purpose	*Literature EU*	*The Netherlands' national model system (NMS)*	*Italian national model*	*Model for Brussels*
Short term:				
Commuting		2.78	0.43	
Home-based business		0.99	2.52	
Non-home-based business		3.08		
Education		0.03	0.45	
Other		0.93	1.00	
Total		1.55		
Long term:				
Commuting	0.52	1.24	0.16	
Home-based business		1.06	2.37	
Non-home-based business		1.09		
Education		0.03	0.11	
Other		0.24	0.90	
Total	0.36	0.65		

In the NMS, the sensitivity of public transport to changes in car time are smaller in the long run than in the short run: in the long run, destination choice effects are partly compensating the initial mode choice effects. Nevertheless, the NMS elasticities for the long run are higher than those from the (in this case mainly Scandinavian) literature. In the Italian model, the sensitivity of commuter kilometres is lower than in the Netherlands and that of business kilometres higher.

Conclusion

From the evidence on elasticities presented above, the following conclusions can be drawn:

- It is highly probable that for most Eastern European countries no studies giving elasticities or values of time exist.
- In general, the average elasticities from the literature and the new runs carried out with the models for the Netherlands, Italy and Brussels, show a broadly similar pattern. For the long-run car time effects on car and public transport kilometres, the Netherlands' National Model

System (NMS) elasticities are (in absolute values) higher than the averages from the literature. The Italian national model elasticities are often higher than those in the literature, because of the focus of this model system on long distance interzonal trips.

- Furthermore, one has to keep in mind that the NMS contains the possibility of feeding back the increased travel time in case of congestion into mode and destination choice. This possibility has not been used in NMS outcomes presented here. With congestion feedback, the elasticities from the NMS would probably have been lower (in absolute values): initially the increase in car time or cost reduces congestion, but this will attract new car travel, which then reduces the initial effect. For the interzonal trips in the Italian model, congestion is probably less important; the runs with the Brussels model do include a congestion feedback.

A 10 per cent change in car time has a bigger impact on trips and kilometres than a 10 per cent change in car cost.

- The short-term elasticities of car kilometrage are more or less half of the long-run counterparts.
- The cross-elasticities of the kilometres travelled by public transport are somewhat higher for the short run than for the long run, because of the destination choice effect that only occurs in the long run.
- The relationship between elasticities and value of time is, when using the point elasticity specification:

$$E_{time}/E_{cost} = VOT/(cost/time).$$

In other words: for some segments, the ratio of the time elasticity to the cost elasticity is equal to the VOT divided by the (average) travel-cost to travel-time ratio. This relationship can be used to check whether time and cost elasticities, if both are available, are broadly consistent with what is known about the appropriate value of time. The average values of travel time for car drivers from the review of European (in fact mostly North Western European) value-of-time studies, which was also part of the TRACE project, are:

- commuting: €5 per hour;
- business: €20 per hour;
- other: €4 per hour;
- all purposes: €6 per hour.

These average values of time are broadly consistent with the average time and cost elasticities found for car trips, but less so with the elasticities found for kilometrage, which contain significant destination choice effects. Values of time in most studies were derived either from revealed preference mode choice or from stated preference experiments (with hypothetical mode choice or with hypothetical alternatives within the same mode), not from destination choice.

Tools for first order assessment

On the basis of the elasticities from the literature and the new model runs, two tools were produced in TRACE, which national and regional authorities can use for a first order assessment of the effects on travel demand of changes in fuel prices, car travel times, road pricing and parking charges:

- *The Elasticity Handbook*, which contains 41 tables with elasticity values;[1]
- a PC program, called TRACER, rooted in the existing traffic models, which can be used to yield elasticities in a fast and user-friendly way for contexts not covered by existing traffic models.[2]

References

Daly, A. J., G. C. de Jong and K. A. Brohm (1990): "Vervoerwijzekeuzemodellen met Carpooling". Paper presented at Colloquium Vervoersplanologisch Speurwerk; CVS, Delft.

Goodwin, P. B. (1992): "A Review of New Demand Elasticities with Special Reference to Short and Long Run Effects of Price Changes". *Journal of Transport Economics and Policy*, 26, 155–168.

Oum, T. H., W. G. Waters II and J. S. Yong (1992): "Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates; An Interpretive Survey". *Journal of Transport Economics and Policy*, 26, 139–54.

Standing Advisory Committee on Trunk Road Assessment (SACTRA) (1999): *Transport and The Economy.* Department of the Environment, Transport and the Regions, London.

