6

Transport resistance factors: time, money and effort

Jan Anne Annema

6.1 INTRODUCTION

As explained in Chapter 2, passenger and freight transport volume is determined by the locations of activities, needs and resistance factors. This chapter aims to describe the transport resistance factors and their impact on passenger and freight transport demand.

From a physical perspective, resistance is everything that stops or obstructs a force. In this image the locations of activities and the need for trips are 'forces', resulting in transport. Resistance factors such as travel time, money costs and effort obstruct these 'forces'. The lower the resistance factors, the higher the amount of transport. For, with low resistance factors even the less important trips will still be made. The opposite is true also: the higher the resistance factors, the lower the amount of transport.

Economists use other jargon but the same basic idea as used in the physical analogy to explain transport. In the economic utility theory, the idea is that a trip results in benefits (see also Chapter 2), for if there are no benefits the trip would not be made. At the same time, the trip comes with costs – the resistance factors. The trip takes time, perhaps a fare or petrol has to be paid and perhaps the trip has to be made in a highly busy and too warm train compartment. The utility theory (see also Chapter 3) states that only if the benefits outweigh the costs will the trip be made. Thus, in countries or regions with poor road infrastructure and, consequently, high costs, relatively few long-distance road trips – only the highly beneficial ones – will be made. Here, it is important to realize that resistance factors not only influence the amount of transport but also the modal choice. For example, if rail carriers succeed in improving rail freight services (e.g., lowering costs, increasing frequencies) some freight will probably be shifted from road to rail.

It is clear from the previous paragraphs that, in this chapter, we define transport resistance broadly. Resistance is not only related to travel time and monetary costs but also to the more vague but sometimes important concepts of 'effort' in passenger transport and 'transport services' in freight transport. Effort and transport services are terms for a broad class of factors influencing the decision to make a trip, such as discomfort, worries about reliability, et cetera.

Most of these ‘effort’ factors influence the decision to travel or to transport goods negatively. Perhaps the only exception is the effort-related factor ‘health benefits’ which people experience when travelling in an active mode which may influence the decisions to travel in a positive way (for more on health and transport, see Chapter 12). Economists sometimes use the term generalized travel or transport costs. With this term, they mean the whole of transport resistance factors. In most cases, they add up all the different transport resistance factors into one generalized travel cost unit, mostly a monetary unit, sometimes a time unit.

Transport experts often speak of demand and supply factors to explain transport volumes. In these terms, forces and resistance factors can also be recognized. For example, a demand factor for freight transport is the number of goods produced and consumed at different locations. A supply factor for freight transport is the infrastructure quality which determines freight transport transit times and tariffs. The final freight transport volume is a result of interaction between demand and supply, or, in other words, between transport attraction forces and resistance.

The importance of resistance factors such as travel time and travel out-of-pocket money costs will be explained in this chapter using so-called elasticities, amongst others (see Chapter 3). In economics, elasticity is the ratio of the percentage change in one variable to the percentage change in another variable. Elasticity in this chapter is a tool for explaining the responsiveness of transport volumes to changes in resistance factors such as travel time and money. For example, the fuel price elasticity of car use explains the responsiveness of car use to changes in fuel price. If the fuel price elasticity is -0.2 it means that a fuel price increase of 1% results in a car use decrease of 0.2%, all other factors explaining car use being equal.

Sections 6.2 to 6.4 discuss the resistance factors time, money and effort for passenger transport respectively. The impact of resistance factors on freight transport is explained in section 6.5. Section 6.6 summarizes the main conclusions.

6.2 THE ROLE OF TRAVEL TIME IN PASSENGER TRANSPORT

6.2.1 Travel Time Components

The time required to make a trip is an important resistance factor. Table 6.1 shows that travel time can be unravelled in different components.

When comparing total travel time from origin to destination between different transport modes, it could be an idea to just add up all the different time components (Table 6.1). However, by doing so the comparer forgets that people value time components differently. For example, public transport waiting time can be perceived as especially burdensome when travellers have to wait in difficult environments, such as in cold, hot or rainy weather, or in a seemingly unsafe or insecure condition. In a large UK study, it was found that on average London bus travellers value changes in their waiting time two times more than changes in their in-vehicle time (Lu et al., 2018). Iseki et al. (2006) found that car time spent in congested traffic conditions is, on average, valued 34% more highly than time spent in free-flow traffic.

Table 6.1 Possible travel time components from origin to destination (from top to bottom) for four modes of transport

Time – passenger transport			
Car	Public transport	Bike	Walking
	Hidden waiting time[a]		
Walking time to the parking lot	Time to get to the bus stop, bus, train or metro station	Time to get to the bike storage location	
In-vehicle travel time: free-flow time congestion time	In-vehicle travel time	Biking time	Walking time
Time to find the parking lot	Walking time transfer	Time to store bike	
Walking time from parking lot to final destination	Waiting time transfer	Time to get from bike storage facility to final destination	
	Time to get from bus, train or metro station to final destination		

Note: [a] Public transport travellers are dependent on the departure schedule as decided by the transport companies. Therefore, travellers sometimes have to wait at their origin location before it makes sense for them to depart.

In other words, people are willing to pay more money to avoid congestion time than to have lower free-flow in-vehicle time. To state the obvious: people feel more resistance to congestion time than to free-flow time.

In some transport studies, researchers apply a weighted summation for the different time components (Table 6.1). In such summations, e.g., one-minute walk time in a public transport transfer weighs heavier than one-minute in-vehicle time.

6.2.2 Value of Time

As already remarked in the introduction to this chapter, the basic economic idea is that people and shippers choose transport modes with the lowest resistance. If only travel time determines resistance, people and shippers would choose the fastest transport mode. For, with faster modes people get more time to carry out their preferred activities such as shopping, visiting family and friends and doing fun activities on their holidays. Also, shippers tend to prefer low freight travel times because in that case, they can transport the same amount of goods with fewer vehicles and fewer personnel, and, thus, save money. Therefore, in transport economics, the concepts of Value of Travel Time (often abbreviated to VOTT) or Marginal Value of Travel Time Savings (MVTTS) play an important role (see also Chapters 3 and 13). MVTTS can be considered as the 'best' term from a theoretical perspective because MVTTS clearly expresses that people value the change in travel time. Marginal in economics relates to costs or benefits of the change (e.g., ten minutes extra or less travel time). For sake of simplicity, in this chapter, the term VOTT will be used from now on.

Table 6.2 gives, as an illustration, some VOTT estimates for short- and long-distance trips by car for different travel purposes (Van Essen et al., 2019). The table shows that per country VOTTs differ which can be explained by income differences between countries. High-income people are on average willing to pay more for travel time savings compared to people with lower incomes. In transport cost–benefit analyses (see also Chapter 15), many countries ignore this difference for ethical reasons, departing from the idea of 'Equity Value of Time'. We refer to Börjesson and Eliasson (2019) for a discussion on this concept. Also, the table shows that people value their travel time less when they travel to family/friends, go shopping or do something recreational ('personal' reasons to travel) compared to travel time for business and commuting trips.

