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Individual needs, opportunities and travel behaviour: a multidisciplinary perspective based on psychology, economics and geography

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3.1 INTRODUCTION

Reducing the use of the private car and stimulating the patronage of public transport, use of active and shared transport modes to combat congestion, climate change and improve public health and well-being are objectives that have prominent positions on the policy agendas of Western countries. Despite the efforts of scientists, policy makers and public and private investors, many transport problems seem hard to solve. This might be due to the following factors. Firstly, economic growth and the increase in population size (largely caused by net migration) and expansion of the number of households are relatively autonomous processes which are largely outside the control of at least transport policy makers. These could have an impact on the volume of traffic. Secondly, many interventions in transport are not sufficiently focused on all relevant determinants and not coordinated and as a consequence, suffer in their effectiveness. For example, investments in public transport are often not accompanied by pricing measures on car use. Yet, congestion charging in London, Stockholm and Singapore (Metz, 2018) show the effectiveness of a combination of policies. The emerging concept of MaaS (Mobility-as-a-Service) has the objective to integrate transport modes and mobility services into one mobility service accessible on demand, but it is unclear how to stimulate adoption of these services and whether and under which conditions the public will adopt these (Butler et al., 2021; Arias-Molinares and García-Palomares, 2020). The final reason for difficulties in solving the above-mentioned transport problems is that car use is highly habitual (Ramos et al., 2020), which could be modified when choice situations change substantially. For example, a change in work and/or residential location might trigger a change in modal split too.

To increase the effectiveness of policies a thorough understanding of the factors influencing travel behaviour of people is needed. For example, to increase the use of MaaS, we need to know what motivates and enables people to use MaaS, and which strategies can be effective to promote MaaS (Butler et al., 2021; Arias-Molinares and García-Palomares, 2020). Often knowledge on travel behaviour has a monodisciplinary character and is not based on the complementary value of the perspectives of behavioural disciplines, such as psychology, economics and geography. An integrated approach to understanding the needs and preferences of people and their willingness and opportunities to change behaviour would lead to the development of more effective integral transport policies. It is the aim of this chapter to discuss the three disciplinary perspectives and to show their connections from a cross-disciplinary perspective. We will ask questions like: Why do we travel? What are the drivers and constraints for travel behaviour? What is the relationship between travel behaviour and other choices, such as the choice of housing, work and ownership of transport modes? Which factors influence these choices?

Based on the contributions from psychology, economics and geography, Section 3.2 will provide a conceptual framework for understanding travel behaviour. Successively, in Sections 3.3, 3.4 and 3.5 we will discuss the perspectives of each of these scientific disciplines on travel behaviour. In Section 3.6 the major conclusions of this chapter will be presented.

3.2 CONCEPTUAL MODEL OF TRAVEL BEHAVIOUR

In national statistics, travel behaviour of people is usually represented by some key indicators differentiated by socio-demographics. In Annex 1 for the United Kingdom and the Netherlands, Table A3.1 shows data on the possession of driving licences and car ownership and Table A3.2 presents averages for the number of trips and kilometres per day. Both tables are differentiated by gender, age and income level. Although differences between the two countries exist, Table A3.1 makes clear that car-driving license holding and car ownership are higher for men, middle aged persons, and higher income households. Similar differences are shown in Table A3.2, for trips and kilometres per day. The only exception seems to be the number of trips which is higher for women than for men.

Although this information on travel behaviour of people is informative, these national statistics hardly give an in-depth understanding of the drivers and constraints of behavioural choices which are behind these socio-demographic differences in travel behaviour. In essence, social disciplines explain behavioural choices by needs, motivations, abilities and contextual factors of people for certain travel choices. The differences between psychology, economics and geography are in their conceptualizations, and emphasis put on different determinants and behavioural mechanisms. The aim of this section is to present a general conceptual framework to understand travel behavioural choices.

Travel is typically not an aim in itself but a means to reach activities and locations, which is whe transport demand is frequently refered to as a 'derived' demand. Pas (1980: 3–4) said: 'if all the activities in which an individual wished to participate were located at the same place, that individual would be expected to undertake little or no travel at all.' This could imply that, if an individual can choose between an attractive destination at a distance of 1 kilometre and in all respects equally attractive destination at 10 kilometres she will definitely opt for the first alternative. Banister (2008) states that this traditional and predominant view on transport should be rethought. Many scholars have argued that travel is not only a derived demand but also has an intrinsic value (see also Chapters 2 and 6). That intrinsic value is expressed in its symbolic and affective factors (Steg, 2003), productivity (e.g. with activities during travel), health and well-being evoked by travelling, or the desire to spend some time between being at two locations such as home and work (Cornet et al., 2021; De Vos et al., 2015; Mokhtarian et al., 2015).