[1] *The Elasticity Handbook* can be downloaded from the TRACE website at www.hcg.nl/projects/trace.

[2] A limited version of TRACER can be obtained by Universities free at HCG; the full version, with a wizard for the creation of a country-specific or region-specific distribution of trips over the relevant segments given user-defined targets, is a commercial product, marketed by HCG.

Appendix: the Literature

Accent and Hague Consulting Group (1995): *The Value of Travel Time on UK Roads - 1994; Final Report*. Report for Department of Transport; Accent and HCG, London/The Hague.

Acutt, M. Z. and J. S. Dodgson (1994): "Multi-modal Traffic Forecasts". *Proceedings of 22nd PTRC European Transport Forum, Seminar G*, pp. 275–86; University of Warwick.

Algers, S., A. Daly, P. Kjellman and S. Widlert (1995): "Stockholm Model System (SIMS): Application". Paper presented at the 7th World Conference on Transport Research, Sydney.

Algers, S., J. Lindqvist Dillén and S. Widlert (1996): "The National Swedish Value of Time Study". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Annema, J. A. and R. M. M. van den Brink (1997): *Verkeer en vervoer in de Milieubalans 1997.* RIVM, Bilthoven.

Atkins, W. S. (1994): *Cambridgeshire County Council: stated preference project.* W. S. Atkins, Epsom, Surrey, England.

Bates, J. I. Williams, D, Coombe and J. Leather (1996): "The London Congestion Charging Research Programme 4; The Transport Models". *Traffic Engineering and Control*, 37, 334–38.

Becker, G. S. (1965): "A Theory of the Allocation of Time". *The Economic Journal*, 75, 493–517.

Blok, P. M. and J. Klooster (1989): *Forecasting Airpollution by Car Traffic Simulation (hoofdrapport).* NEI, Rotterdam.

BMW (1994): *Kalkulation der Volkswirtschaftlichen Kosten durch behinderten Verkehr*. BMW, München.

Boose, J. and B. van Wee (1995): "Invloed van Prijsmaatregelen op Autobezit, en -gebruik, Energiegebruik en Emissies". Paper presented at Colloquium Vervoersplanologisch Speurwerk, CVS, Delft.

Borger, B. de, I. Mayeres, S. Proost and S. Wouters (1996): "Optimal Pricing of Urban Passenger Transport, A Simulation Exercise for Belgium". *Journal of Transport Economics and Policy*, 30, 31-54.

Bovy, P. H. L., A. L. Loos and G. C. de Jong (1991): *Effecten van de Openstelling Ringweg Amsterdam; Integraal Eindrapport.* Dienst Verkeerskunde, Rijkswaterstaat, Rotterdam.

Bradley, M. A. and A. J. Daly (1997): "Estimation of Logit Choice Models using mixed stated-preference and Revealed-preference Information". In P. Stopher and M. Lee-Gosselin (Eds.): *Understanding Travel Behaviour in an Era of Change.* Pergamon, Oxford.

Brown, M., C.-D. Dünkel, F. S. Pekhterev and C. Teo (1996): "Rail Market Research in the CIS". *Proceedings of 24th PTRC European Transport Forum; Seminar A.* Brunel University.

Bureau Goudappel Coffeng (1990): *Flankerend Overheidsbeleid, Samenvattende Rapportage, Effecten van Wijzigingen in Kosten en Kwaliteit van Openbaar Vervoer.* BGC, Deventer.

Christie, C. (1995): "The Effects of Congestion on Drivers' Behaviour". *Proceedings of the 23rd PTRC European Transport Forum, Seminar F*, 41–56.

Clark, S. D. (1996): "National Multi-modal Travel Forecasts Literature Review Aggregate Models". Working paper 465; Institute for Transport Studies, University of Leeds.

Daly, A. J. (1996): "Estimating Values of Travel Time". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Dargay, J. M. and P. C. Vythoulkas (1999): "Estimation of a Dynamic Car Ownership Model: A Pseudo-panel Approach". *Journal of Transport Economics and Policy*, 33, 287–302.

Deaton, A. and J. Muellbauer (1980): *Economics and Consumer Behavior*. Cambridge University Press, Cambridge.

Department of Transport (1989): *National Road Traffic Forecasts (Great Britain) 1989*. HMSO, London.

Department of Transport (1997): *National Road Traffic Forecasts (Great Britain) 1997*. HMSO, London.

Department of Transport (1997): *Guidance on Induced Traffic; Design Manual for Roads and Bridges 1997*. HMSO, London.