Table 6.2 Value of travel time estimates for car trips for a selection of European countries by travel purpose, euro/hour

Country	Short distance (urban)		Long distance (inter-urban)	
	Commuting – business	Personal	Commuting – business	Personal
Austria	16.9	7.8	19.8	7.8
Belgium	15.6	7.2	21.2	7.2
Bulgaria	6.5	3.0	8.5	3.0
Cyprus	11.0	5.1	12.5	5.1
Croatia	8.0	3.7	9.6	3.7
Czech Republic	11.6	5.4	14.0	5.4
Denmark	16.4	7.6	20.7	7.6
Estonia	10.0	4.6	12.1	4.6
Finland	14.5	6.7	20.6	6.7
France	13.8	6.4	15.7	6.4
Germany	16.4	7.6	20.0	7.6

Source: Van Essen et al. (2019), in prices 2018.

The VOTT refers to the amount of money consumers or shippers are willing to pay to save a certain amount of travel time. In a cost–benefit analysis for new road infrastructure travel time savings (in money terms) are in most cases the most important societal benefit category.

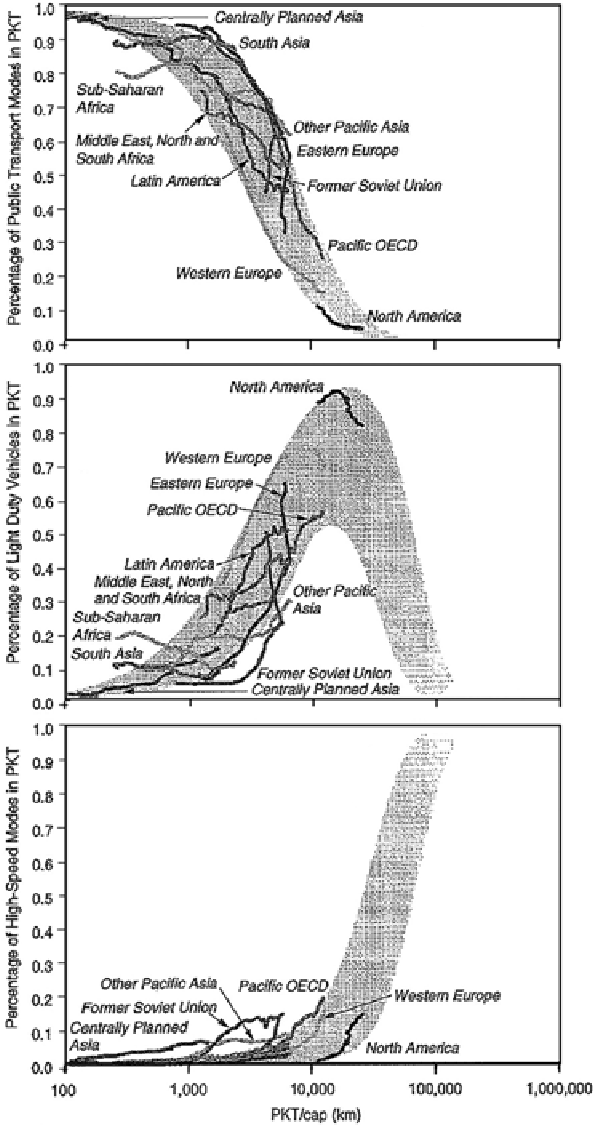
Different cities and countries have estimated total annual congestion costs: for example, £4.9 billion for London in 2019 (Inrix, 2022) and €3.3 to €4.3 billion in 2018 for the Netherlands (KIM, 2019). In these studies using VOTT estimates, the direct travel time losses compared to the 'ideal' free-flow situations are valued in monetary terms. These direct travel time losses are the main cost item in these estimates. In these estimates also so-called indirect travel time costs are considered. The reason is that in often congested areas some people and haulers will involuntarily choose to avoid the traffic jams. For example, some people will choose to go by public transport and some haulers will decide to change their planning by transporting goods outside rush hour. In both cases these involuntary choices are considered to be benefit losses (or costs) because in the free-flow situation these people and haulers would choose differently.

There is some expectation that in the future so-called autonomous vehicles (AVs) will be used instead of conventional cars. Theoretically, this might lead for the driver to a lower VOTT if s/he travels with an AV compared with a conventional car because s/he can now spend his/her time more usefully. Correia et al. (2019) indeed found in a Stated Choice experiment that the average VOTT for an AV with an office interior (5.50 €/h) to be lower than the VOTT for a conventional car (7.47 €/h). Pudane and Correia (2020, p. 327) point out that 'AVs may "give back" the travel time to the travellers.' In a large survey in the Netherlands, Pudane et al. (2021) found that respondents expect that they will spend their on-board time in an AV on activities such as more frequent work and meals, longer work and leisure.

6.2.3 Constant Time Budgets

Consumers devote a limited amount of their time to travel. This is not extraordinary. However, the remarkable aspect is that this limited travel time budget has remained relatively constant on average on a country level over the past decennia. Szalai (1972) and others carried out travel time research at the beginning of the 1970s in Eastern Europe, Western Europe and the United States. They concluded that the average travel time per person is similar in all three regions despite the large differences in transport means and infrastructure. Schafer and Victor (2000) concluded that on average people spend 1.1 hours on travelling. They do that in the US, in Europe, in Africa, in South America and so forth. Of course, on an individual level large differences in travel time exist between, for example, a person living in a small African village and an inhabitant of Shanghai, but on the most aggregate level travel time budgets seem to be similar and fairly constant (Mokhtarian and Chen, 2004), although these authors conclude that for different regions and times of study results for the average hour on travelling per person can be highly diverging. Stopher et al. (2017) used data of GPS devices and found in their study that the average expenditure of travel time is around an hour per person per day. They found significant difference in travel time per person per day at a disaggregate level, although a majority (around 55%) average within ±15 minutes of the overall mean of 1 hour and 2 minutes.

The theory of constant travel time budgets on the most aggregate level has important implications, as illustrated by Figure 6.1 (Schafer, 2006). If people keep their time budgets constant, they will travel longer distances when the transport resistance factor 'time' decreases, all other things being equal. All over the World there was a tendency of increasing market share in person kilometres travelled of fast modes at the cost of the slower modes (Figure 6.1). Schafer (2006) expects this trend to continue; see the shaded surfaces in Figure 6.1. His expectation is based on two main assumptions. First, people or households will need a higher absolute transport money budget in the future in order to be able to afford the faster but more expensive travel modes. As the world has shown on average continuing economic growth (despite some occasional major dips), this first assumption of an increasing absolute household transport budget seems not to be too wild. Secondly, faster transport modes will have to be available in the future. Also, this assumption seems not to be too far off from reality as, for example, many governments at the time of writing this book chapter (June 2022) invest or have plans to invest in new airports capacity and high-speed rails.



Source: Schafer (2006).