To explain travel behaviour it is important to understand first why people participate in activities at their destination(s) or while travelling (e.g. making a phone call or reading a book) and the options they have to fulfil these needs. Figure 3.1 describes the NOA model from psychology which could serve as a general conceptual framework to explain travel behaviour. As will be shown in Sections 3.3–3.5, the social disciplines put central in this chapter differ in the interpretation of these concepts and the behavioural mechanisms they consider. This model distinguishes three general factors that influence (travel) behaviour: needs, opportunities and abilities. The motivation for behaviour arises from needs (N) (e.g. to travel safely, to buy food) and the presence of opportunities (O) in an individual's context to fulfil these needs, like the supply of transport alternatives and distance to destinations. Individual abilities (A) refer to the available time, money, skills and capacity for certain travel choices. These abilities, in combination with the contextual opportunities, determine the choice set of an individual – the feasibility of different travel and activity options. This figure makes clear that travel behaviour can change in response to changes in needs, opportunities and individual abilities.

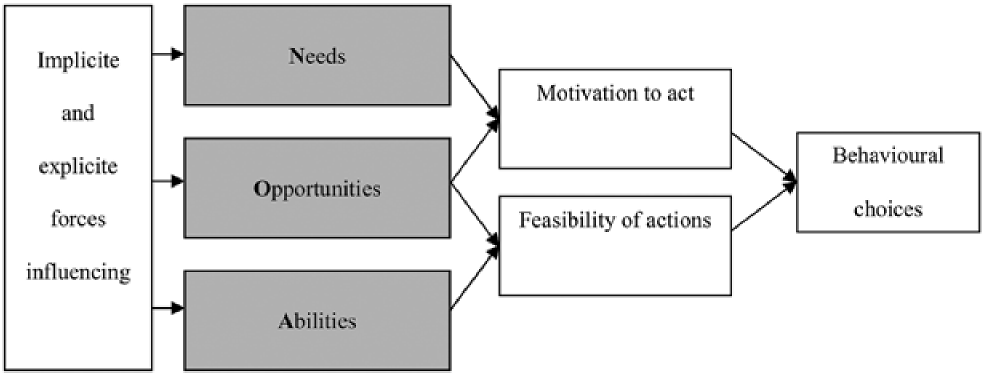

Figure 3.1 Individual factors influencing travel behaviour: the NOA model

Source: Steg et al. (1998)

Notably, it is important to not only consider the observed or 'objective' feasibility of options, but also or even more so the perceived feasibility of options that affects choices people actually make. Notably, perceptions may diverge from reality. For example, people often systematically overestimate the advantages of their own behaviour (like time to drive to work), while systematically underestimating the disadvantages of this behaviour (e.g. costs of driving). And the reverse: people tend to overestimate the negative aspects of alternative behavioural options (like the time needed to commute by public transport) and underestimate the positive aspects of it (Golob et al., 1979). This may be partly due because people often lack information and knowledge on behavioural alternatives.

Feasibility and motivation for behaviour are not independent of each other. A lack of motivation to engage in a behaviour might lead to a denial of opportunities or abilities to use it. On the other hand, if specific behaviour options are difficult or even not feasible, we may trivialize or deny the negative consequences caused by our behaviour. This mechanism is called 'cognitive dissonance reduction' (Festinger, 1957): a person may experience cognitive dissonance when his or her behaviour (e.g. 'I travel by car') does not match with his or her attitudes (e.g. 'Car use causes environmental problems'). This causes negative feelings, which can be solved by adjusting the behaviour (reduce car use) or the cognition ('Car use does not have a big negative impact on the environment'). In general, it will be easier to change one's attitudes than one's behaviour (Steg and Tertoolen, 1999).