EURET (1994): *Concerted Action 1.1 - Cost-benefit and Multi-criteria Analysis for New Road Construction*. EURET project.

Forschungsgesellschaft für Straßen- und Verkehrswesen (1996): *Empfehlungen für Wirtschaftlichkeitsuntersuchungen von Straßen (ESW-96)*; FSV, Köln.

Fowkes, A. S. (1996): "Issues in Evaluation: a Justification for Awarding all Time Savings and Losses, Both Small and Large, Equal Unit Value in Scheme Evaluation". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Fowkes, A. S., N. Sherwood and C. A. Nash (1993): "Segmentation of the Travel Market in London: Estimates of Elasticities and Values of Time". ITS Working Paper 345, The University of Leeds.

Gallez C. and J.L Madre (1993): "Démêler ler facteurs structurels et économiques: la dynamique de l'usage de l'automobile". In INRETS: *Dixièmes journées de micro économie appliquée*; SFAX, Paris.

Galli, M. O., M. Pursula, D. Milne, M. Keranen, M. Daleno and M. Vougioukas (1997): *Assessing the Impact of Integrated Trans Modal Urban Transport Pricing on Modal Split*. TRANSPRICE project, York, England.

Geurs, K. and B. van Wee (1996): "Effecten van Prijsbeleid". Paper presented at Colloquium Vervoersplanologisch Speurwerk; CVS, Delft.

Gibbons, E., M. O'Mahony and D. O'Sullivan (1998): *Evaluation of Transport Policy Options Using Welfare as an Indicator*. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Goodwin, P. B., T. H. Oum, W. G. Waters II and J. S. Yong (1992): *An Annotated Bibliography on Demand Elasticities*. Transport Studies Unit report 682; TSU, University of Oxford.

Gunn, H. F. (1987): *Level-of-service Elasticities from NSES*. HCG, The Hague.

Gunn, H. F. (1996): "Research into the Value of Travel Time Savings and Losses; The Netherlands 1985 to 1996". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Gunn, H. F., M. A. Bradley and C. L. Rohr (1996): "The 1994 National Value of Time Study of Road Traffic in England". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Hague Consulting Group (1990): *The Netherlands' "Value of Time" Study: Final Report*. Report for Dienst Verkeerskunde, Rijkswaterstaat; HCG, The Hague.

Hague Consulting Group (1991): *Elasticiteiten Volgens het Landelijk Model.* HCG, The Hague.
Hague Consulting Group (1991): *De Effecten van Rekening Rijden Volgens het Landelijk Model - Rapport B.* HCG, The Hague.
Hague Consulting Group (1992): *Lange Afstands Zakelijk Verkeer in het Landelijk Model.* HCG, The Hague.
Hague Consulting Group (1996): *Rapport de Validation.* Rapport Final Préparé pour le Compte de Syndicat des Transport Parisiens. HCG, Paris.
Hague Consulting Group (1997): *ILCM, Integrale Luchthaven Competitie Model; Losbladige Documentatie.* HCG, The Hague.
Hague Consulting Group (1998): *Value of Dutch Travel Time Savings in 1997 - Volume 1; Report for Adviesdienst Verkeer en Vervoer.* HCG, The Hague.
Hamerslag, R. (1984): "Mobiliteitsontwikkeling in de Komende 15 Jaar". *Verkeerskunde*, 35, 360–64.
Hamerslag, R., L. H. Immers and W. H. Scheltes (1986): *The Influence of Economic Recession and Changing Fuel Prices on Car Mobility in the Netherlands.* Department of Civil Engineering, Delft University of Technology.
Hensher, D. A. (1977): *Value of Business Travel Time.* Pergamon Press, Oxford
INRETS (1997): *MATISSE, Test de la Version du 15/05/97, Document Technique.* INRETS, Paris.
Institute of Transport Economics (TØI) and Hague Consulting Group (1990): *A Model System to Predict Fuel Use and Emissions from Private Travel in Norway from 1985 to 2025; Final Report to the Norwegian Ministry of Transport for the "Climate project".* HCG, The Hague.
Internationales Verkehrswesen (1992): "Berücksichtigung projektbedingter Ersparnisse an Reisezeit im nicht-gewerblichen Personenverkehr bei der Planung von Verkerhswegen des Bundes". *Internationales Verkehrswesen*, 44 (1992) 12. Heft, Dokumentation 175, 493–94.
Jager, J. M. (1985): "De Invloed van Brandstofprijzen op het Autopark en de (Auto)mobiliteit". Paper presented at Colloquium Vervoersplanologisch Speurwerk; CVS, Delft.
Jansson, K. (1994): "Valuation of Travel Time and Information — With and Without the Use of a Timetable". *Proceedings of 22nd PTRC European Transport Forum, Seminar G*, 97–109, University of Warwick.
Jara-Díaz, S. R., (1994): "A General Micro-model of Users' Behavior: The Basic Issues". Paper presented at the 7th International Conference on Travel Behaviour; Valle Nevado, Santiago, Chile.
Jara-Díaz, S. R. (1996): "Income, Leisure and Value of Time from Discrete Choice Models". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.
Jincheng, N. I. (1996): "Valeur du Temps: Log-normalité, Choix Modal et Modèles de Prévision". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.
Jong, G. C. de (1989): "Some Joint Models of Car Ownership and Car Use". Ph.D. thesis, Faculty of Economic Science and Econometrics, University of Amsterdam.
Jong, G. C. de, M. A. Gommers and J. P. G. N. Klooster (1992): "Time Valuation in Freight Transport; Method and Results". *Proceedings of 20th PTRC Summer Annual Meeting, Manchester.*
Jong, G. C. de (1997): "A Microeconomic Model of the Joint Decision on Car Ownership