Figure 6.1 Three phases in worldwide persons mobility development (1950–2000): the decreasing share of the relatively slow public transport (top), the growth and decline of the passenger car (middle) and the start of the high-speed era (high-speed trains and aircraft)

If transport resistance factor time decreases and, consequently, people travel long distances, the question is: why? Faster transportation options could also result in smaller travel time budgets because, thanks to the speed increase, people could decide to travel the same distance in less travel time; in other words, they could trade-off their travel time for spending time on other things. Still, the constant Travel Time Budget (TTB) combined with faster transport modes seems to imply that people on average prefer to expand their distances. Marchetti (1994) thinks of an anthropologic explanation. According to him, history shows that humankind lives just like an animal defending and expanding its territory. Trying to find and explore new territories located farther away is a basic instinct, in his view. Thus, if travel time resistance is increasingly lower, people tend to expand their territory. Economists argue that the probability of finding a new partner, a new job or a new house that satisfies people's preferences is perhaps higher in a larger searching area compared to looking in one's own village or town. Thus, chances for higher benefits drive the need for travelling longer distances, according to them. Others point at novelty- or variety-seeking behaviour as explanations for a drive for travelling (for example, Lal, 2006 explains long-distance migration partly on genetic causes). An interesting question is if teleactivities will replace physical travel. In a large review study, Mouratidis et al. (2021) conclude that teleactivities may substitute some trips but generate others. They found that telecommuting and teleconferencing may result in reductions in total travel distances. However, their study showed that online shopping, online education, teleleisure, telehealth and online social networking do not seem to reduce overall travel distances, as, in line with a constant TTB, the time saved by these online activities on physical travel may be spent on travelling to other destinations.

6.2.4 Travel Time Elasticities, Induced Traffic

As mentioned in the Introduction the responsiveness of people to travel time changes are often expressed in elasticities. In scientific and applied transport research papers and reports, the reader can find many studies on travel time elasticities (e.g., Goodwin, 1996; de Jong and Gunn, 2001; Hensher, 2008; Paulley et al., 2006; Dunkerley et al., 2018; Litman, 2021).

We just give one example. In a large European study de Jong and Gunn (2001) compared modelled car travel time elasticities for commuting between different European regions: the Brussels region (Belgium), Italy and the Netherlands. They found short-term (less than one year) elasticities of -0.31 (Brussels), -0.87 (Italy) and -0.64 (the Netherlands), and long-term elasticities of -0.49 (Brussels), -1.38 (Italy) and -2 (the Netherlands). This example illustrates five important aspects:

1. In interpreting elasticities it is always important to be aware of the specifications. In this case, the travel time elasticity is only related to car commuting travel volumes.
2. It is always important to realize that the difference between the elasticities could be explained because of methodological reasons. It is for the purpose of this book too much detail to discuss methodological issues related to transport elasticities (see Hensher, 2008, for an assessment of systematic sources of variation in public transport elasticities). Here, the main message is that whenever elasticities from other studies are used the user should be aware of the influence of methodological choices on the outcomes.
3. The same elasticity may differ significantly between regions and/or countries, as this example shows, because of different transport circumstances. For example, the regions may differ significantly in public transport quality and availability which makes substitution to public transport when car travel time increases in one region far easier compared to another region. So, this example shows that it is quite risky in policy studies to transfer

uncritically elasticities established for one specific region or country to another. If these elasticities are then used for 'another' region to estimate a policy impact, for example, of a measure to increase public transport travel times, the policy conclusions could be highly wrong.

4. The long-term elasticities are higher compared to the short-term elasticities. This is an often occurring phenomenon related to the fact that in the long term people have more choice options when travel times decrease such as moving or looking for another job compared to the short term.
5. Car commuting is relatively sensitive to travel time changes. The long-term elasticities are often higher than -1 while the average travel time is -1 based on constant travel time budgets (Goodwin, 1996).

From a policy planning perspective, the notion that people are sensitive to travel time changes leads to an important consequence. When governments invest in extra road capacity to relieve present or expected future congestion – as they often do all over the world – new traffic will be generated. Generated traffic refers to all the traffic which would be present if an expansion of road capacity occurred, which would not be there without the expansion (Goodwin and Noland, 2003). These authors also state that the generated traffic hypothesis implies, in essence, that there exists a demand curve for travel – the cheaper the travel, the more will be demanded. So, one effect of making transport 'cheaper' (i.e., faster) by building new roads or extra road lanes is that it results in generated traffic. Generated traffic is also related to the indirect travel time losses; see before. Consequently, congestion relief will be less than anticipated, or shorter in duration, than if there is no such extra traffic. This will influence the cost–benefit appraisal (CBA; see Chapter 15) of the road project, as well as environmental impacts. An elasticity can be estimated that relates the percentage increase in travel demand (vehicle kilometres travelled) to the percentage decrease in travel times due to the added road lanes. Drabicki et al. (2020) summarize the literature on this topic and found that the exact value of elasticities (travel time change due to added road lanes for vehicle kilometres travelled) vary in specific case studies; the literature review part in their paper suggests that the elasticities range usually between -0.3 and-0.6 in the short-term horizon and around -0.5 and -1.1 in the long term. It is important to realize that the generated traffic consists of two kinds of 'new' traffic on the expanded roads, namely diverted traffic and induced traffic, as Drabicki et al. (2020) point out. Diverted traffic is traffic that without the expansion would travel via other roads or by public transport, for example. Induced traffic is really newly generated traffic. In the short and medium term this induced traffic consists of travellers that 'spontaneously' respond to the improved quicker opportunity to travel while in the long run, the improved roads could even induce traffic because people decide to move house or change jobs (or locations of other destinations) or because of other land-use shifts which expand their travel distances (see Figure 2.1 and Chapter 5). This explains the difference between the short- and long-term elasticities for generated traffic, as mentioned before.

6.2.5 Cross Travel Time Elasticities

In many countries policymakers hope to achieve policy goals such as less traffic jams and environmental benefits by investing in public transport. For example, the European Commission aims in their 2011 White Paper that by 2050, the majority of medium–long distance passenger transport (300–800 km) should be by rail, and that by the same year a European high speed rail network should have been completed (Pastori et al., 2018). Despite these ambitions and the expected extension of the high-speed rail network the share of high-speed rail in the modal share for medium–long distance is expected to only increase from 8% in 2020 to 10% in 2050. In this study in 2050 still 70% of all medium–long distance kilometres in Europe will be travelled by car and 13% by plane. This points at low responsiveness of car and aeroplane users to shift to high-speed rail when improvements in high-speed rail are carried out. A manner to express this responsiveness is using cross travel time elasticities. The term ‘cross’ means that these kinds of elasticities reflect the responsiveness of a percentage change in a characteristic in one mode (e.g., rail travel time changes) to a percentage change in the use of another mode (e.g., car use). Many cross-elasticities from different regions in the world can be found in Litman (2021). To give an example: Paulley et al. (2006) cite UK rail time cross-elasticities for car use of 0.057 and for coach use of 0.20 (based on a study Wardman, 1997). These figures imply that improving rail travel time will have a relatively low impact on car use. The impact on the competing coach market is higher. However, it is important to note that in absolute numbers the car use decrease may still be significant in the UK when train travel time increases by 1%. The reason is that car use expressed in car kilometres travelled has a high market share in the UK, implying that a 0.057% decrease is still a relatively high amount of absolute car kilometres that are substituted to train kilometres. With cross-elasticities it is always important to be aware of the market shares of the modes considered. Transferring a cross-elasticity estimated for a certain region to another region can give highly wrong policy information if the two regions differ significantly in transport mode market shares (Balcombe et al., 2004).