The needs, opportunities and abilities of an individual are related to developments in society. Economic growth, changes in the demographic composition of population and households, changes in the values and norms of different groups in society are examples of developments that may affect individual needs, opportunities and abilities. These changes between two moments in time (T0 and T1) are taking place at the macro-level (Figure 3.2). At the same time, individual behaviour changes may aggregate to macro-level changes. For example, when more people travel with a private car, congestion levels in a city may increase, and CO_2 emissions can increase. Next, travel behaviour in the short term depends on other choices of people in the mid-term, like the purchase of a private car, choice of a dwelling and lifestyle choices in the long-term for work, household and leisure. Cullen (1978) was one of the first studying in particular the integrative character of time (see also van Acker et al., 2016; Gerhrke et al., 2019; Salomon and Ben-Akiva, 1983). Figure 3.3 makes clear that all these decisions are related to each other. As an analogue to the choices for travel behaviour, mid- and long-term choices are influenced by the variables included in the NOA model in Figure 3.2.

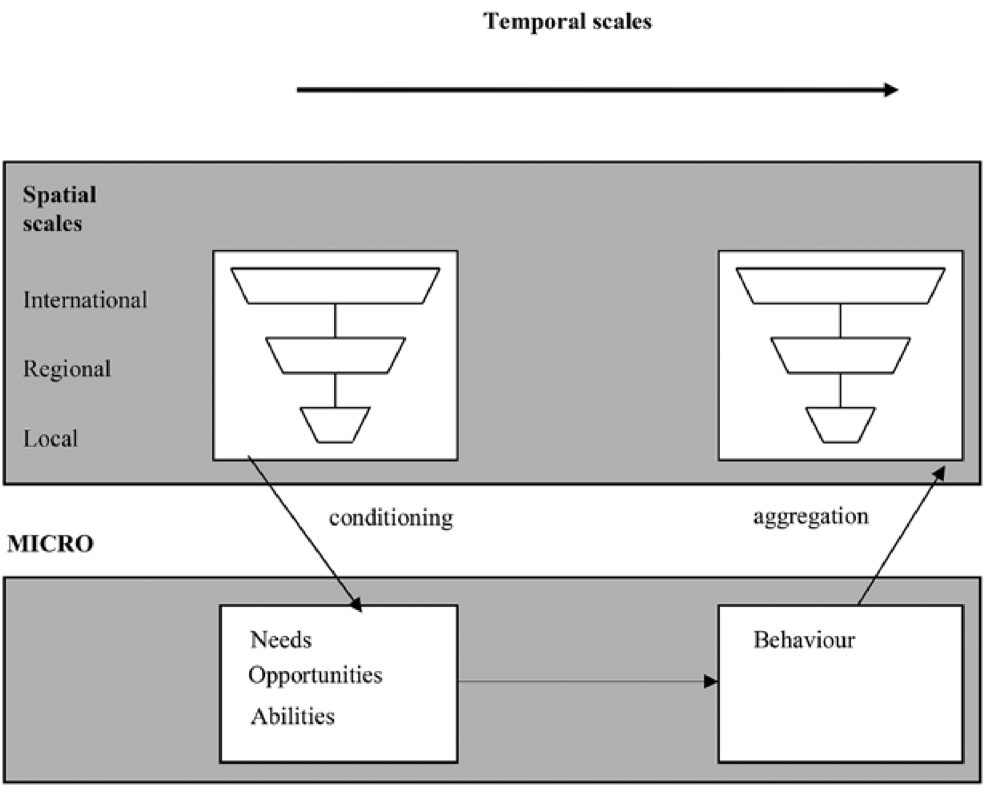

Figure 3.2 Relation between macro- and micro-developments for behavioural choices in time