and Use". In Stopher, P. and M. Lee-Gosselin (Eds): *Understanding Travel Behaviour in an Era of Change*; Pergamon, Oxford.

Jong, G. C. de, D. F. Ettema, H. F. Gunn, Y. H. F. Cheung and H. J. Kleijn (1998): "Preparatory Research into Updating Values of Travel Time in The Netherlands". Paper to be presented at 8th WCTR Conference, Antwerp.

Kampmann, C. (1995): *Empirische Analyse der Verteilungswirkungen Umwelt-politischer Instrumente am Beispiel einer erhöhten Mineralölbesteuerung.* Institut für Sozialwissenschaften, Ruhr-Universität Bochum.

Keuchel, S. (1994): *Wirkungsanalyse von Maßnahmen zur Beeinflußung des Verkehrmittelwahlverhaltens; Eine Empirische Untersuchung des Berufsverkehrs der Stadt Münster.* Universität Münster

Mackett, R. L. (1984): *The Impact of Transport Policy on the City*. TRRL publication SR 821, TRRL, Crowthorne.

Mackie, P. (1996): "Outstanding Issues for Evaluation". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

McDonald, J. F. (1983): "Route Choice and the Value of Commuting Time". *Transportation Research*, 17b, 463–70.

Marshall, A. (1890): *Principles of Economics.* MacMillan, London.

Mouchart, M. and A. M. Rutgeerts (1983): *Le Choix du Mode de Transport dans les Déplacements Domicile-travail; Analyse du Systeme Energetique.* University of Louvain.

MuConsult (1992): *Evaluatie Tussenbalans: Effecten van Verandering in Vervoers-kosten op de Mobiliteit.* MuConsult, Amersfoort.

MVA Consultancy (1987): *LDTM Travel Demand Elasticities.* MVA, London.

MVA Consultancy, ITS University of Leeds, and TSU University of Oxford (1987): "Value of Travel Time Savings". *Policy Journals*, Newbury, Berkshire, England.

Nederlands Economisch Instituut (1986): *De Emissies bij het Bezit en Gebruik van Personenauto's 1981–2000.* NEI, Rotterdam.

Ortuzar, J. de D. (1996): "Main Sources of Data for Value of Time Estimation". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Ortuzar, J. de D. and P. M. Armstrong (1995): "Confidence Intervals and the Social Value of Travel Time Savings". *Proceedings of 23rd PTRC European Transport Forum*, University of Warwick.

Pekkarinen, S. M. (1993): "Gender and Life-cycle Effects on the Values of Travel Time in the Mode Choice Model". *Proceedings of 21st PTRC European Transport Forum, Seminar D*, 123–38, Manchester.

PLANCO Consulting GmbH and Heusch-Boesefeldt GmbH (1991): *Aktualisierung der Kosten für die BVWP*. PLANCO and Heusch-Boesefeldt, Essen/Aachen.

Polak, J., P. Jones, P. Vythoulkas, R. Sheldon and D. Wofinden (1993): "Travellers' Choice of Time of Travel Under Road Pricing". Paper presented at 21st PTRC European Transport Forum, Manchester.

Pronk, M., M. Gommers and P. Blok (1991): "Elasticiteiten van de Vraag naar Brandstof". Paper presented at Colloquium Vervoersplanologisch Speurwerk, CVS, Delft.