Nevertheless, the rather low car responsiveness is still disappointing for many politicians. One reason for the low responsiveness is that, next to travel time, consumers take other factors into account when deciding to take a certain transport mode. These include monetary costs (see Section 6.3) and effort (see Section 6.4). Also ‘inertia’ plays a role in the low responsiveness. Inertia relates to habit and refers to the tendency that the outcome of previous choices affect the present choice (La Paix et al., 2022 and Chapter 3 in this volume). The role of habit in decision-making is that people do not tend to consider all the pros and cons of a choice all the time. This practice saves time and energy. Taking the car for commuting could become a kind of a habit and the people with this habit are unaware of or not interested in – perhaps better put: they are less open – information on positive changes in competing transport modes. ‘Old habits die hard’ describes poignantly people’s travel behaviour, as people do not change their travel habits easily (Haggar et al., 2019). Changes in choices often happen only when large new events take place in people’s life such as obtaining a new job or when they move (Zarabi et al., 2019). Also large changes in transport mode characteristics could trigger reconsideration of transport mode choice such as the opening of a complete new train line to their village or suburb or ‘sudden’ large increases in road congestion.

6.3 THE ROLE OF TRAVEL MONETARY COSTS IN PASSENGER TRANSPORT

The second important resistance factor is the money people have to spend for the trip. Like travel time, monetary costs can be split in subcomponents (Table 6.3).

Table 6.3 Possible travel money cost components for four modes of transport

Money – passenger transport			
Car	Public transport	Bike	Walking
Depreciation costs	Fares	Depreciation costs	Depreciation costs (shoes)
Car maintenance costs	Costs for trip to and from station (e.g., taxi)	Maintenance costs	Repair costs (shoes)
Parking costs		Parking costs (in commercial storing facilities)	
Tolls		Insurance costs	
Fuel costs			
Taxes			
Insurance costs			

Monetary costs can be classified in many ways. An often-used classification is fixed costs versus variable costs. Fixed costs are the amount of money to be paid independent of the distance travelled; for example, depreciation costs and yearly annual taxes. In contrast, variable costs are dependent on the distance travelled, such as car fuel costs and public transport fares.

6.3.1 Constant Money Cost Budgets

There seems to be a constant money budget for persons mobility as a percentage of people's income. Schafer (1998) researched worldwide mobility expenditures and confirmed a previous result of Zahavi (1979): on average people per class of income tend to spend a constant share (10–15%) of their income on transportation. Mokhtarian and Chen (2004) comment that at the aggregate level travel expenditures indeed appear to have some stability but they found many empirical studies that gave widely different results related to different times of study and regions. One implication of this 'more or less' constancy at the very aggregate level is that if the resistance factor monetary costs increases travel decreases and vice versa, all other things being equal.

6.3.2 Price and Monetary Costs Elasticities

The responsiveness to monetary changes can be expressed in elasticities, like in the travel time case (Section 6.2). A large amount of transport price, fare and costs elasticities can be found (e.g., Litman, 2021 gives a large overview of all kinds of price and monetary costs which were estimated in studies from all over the world).

To avoid confusion, it is important to realize that in the literature one can find price and fare elasticities and travel costs elasticities. Price elasticities relate to the responsiveness to changes in prices such as fuel price. Travel or transport costs elasticities relate to behavioural changes dependent on actual costs changes. For example, suppose that in a certain region the price of petrol is 2.0 euros per litre. All car users who fill their car tank in that region have to pay this fuel price. However, the actual petrol costs per kilometre driven in that region can be 0.1 euros for a relatively fuel-efficient car user and 0.15 euros for a less fuel-efficient car user.

It seems plausible that fuel price increases will not only result in less car kilometres to avoid the increased travelling costs, but they will probably also result in the purchase of more fuel-efficient cars in order to avoid the costs to increase. In other words, it seems plausible that fuel price elasticities for fuel use are lower compared to fuel cost elasticities for fuel use. To put it differently, fuel price elasticities for car use will probably be lower compared to fuel price elasticities for fuel use; see below when will be shown that this phenomenon is indeed true.

It is impossible to fully summarize the huge amount of scientific research. Very broadly, one could conclude that empiric research worldwide shows that:

1. transport consumers are indeed price and cost sensitive;
2. the extent of their responsiveness is dependent on many factors (culture, income, time and so forth);
3. the responsiveness to price changes is fairly modest in most cases (elasticities are in most cases between 0 and 1).

An overview of fuel price elasticities of fuel demand for many different countries and over different periods of time (from 1970 to roughly 2010) can be found in Hössinger et al. (2017). Another example is the study by Geilenkirchen et al. (2009) who have summarized, as found in numerous studies and reviews, fuel price elasticities for car use and car ownership (Table 6.4a) and fare elasticities for public transport use (Table 6.4b). The numbers presented are applicable – more and less – for Western European countries. However, as in the case of the time travel elasticities (see before), it is important to stress that the specific elasticities for a region can differ considerably from the values presented in Table 6.4a and b dependent on the specific geographic, cultural and technical circumstances. For example, Hössinger et al. (2017) show lower price elasticities for fuel demand in the USA compared to European countries because, amongst others, in the USA average income levels are higher and fuel prices are (far) lower which implies that a percentage change in fuel price in the USA has much less impact on the US consumer compared to a percentage change in fuel price in Europe by the European consumer. The elasticities presented in Tables 6.4a and 6.4b have to be considered indicative.

Table 6.4a Indicative fuel price elasticities

	Short term (1 year)	Long term (5 to 10 years)
Car ownership	−0.05 to −0.2	−0.1 to −0.65
Car use	−0.1 to −0.2	−0.25 to −0.5
Car fuel efficiency	0.1 to 0.15	0.3 to 0.4
Car fuel use	−0.25 to −0.35	−0.6 to −0.8

Source: Geilenkirchen et al. (2009).

Table 6.4b Indicative fare elasticities

	Short term (1 year)	Long term (5 to 10 years)
Bus	−0.2 to −0.5	−0.6 to −1.0
Train	−0.3 to −0.7	−0.6 to −1.1
Metro	−0.1 to −0.3	−0.3 to −0.7

Source: Geilenkirchen et al. (2009).

Tables 6.4a and 6.4b show two interesting aspects. First, regardless the exact values, it is clear that the long-term fuel price elasticity for car use and car fuel usage are higher compared to the short-term elasticities. Hössinger et al. (2017) show exactly this same trend in elasticities for all countries and all periods they included in their study. Also, the price responsiveness for public transport usage is higher in the long term. The explanation is simple: in the short term, it is relatively difficult for people to make changes. In the longer term, this is different. Then, people can choose a different car or change their dwelling or job locations. Secondly, fuel price elasticities for car fuel use are indeed higher compared to the fuel price elasticities for car use, roughly two times (Table 6.4a). Especially in the long run, the elasticities (-0.6 to -0.8) show that as a response to a fuel price increase people do not only use their car somewhat less but, even more, they try to avoid higher fuel costs by purchasing more fuel-efficient cars or, eventually, by driving more fuel-economically.

Dargay and Gately (1997) concluded that consumers show a stronger response to price increases compared to price decreases. This implies that a fuel price increase followed by a price decrease of the same magnitude does not result in restoring the transport and fuel demand which occurred just before the price increase. Dargay (2007) found that an income increase has a greater impact on car ownership compared to an income decrease of the same magnitude. Also, in the relation between air fare changes and demand for aviation, there seems to be asymmetry. Wadud (2015) found for the US a short-run elasticity of demand during an air fare rise of 0.143, and for air fare fall of 0.113. In the long run, these differences are magnified: the long-run demand elasticities for an air fare rise and fall are 0.526 and 0.417, respectively. Wadud suggests that their results tend to agree with the prospect theory of Kahneman and Tvesrky (1979). In this theory, it is assumed that people tend to value losses (e.g., air fare increase) more than gains (e.g., air fare decrease).