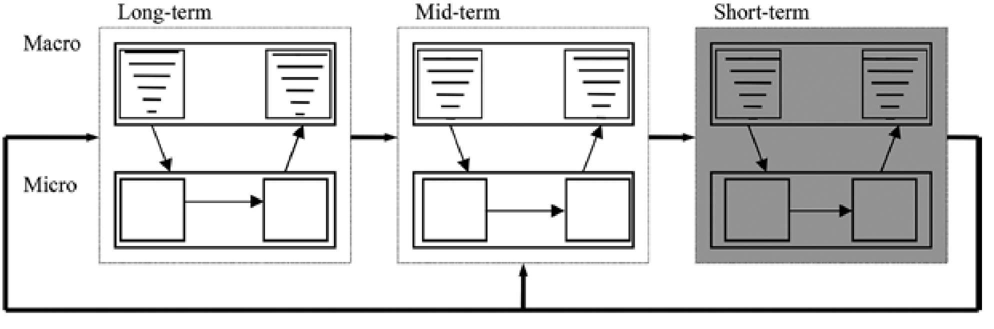

Figure 3.3 Continuum of related choices at various temporal scales

As shown in Figures 3.2 and 3.3, the macro-level at which changes take place can be disaggregated into various spatial scales like the neighbourhood, a city, a region, country or continent. At these spatial scales, economic, demographic and cultural changes can manifest differently. In geographic research, a multilevel perspective including attributes of structures at various spatial scales is often used to explain transitions in society (Geels, 2020; Kleider and Toubeau, 2022; Moradi and Vagnoni, 2018). In various scientific disciplines, theories and models have been developed which explain the travel choices of people and the factors which influence their choice options. Psychology, economics and geography are by far the most dominant disciplines studying travel behaviour. In the next three sections these disciplinary perspectives will be discussed. Although these disciplinary perspectives show differences in describing and conceptualizing different determinants and behavioural mechanisms, they cannot be discussed in isolation from each other. Implicitly, they often take into account the ideas from other disciplines.

3.3 BEHAVIOURAL CHOICES FROM A PSYCHOLOGICAL PERSPECTIVE

In psychology, different theoretical perspectives have been put forward to study behaviour and, more particularly, travel behaviour. Below, we describe three lines of research that focus on different types of individual motivation that affect travel behaviour: perceived cost and benefits, moral and normative concerns, and affect, respectively. We also indicate how these different perspectives may be integrated into an all-encompassing framework. Next, we identify two shortcomings of these theoretical perspectives. First, they do not pay explicit attention to the effects of contextual factors (as reflected in opportunities; see Figure 3.1) on travel behaviour. We propose ways to study individual and contextual factors simultaneously. Second, they implicitly assume that people make reasoned choices. However, in many cases people act habitually, which we discuss at the end of this section.

3.3.1 Motivational Factors: Three Lines of Research

Weighing various individual costs and benefits

Various studies on travel behaviour started from the assumption that individuals make reasoned choices and choose alternatives with the highest benefits against the lowest costs, thereby not only considering financial cost and benefits, but also social costs and benefits, effort, time and convenience, among others. One influential framework is the theory of planned behaviour (TPB) (e.g. Ajzen, 1991), which assumes that behaviour results from an intention to engage in the relevant behaviour. Intention is assumed to depend on three factors: attitudes, subjective norms and perceived behavioural control (PBC). Attitudes reflect how positively or negatively people evaluate a particular action. They depend on beliefs that a behaviour will result in particular outcomes and thus will yield different costs and benefits (e.g. driving a car is expensive, saves time, provides freedom or enhances one's status) and on how important these outcomes (i.e. costs and benefits) are for an individual. Social norms reflect the extent to which one believes that important others (e.g. friends, family members, colleagues) approve or disapprove of the behaviour, and the motivation to comply with these expectations, and thus reflects social costs and benefits of actions. PBC reflects the extent to which people think they are capable of engaging in the relevant behaviour (see Figure 3.4), which reflects the perceived feasibility of a behaviour. PBC can influence behaviour indirectly, via intentions, but also directly. For example, people can have the intention to travel by bus and feel capable of doing so (for example, because they know the timetable and can afford to buy a ticket), but, if they then learn that the bus drivers are on strike, PBC will affect behaviour directly.