Pursula, M. and J. Kurri (1996): "Value of Time Research in Finland". Paper for the Course and Seminar on Value of Time; Easthampstead, Berkshire, England.

Ramjerdi, F. (1994): "Some Evidence on the Impact of the Toll Ring in Oslo". *Proceedings of 22nd PTRC European Transport Forum, Seminar G*, University of Warwick.

Ramjerdi, F., L. Rand and K. Sælensminde (1996): "The Norwegian Value of Time Study: Some Preliminary Results". Paper for the Course and Seminar on Value of Time;

Easthampstead, Berkshire, England.
Ramjerdi, F., L. Rand and K. Sælensminde (1997): *The Norwegian Value of Time Study*. Report 379/1997, Institute of Transport Economics, Oslo.
Ramjerdi, F., J.-E. Lindjord and G. Pepping (1997): *Comparative Assessment of Cost Elasticity Values in Each Member State*. EXTRA project for EC-DGVII, Deliverable No. 4
Rosenberg, F. A., H. Meurs and E. Meijer (1997): "Grote Prijsveranderingen: Een Empirische Budgetrestrictie-benadering". Paper presented at Colloquium Vervoers-planologisch Speurwerk; CVS, Delft.
Selvanathan, E. A. and S. Selvanathan (1994): "The Demand for Transport and Communication in the United Kingdom and Australia". *Transportation Research* 28B, 1–9.
Serpa, A. de (1971): "A Theory of the Economics of Time". *The Economic Journal*, 81, 828–46.
Standing Advisory Committee on Trunk Road Assessment (SACTRA) (1994): *Trunk Roads and the Generation of Traffic*. HMSO, London.
Terzis, G., M. Dix, J. Bates and G. Dawe (1995): "Effects and Elasticities of Higher Fuel Prices". *Proceedings of 23rd PTRC Summer Annual Meeting, Seminar C*, University of Warwick.
Toner, J. P., M. Wardman and G. A. Whelan (1995): "Competitive Interactions in the Inter-urban Travel Market in Great Britain". *Proceedings of 23rd PTRC European Transport Forum, Seminar F*, University of Warwick.
TRACE consortium (1998): *Deliverable 1: Outcomes of Review on Elasticities and Values of Time*. TRACE Consortium, The Hague.
TRACE Consortium (1998): *Deliverable 2: Theoretical Structure and Prototypical Contexts*. TRACE Consortium, The Hague.
TRACE Cnsortium (1998): *Deliverable 3: National Elasticities*. TRACE Consortium, The Hague.
TRACE Consortium (1999): *Deliverable 4: Model Applications and Sketch Planning Model*. TRACE Consortium, The Hague.
TRACE Consortium (1999): *Deliverable 5: Elasticity Handbook*. TRACE Consortium, The Hague.
Train, K., and D. McFadden (1978): "The Goods/Leisure Trade-off and Disaggregate Work Trip Mode Choice Models". *Transportation Research*, 12, 349–53.
Vaes, T. (1982): "Forecasting Petrol Consumption". Paper presented at PTRC Summer Annual Meeting, University of Sussex.
Waard, J. van der (1990): *Koncept Elasticiteiten Handboek*. Rijkswaterstaat, Dienst verkeerskunde, Rotterdam.
Wardman, M. (1997): "Disaggregate Inter-urban Mode Choice Models: A Review of British Evidence with Special Reference to Cross Elasticities". Working Paper 504; Institute of Transport Studies, University of Leeds.
Wardman, M. (1997): "Disaggregate Urban Mode Choice Models: A Review of British Evidence with Special Reference to Cross Elasticities". Working Paper 505; Institute of Transport Studies, University of Leeds.
Wardman, M. (1997): "A Review of Evidence on the Value of Travel Time in Great Britain". ITS Working Paper 495, ITS, University of Leeds.
Wardman, M. and P. Mackie (1997): "A Review of the Value of Time; Evidence from British Experience". *Proceedings of 25th PTRC European Transport Forum*, Brunel University, London.

Webster, F. V. and P. H. Bly (eds.) (1980): *The Demand for Public Transport; Report of an International Collaborative Study*. TRRL, Crowthorne.

Winkelbauer, S. (1996): "Cost-benefit Analysis of Transport Policy Measures: Valuation Based on Shadow Prices or Willingness to Pay". *Proceedings of 24th PTRC European Transport Forum; Seminar D+ E*, Brunel University, London.