6.4 EFFORT RESISTANCE FACTORS

Next to time and money, there are more resistance factors that determine the amount of passenger transport. We summarize these factors in this paragraph as ‘effort’ factors. ‘Effort’ may seem to be a relatively unimportant rest factor. However, Chapter 3 shows the existence of a large amount of social and psychological factors which influence travel behaviour.

Effort as a transport resistance factor consists of different aspects (Table 6.5).

Table 6.5 Possible effort aspects for four transport modes that are considered resistance factors

Effort – passenger transport			
Car	Public transport	Bike	Walking
Discomfort/ Physical and mental effort of car driving	Discomfort	Discomfort/ Physical effort[a]	Discomfort/ Physical effort[a]
(Mental) strain, stress	(Mental) strain, stress		
Reliability	Reliability	Accident risk	Accident risk
Accident risk	Physical effort (stairs, walks during transfer, luggage carrying)	Women – feelings of insecurity	Women – feelings of insecurity
Availability of information	Availability of information	Availability of information	Availability of information
	Women – feelings of insecurity		

Note: [a] As mentioned, physical effort due to cycling and walking is perhaps the only resistance factor that is also a kind of attractiveness factor. Some people may assess the physical effort of cycling and walking as just an additional reason to choose these modes, for example, for commuting. These modes give them an ‘easy’ daily opportunity to be weekly 150 minutes moderately physically active which is beneficial for their health (see Chapter 12)

We will now discuss some effort factors more in detail. We do not pretend to be exhaustive in all effort factors possible but we think we mention the most important ones.

6.4.1 Discomfort, Physical Effort, Status

The resistance factor discomfort contains a large number of different issues. Especially related to public transport discomfort is considered an important resistance factor. In Balcombe et al. (2004) and Paulley et al. (2006) different aspects are mentioned which may influence the comfort of public transport travelling: the waiting environment quality, the vehicle and rolling stock quality, the quality of the front-line staff to customers, crowding, seat-place availability, the quality of on-board facilities, cleanliness and the interchange quality between modes. In an Iranian study on intercity bus users, the viewpoints of bus users on their level of satisfaction were analysed (Ganji et al., 2021). A very diverse group of comfort factors were mentioned:

seat availability, seat cleanness, ticket reservation methods, bus appearance, driver respect for traffic rules and quiet bus with no disturbing engine noise.

For cycling discomfort factors related to the natural environment have a large influence on both the decision to cycle and the frequency (Heinen et al., 2010). These authors found, based on an overview of the literature on commuting by bicycle, that hilliness has a negative effect on cycling and weather has a large influence on the cycling frequency. Commuters are less influenced by temperature than other cyclists, implying that many people only choose to cycle for leisure purposes when the weather is pleasant (Heinen et al., 2010). Kask and Tan (2019) explored key factors influencing school-going children's choice to cycle in Tallinn, Estonia. They found as often mentioned hindering factors: 'there is no good cycle parking facility at school', 'cycling is unsafe because there are no good cycle paths', 'I do not feel comfortable while cycling' and 'my friends/classmates do not cycle to school'. So, also the 'uncoolness' of a particular mode can resist people from using it.

6.4.2 Reliability

A reliable transportation system means that travellers and hauliers can make trips according to their expectations, especially related to expected travel time. The USA Department of Transportation defines travel time reliability as a measure of the consistency, timeliness, predictability and dependability of a trip (FHWA/DoT, 2022). For example, a car commuter who faces every working day the 'same' traffic jam with a 30- to 40- minute delay loses travel time compared to free flow but still has a rather reliable trip. This commuter knows beforehand rather exactly what time (within a 10 minute spread) s/he will be at work or at home and can make arrangements accordingly. However, if the traffic jam in the day-to-day commute is unpredictable – sometimes it is only a few minutes, another day suddenly more than an hour – this commuting trip becomes highly unreliable. The consequence of the unpredictability of travel times means that people will have to adapt their behaviour but because of the unpredictability, they are uncertain about the best course of action. This uncertainty comes with a cost. So, like a VOTT, also a so-called Value of Reliability (VOR) exists which is people's willingness to pay to make their trips more reliable.

Table 6.6 Values of Reliability (VORs) on 2010 euros per hour per person, including VAT

	Car	Train	Bus, tram, metro	All surface modes	Air	Recr. navigation
Commute	3.75	4.75	3.25	4.00		
Business employee	14.50	18.00	12.00	15.50	56.00	
Business employer	15.50	4.75	9.75	12.25		
Business	30.00	22.75	21.75	27.75	56.00	
Other	4.75	4.50	3.75	4.50	30.75	0
All purposes	5.75	5.50	3.75	5.25	33.75	0

Source: Kouwenhoven et al. (2014).

Table 6.6 summarizes the VORs which are estimated to be used in Dutch cost–benefit analysis practices (see Chapter 15 for more on cost–benefit analysis). VORs in the Dutch context give people's willingness to pay for a smaller spread (smaller standard deviation) in their travel times. The table shows, amongst others, that for business purposes and aviation reliability in travel time is valued highest. For air travel, reliability is important because missing a transfer to another flight or arriving too late at the destination (and, for example, missing the arranged bus to the hotel) can be highly stressful and costly for people.

6.4.3 Travelling Information

Another effort resistance factor is *information*, or perhaps better put, the insufficient availability of travelling information or good quality travelling information. There are numerous studies on travel behaviour under limited knowledge (for an overview, see Chorus et al., 2006). These studies have uncovered travellers' dislike of knowledge limitations, and their inclination to reduce these knowledge limitations by acquiring information. Broadly speaking, traveller information relates to route information (en route and beforehand) and mode information (e.g., fares and travel times to be expected, waiting and bicycle storage facilities and so forth). The availability of high-quality traveller information can improve travelling comfort, trip reliability and decrease travel stress. Chorus et al. (2010) used search theory to evaluate the value of travelling information. Their results indicate, amongst others, that travellers prefer information that adds previously unknown alternatives to their choice set over information that provides estimates for uncertain attributes of known alternatives. As to be expected, Chorus et al. (2010) found substantial heterogeneity with respect to travellers' valuation of the costs and benefits of travel information.

Travel information and transport services increasingly become more digitalized. Without apps, PCs, laptops and iPads it becomes increasingly difficult to buy tickets or to find travel information. A potential new transport service – 'Mobility as a Service' (MaaS; see also Chapter 8) – is even completely dependent on digital technology. People can only book a preferred trip at a MaaS provider digitally, e.g., via a MaaS app. For one, digitalization is a good thing because it can lower travel resistance because people can find travel information easily and in real time and they can book transport services quickly and wherever they are. However, there is also a downside: digitization can also increase travel resistance for people who do not have access to digital technologies or who do not have the capabilities to understand digital tools. So, digital technology can for a part of the population lead to higher accessibility but also for a smaller part of the population to lower accessibility, i.e., digitization can lead to digital inequality (Durand and Zijlstra, 2020).

6.4.4 Travellers' Feelings of Insecurity

Travellers' feelings of insecurity is a resistance factor for public transport and the slow modes biking and walking. The factor relates to feelings of uneasiness when people travel, have to wait or transfer on stations or bus stops. Also, using dark or remote roads for biking and walking can be an unattractive endeavour. Heinen et al. (2010) mention darkness as a factor that results in people choosing to cycle less. There is increasing literature on transport and gender (e.g., Ceccato and Loukaitou-Sideris, 2020; Chowdhury and van Wee, 2020; Stark and Meschik, 2018). This literature shows that women experience especially high levels of perceived insecurity – and particularly in relation to sexual harassment and assault – compared to their male counterparts. Women also experience more superficial incidents such as stalking, sexual slur, groping and other events with sexual undertones which can all fuel feelings of anxiety and fear in transit environments. These experiences make women adapt their behaviour in transit and they result in all kinds of mobility constraints for them, such as avoiding certain lines, not travelling at certain times of day, not travelling alone and so forth.

6.4.5 Accident Risk

People might fear that they or their children get involved in traffic accidents when they choose a certain transport mode. This fear might influence their mode choice. US data showed that in 1969 48% of children five to 14 years of age usually walked or cycled to school; in 2009 this decreased to 13% (The National Center for Safe Routes to School, 2011). Next to increased distances, the most important reason for this was ’traffic-related danger’. Also in the Estonian research (see before; Kask and Tan , 2019) worries about unsafe roads with no dedicated cycle paths were often mentioned as a reason not to cycle to school.

6.4.6 Mental Strain, Stress

Stress can be seen as an indicator of the importance of effort resistance factors. Wener and Evans (2011) compared the stress of car and train commuters in Metropolitan New York City. In their paper, they mention several studies that relate travel effort factors to stress such as crowded trains, discomfort from poor design, feelings of no control (a car driver often finds that he or she has more control over a particular trip when driving a car compared to using public transport) and unpredictability. Wener and Evans (2011) found that car commuters showed significantly higher levels of reported stress compared to train commuters. Driving effort and predictability largely accounted for the elevated stress associated with car commuting, according to this study.

6.4.7 Specific Constants

The resistance factors, time and money, are often objectively measurable, however this is far more difficult for most of the effort resistance factors. An often-used method to include effort components in the total resistance factor is using specific weighting factors for the different parts of the trip such as the already mentioned penalties for waiting time or arriving unexpectedly too early at the destination. In transport models often so-called alternative specific constants are used in the resistance functions per transport mode in order to include all kinds of effort components (Chapter 16).

6.5 GOODS TRANSPORT AND RESISTANCE FACTORS

In Sections 6.2 to 6.4, we have focused on passenger transport. Therefore, in this section, we focus specifically on the role of transport resistance factors in freight transport. Broadly speaking, shippers and hauliers take transport resistance factors into account similar to consumers. Monetary costs and transit time are also important factors shippers consider when deciding on a specific transport mode. Additionally, ‘transport service quality’ (reliability, frequencies and so forth) plays a role in the decision-making process to transport freight and by what mode. Like the ‘effort’ factor this may seem a vague resistance factor, but increasing empirical evidence shows that it is an important factor.

6.5.1 Transport Time

It seems obvious that in freight transport actors are willing to pay for transport time savings. For example, when due to infrastructural improvements freight transport time is saved carriers can deliver the same amount of goods in less time compared to the situation without the infrastructural improvement, and, by doing so, save personnel and vehicle operating costs. Binsuwadan et al. (2021) performed a large meta-analysis to explain variations in the value of freight travel time savings (VFTTS). Both carriers who transport goods and shippers who supply or own the goods (see also Chapter 4) value transport time savings. Table 6.7 gives for a selection of countries from their study the implied VFTTS. With ‘implied’ it is meant that their VFTTS values for the different countries are the results of their meta-model.

Three important observations can be made related to Table 6.7. First, like in VOTT for passenger transport, average income (GDP per capita) in a country has an important influence on the willingness to pay for freight travel times savings. Second, the different transport modes have very different VFTTS. Not surprisingly, the faster modes, especially air and to some extent road transport, have relatively high VFTTS. It can be assumed that these modes carry the relatively high value and more time-sensitive commodities (e.g., flowers, non-frozen food), for which it is relatively attractive to trade-off money when that would result in even shorter transport times. For lower value bulk commodities (mainly transported by rail, sea-going and inland shipping) decreasing freight transport times is far less important, and thus less valuable to do. Third, who is the decision-maker explains VFTTS. Carriers consider transport costs while shippers consider cargo costs of which transport costs are just one factor. So, a carrier is more willing to trade-off money against transport time savings because these time savings can, for example, via savings on the wages he has to pay his personnel, directly lower his transport costs and, thus, increase his profits.

Table 6.7 Implied values of travel time in freight transport ($ per-tonne/hour), 2017 incomes and prices for a selection of countries

Country	GDP per capita	Carriers		
		Road	Rail	Air
Netherlands	48,555	11.16	1.90	161.15
Nigeria	1969	0.86	0.15	12.40
Norway	75,704	15.92	2.71	229.91
Pakistan	1467	0.68	0.12	9.80
Philippines	2982	1.20	0.20	17.29
Poland	13,861	4.09	0.70	59.11
Russian Federation	10,751	3.34	0.57	48.24
Saudi Arabia	20,804	5.67	0.96	81.80
Singapore	60,298	13.27	2.26	191.64
South Africa	6127	2.13	0.36	30.77
Spain	28,208	7.23	1.23	104.37
Sweden	53,253	12.02	2.05	173.51
Switzerland	80,333	16.70	2.84	241.09
Thailand	6578	2.26	0.38	32.56
Turkey	10,5	3.28	0.56	47.34
United Arab Emirates	40,325	9.62	1.64	138.90
United Kingdom	39,932	9.54	1.63	137.82
United States	59,928	13.21	2.25	190.70

Source: Binsuwadan et al. (2021).

6.5.2 Monetary Costs

Like in the case of passenger transport, the monetary cost resistance factor for freight transport can be explained using elasticities. For example, Table 6.8 shows the responsiveness of road freight transport in the Netherlands for price increases. The figures are based on international literature but highly indicative as empirical data are relatively scarce. It should be noted that freight demand elasticity studies vary significantly in terms of the demand measure, data type, estimation method, commodity type and so forth (Li et al., 2011). According to Li et al. (2011), this wide variation makes it difficult to compare empirical estimates when the differences may arise partly from the methods and data used.

Table 6.8 Indicative price elasticities for road freight transport demand (in tonne kilometres)

Price elasticity, total[a]	-0.6 to -0.9
Whereof **substitution** (less tonne kilometres road transport, more tonne kilometres rail and/or barge, similar tonnes production and consumption)	-0.4 to -0.5
Whereof **less transport** (less tonne kilometres road transport, similar amount of tonne kilometres rail and/or barge, similar amount of tonnes production and consumption)	-0.2 to -0.4
Whereof **less production and consumption** (less tonne kilometres road transport, similar amount of tonne kilometres rail and/or barge, less tonnes production and consumption)	Low (<-0.1)

Notes: [a] The top row is a summation of the three rows underneath. The elasticities are valid for limited price increases.
Source: Geilenkirchen et al. (2009).

Many people argue that freight transport is non-responsive to price increases as transport costs have a modest share in final product prices. This can be debated. Rodrigue (2020) estimates, for example, that for a product with relatively low added value (stone, clay and glass) the share of transport costs in the product price can be 20% to 25% which is not modest. For higher value products this share is indeed lower and in the range of only a few to 10%. As Table 6.8 illustrates for road transport, even a modest share does not mean that price increases will not affect road transport volumes (in tonne-kilometres) as shippers and carriers have different possible behavioural reactions to deal with a road price increase next to just passing on the price increase to the consumers of goods.

First, transport mode substitution may take place (Table 6.8 second row). Increase of road freight costs by, e.g., new taxes, tolls or oil price rises may entice shippers to switch to other modes such as rail. Secondly, carriers may react by trying to implement increased efficiency in the road freight sector (Table 6.8 third row) in terms of, for example, using larger vehicles (more tonnes per kilometre driven), reducing the number of empty runs (more tonnes per kilometre driven), improved loading (more tonnes per kilometre driven), buying more fuel-efficient trucks (fewer fuel costs per kilometre driven) and concentration in the haulier business (cost reductions because of less overhead). Thirdly (Table 6.8 fourth row), less production and consumption of freight may take place. Shippers may include (a part of the) higher transport costs in the final product price. It is imaginable that for some products the resulting higher prices lead to lower demand and, subsequently, lower production. Nevertheless, this third possible response to a transport price increase is not very strong as shown in Table 6.8. The reason is twofold. First – as remarked before – freight transport costs have only a modest share in final product prices. Secondly, by mode substitution and/or increased transport efficiency (more tonne per kilometre lifted) carriers will absorb some or all of the price increase.

6.5.3 Transport Service and Reliability

Shippers also take transport service quality and reliability into account when deciding to use a particular transport freight mode. For example, Kim et al. (2017) show that for New

Zealand shippers' reliability is an important factor in choosing a particular freight mode. The definition of reliability in this study was the probability of the cargo arriving within a given time. Additionally, also transport service factors, such as more frequent services and less risk for damage, influence their decisions. Kim et al. (2017) identified different classes of shippers, amongst others based on freight distance and specific product markets, and they show that per cluster identified the importance of the service and reliability factors can differ greatly.

6.6 CONCLUSIONS

The most important conclusions of this chapter are next:

1. Important transport resistance factors for passenger transport are travel time, monetary costs and effort. Passengers are responsive to changes in these resistance factors.
2. Important resistance factors for freight transport are transit time, monetary costs and transport services. Shippers and freight forwarders are responsive to changes in these resistance factors.
3. On an aggregated scale (large region or country level) it turns out that people on average tend to keep their travel time budget constant. Thus, on an aggregate level, people tend to exchange lower transport travel times for more kilometres travelled and not to spend the saved travel time on other activities.
4. Travel time and price elasticities for passenger transport, in the long run, are higher compared to short-term elasticities. This phenomenon is related to the fact that in the long term people have more choice options when travel times or prices change compared to the short term such as moving or finding another job.
5. A rise in transportation monetary costs for a certain mode results in less transport and/or mode shifts. However, higher fuel prices do not only result in less road transport and to a small extent to some mode shift but the higher prices also result in the purchase of more fuel-efficient cars. By buying more fuel-efficient cars people can avoid (a part of) the price increase and, thus, can continue to travel by car.

REFERENCES

Balcombe, R., R. Mackett, N. Paulley, J. Preston, J. Shires, H. Titheridge, M. Wardman and P. White (2004), *The Demand for Public Transport: A Practical Guide*, TRL report TRL593, accessed June 2022 at www.demandforpublictransport.co.uk/TRL593.pdf.

Binsuwadan, J., G. De Jong, R. Batley et al. (2021), 'The value of travel time savings in freight transport: a meta-analysis', *Transportation*, 49, 1183–1209, https://doi.org/10.1007/s11116–021–10207–2.

Börjesson, M. and J. Eliasson (2019), 'Should values of time be differentiated?', *Transport Reviews*, 39(3), 357–75, https://doi.org/10.1080/01441647.2018.1480543.

Ceccato, V. and A. Loukaitou-Sideris (eds) (2020), *Transit Crime and Sexual Violence in Cities: International Evidence and Prevention*, New York: Routledge.

Chorus, C.G., E.J.E. Molin and G.P. van Wee (2006), 'Use and effects of advanced traveller information services (ATIS): a review of the literature', *Transport Reviews*, 26(2), 127–49.

Chorus, C.G., J.L. Walker and M.E. Ben-Akiva (2010), 'The value of travel information: a search-theoretic approach', *Journal of Intelligent Transportation Systems*, 14(3), 154–65.

Chowdhury, S. and B. van Wee (2020), 'Examining women's perception of safety during waiting times at public transport terminals', *Transport Policy*, 94, 102–08.

Correia, G., E. Looff, S. van Cranenburgh, M. Snelder and B. van Arem (2019), 'On the impact of vehicle automation on the value of travel time while performing work and leisure activities in a car: theoretical insights and results from a stated preference survey', *Transportation Research Part A*, 119, 359–82.

Dargay, J.M. (2007), 'The effect of prices and income on car travel in the UK', *Transportation Research Part A*, 41, 949–60.

Dargay, J.M. and D. Gately (1997), 'The demand for transportation fuels: imperfect price- reversibility?' *Transportation Research*, 31(1), 71–82.

Drabicki, A., A. Szarata and R. Kucharski (2020), 'Suppressing the effects of induced traffic in urban road systems: impact assessment with macrosimulation tools – results from the city of Krakow (Poland)', *Transportation Research Procedia*, 47, 131–38, https://doi.org/10.1016/j.trpro.2020.03.085.

Dunkerley, F., M. Wardman, C. Rohr and N. Fearnley (2018), *Bus fare and journey time elasticities and diversion factors for all modes*, RR-2367-DfT, RAND Europe and SYSTRA.

Durand, A. and T. Zijlstra, (2020), *The Impact of Digitalisation on the Access to Transport Services: a Literature Review*, The Hague: KIM, https://doi.org/10.13140/RG.2.2.22686.97600.

EC (European Commission) (2011), *White Paper: European Transport Policy for 2010: Time to Decide*, COM (2001)370, Brussels: EC.

Essen, H. van, A. Schroten, D. Sutter, C. Bieler, S. Maffii, M. Brambilla, D. Fiorello, F. Fermi, R. Parolin and K. El Beyrouty (2019), *Handbook on the External Costs of Transport*, Version 2019 – 1.1, Delft: CE Delft.

FHWA/DoT (2022), What is travel time reliability?, https://ops.fhwa.dot.gov/publications/tt_reliability/ttr_report.htm#:~:text=Travel%20time%20reliability%20measures%20the,different%20times%20of%20the%20day.

Ganji, S.S., A.N. Ahangar, A. Awasthi and S. Jamshidi Bandari (2021), 'Psychological analysis of intercity bus passenger satisfaction using Q methodology', *Transportation Research Part A*, 154, 345–63.

Geilenkirchen, G.P., K.T. Geurs, H.P. van Essen, A. Schroten and B. Boon (2009), *Effecten van prijsbeleid in verkeer en vervoer*, Bilthoven, Planbureau voor de Leefomgeving/Delft: CE Delft.

Goodwin, P.B. (1996), 'Empirical evidence on induced traffic: a review and synthesis', *Transportation*, 23, 35–54.

Goodwin, P. and R. Noland (2003), 'Building new roads really does create extra traffic: a response to Prakash et al.', *Applied Economics*, 25(13), 1451–57.

Haggar, P., L. Whitmarsh and S.M. Skippon, S.M. (2019), 'Habit discontinuity and student travel mode choice', *Transportation Research Part F*, 64, 1–13.

Heinen, E., B. van Wee and K. Maat (2010), 'Commuting by bicycle: an overview of the literature', *Transport Reviews*, 30 (1), 59–96.

Hensher, D.A. (2008), 'Assessing systematic sources of variation in public transport elasticities: some comparative warnings', *Transportation Research Part A*, 42, 1031–42.

Hössinger, R., C. Link, A. Sonntag and J. Stark (2017), 'Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach', *Transportation Research Part A*, 103, 154–71.

Inrix (2022), https://inrix.com/scorecard/.

Iseki, H., B.D. Taylor and M. Miller (2006), *The Effects of Out-of-Vehicle Time or Travel Behavior: Implications for Transit Transfers*, Los Angeles: Institute of Transportation Studies, University of California, Los Angeles, accessed at www.its.ucla.edu/research/EPIC/ Appendix%20A.pdf.

Jong, G. de and H. Gunn (2001), 'Recent evidence on car cost and time elasticities of travel demand in Europe', *Journal of Transport Economics and Policy*, 35(2), 137–60.

Kahneman, D. and A. Tvesrky (1979), 'Prospect Theory: an analysis of decision making under risk', *Econometrica*, 47(2), 263–91.

Kask, O. and W.G.Z. Tan (2019), *Cycling to School: Exploring Key Factors Influencing School-Going Children's Mobility Choice to Cycle in Tallinn, Estonia*, AESOP Annual Congress 2019, Italy: Venice, accessed June 2022 at www.aesop2019.eu/wp-content/uploads/2020/02/AESOP_book_of_papers_2.pdf#page=2646.

KIM (2019). *Mobiliteitsbeeld 2019* [Mobility report], Den Haag: Ministerie van Infrastructuur en Waterstaat (in Dutch).

Kim, H., A. Nicholson and D. Kusumastuti (2017), 'Analysing freight shippers' mode choice preference heterogeneity using latent class modelling', *Transportation Research Procedia*, 25, 1109–25.

Kouwenhoven, M., G.C. de Jong, P. Koster, V.A.C. van den Berg, E.T. Verhoef, J. Bates and P.J.M. Warffemius (2014), 'New values of time and reliability in passenger transport in the Netherlands', *Research in Transportation Economics*, 47(1), 37–49.

Lal, D. (2006), *Reviving the Invisible Hand: The Case for Classical Liberalism in the Twenty-First Century*. Princeton, NJ: Princeton University Press.

La Paix, L., Oakil, A.T., Hofman, F., Geurs, K. (2022), 'The influence of panel effects and inertia on travel cost elasticities for car use and public transport', *Transportation*, 49, 989–1016.

Li, Z., D.A. Hensher and J.M. Rose (2011), 'Identifying sources of systematic variation in direct price elasticities from revealed preference studies of inter-city freight demand', *Transport Policy*, 18(5), 727–34.

Litman, T. (2021), *Understanding Transport Demands and Elasticities How Prices and Other Factors Affect Travel Behavior*, Victoria Transport Policy Institute, at www.vtpi.org/elasticities.pdf.

Lu, H., P. Burge, C. Heywood, R. Sheldon, P. Lee, K. Barber and A. Phillips (2018), 'The impact of real-time information on passengers' value of bus waiting time', *Transportation Research Procedia*, 31, 18–34.

Marchetti, C. (1994), 'Anthropological invariants in travel behavior', *Technological Forecasting and Social Change*, 47, 75–88.

Mokhtarian, P.L. and C. Chen (2004), 'TTB or not TTB, that is the question: a review and analysis of the empirical literature on travel, time (and money) budgets', *Transportation Research Part A*, 38(9/10), 643–75.

Mouratidis, K., S. Peters and B. van Wee (2021), 'Transportation technologies, sharing economy, and teleactivities: Implications for built environment and travel', *Transportation Research Part D*, 92, 1–23.

Pastori, E., M. Brambilla, S. Maffii, R. Vergnani, E. Gualandi and I. Skinner (2018), Research for TRAN Committee – *Modal shift in European transport: a way forward*, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

Paulley, N., R. Balcombe, R. Mackett, H. Titheridge, J. Preston, M. Wardman, J. Shires and P. White (2006), 'The demand for public transport: the effects of fares, quality of service, income and car ownership', *Transport Policy*, 12, 295–306.

Pudane, B. and G. Correia (2020), 'On the impact of vehicle automation on the value of travel time while performing work and leisure activities in a car: Theoretical insights and results from a stated preference survey – A comment', *Transportation Research Part A*, 132, 324–28.

Pudane, B., S. van Cranenburgh and C. Chorus (2021), 'A day in the life with an automated vehicle: empirical analysis of data from an interactive stated activity-travel survey', *Journal of Choice Modelling*, 39, 100286.

Rodrigue, J.-P. (2020), *The Geography of Transport Systems*, London: Routledge.

Schafer, A. (1998), 'The global demand for motorized mobility', *Transportation Research A*, 32(6), 455–77.

Schafer, A. (2006), 'Long-term trends in global passenger mobility', *The Bridge*, 36(4), 24–32.

Schafer, A. and D.G. Victor (2000), 'The future mobility of the world population', *Transportation Research A*, 34(3), 171–205.

Stark, J. and M. Meschik (2018), 'Women's everyday mobility: Frightening situations and their impacts on travel behaviour', *Transportation Research Part F*, 54, 311–32.

Stopher, P.R., A. Ahmed and W. Liu (2017), 'Travel time budgets: new evidence from multi-year, multi-day data', *Transportation*, 44, 1069–82.

Szalai, A. (ed.) (1972), *The Use of Time: Daily Activities of Urban and Suburban Populations in Twelve Countries*, The Hague: Mouton.

The National Center for Safe Routes to School (2011), 'How Children Get to School: School Travel Patterns from 1969 to 2009', accessed June 2022 at https://www.healthworkscollective.com/wp-content/uploads/2013/07/NHTS_school_travel_report_2011_0.pdf.

Wadud, Z. (2015), 'Imperfect reversibility of air transport demand: Effects of air fare, fuel prices and price transmission', *Transportation Research Part A: Policy and Practice*, 72, 16–26.

Wardman, M. (1997), 'Inter-urban rail demand, elasticities and competition in Great Britain: Evidence from direct demand models', *Transportation Research Part E*, 33, 1, 15–28.

Wener, R.E. and G.W. Evans (2011), 'Comparing stress of car and train commuters', *Transportation Research Part F*, 14, 111–16.

Zahavi, Y. (1979), *The UMOT Project*, Washington, DC: US Ministry of Transport.

Zarabi, Z., K. Manaugh and S. Lord (2019), 'The impacts of residential relocation on commute habits: A qualitative perspective on households' mobility behaviors and strategies', *Travel Behaviour and Society*, 16, 131–42.