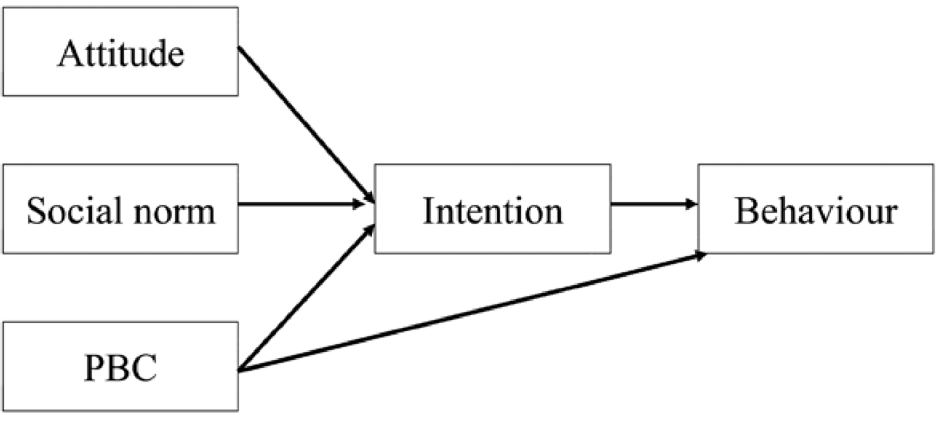

Figure 3.4 The theory of planned behaviour

The TPB assumes that other factors, such as demographics and personal values, affect behaviour indirectly, via attitudes, subjective norms and PBC. For example, men may travel more by car because they like driving (a positive attitude), low-income groups may drive less because they have a lower PBC (e.g. they cannot afford to drive more) and people with strong environmental values may drive less because they are concerned about the negative environmental consequences of driving, resulting in less positive attitudes towards driving. However, as of yet, studies have hardly tested explicitly whether demographics and values indeed affect travel behaviour indirectly, via attitudes, subjective norms and PBC. The extent to which attitudes, subjective norms and perceived behaviour influence intentions and behaviour differs across different types of behaviour. For example, subjective norms are likely to be less influential when the particular behaviour is private and hardly visible to others (e.g. your friends are unlikely to observe which route you take to your holiday in France). In such cases, attitudes and PBC are likely to exert a stronger influence on behaviour than subjective norms.

The TPB has proven to be successful in explaining travel mode choice (Verplanken et al., 1998; Harland et al., 1999; Heath and Gifford, 2002; Bamberg and Rölle, 2003; Donald et al., 2014; Zhang and Li, 2020).

Various scholars have added further factors to the TPB, such as habits (Verplanken et al., 1997; see below). Others have added positive and negative affect as predictors to the TPB. This reflects the extent to which individuals anticipate that behaviour will result in positive or negative affect (we elaborate on the role of affect below). For example, some people may anticipate positive feelings when cycling in sunny weather or when driving during rain, which may motivate them to cycle and drive, respectively. Most studies testing the TPB rely on correlational evidence, so the causality of the relationship between predictors and travel behaviour remains unclear. Yet, some studies suggest that people may adapt their attitudes to their behaviour (Kroesen et al., 2017).

Moral and normative concerns

Many people evaluate car use much more favourably than using public transport (Steg, 2003). This implies that reductions in car use are not very likely when people base their decisions mainly on weighing the various individual costs and benefits of different travel modes or when travel behaviour became habitual. They will probably only reduce their car use when they value the environment and when they are concerned about the problems caused by car use. This implies that morality may play a key role in motivating people to reduce car use: people need to forgo individual benefits to safeguard collective benefits like environmental quality.

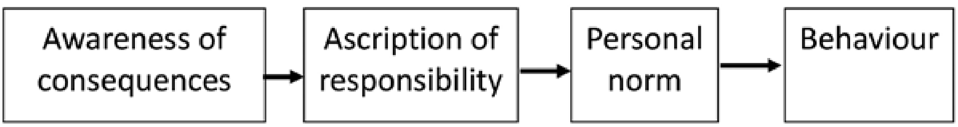

Figure 3.5 The norm activation theory

Various studies have examined the role of moral and normative considerations underlying travel behaviour, in particular to reduce car use, from different theoretical perspectives. First, scholars have tested the Norm Activation Model(NAM) to understand the role of moral considerations (see Figure 3.5; Schwartz, 1977; Schwartz and Howard, 1981). The NAM posits that people will engage in certain behaviours when they feel morally obliged to do so, which is reflected in personal norms. For example, when one holds strong personal norms to reduce CO_2 emissions, one would be more likely to engage in sustainable mobility behaviour. According to the NAM, personal norms are activated when people are aware of the consequences of their behaviour, such as the air pollution or CO_2 emissions caused by their car use. In other words, they need to have some level of problem awareness. Additionally, they need to feel responsible for these problems and think their actions can be effective in reducing these problems (outcome efficacy, e.g. 'When I drive less, local air pollution will reduce'). People can be highly aware of the problems of climate change but if they believe their actions do not matter or that they are not able to change, they may feel less morally obliged to do so (Bamberg and Rölle, 2003; de Groot and Steg, 2009; Steg and de Groot, 2010; Jakovcevic and Steg, 2013; Hiratsuka et al., 2018; Ünal et al., 2018; Ünal, Steg and Granskaya, 2019).

The NAM appeared to be successful in explaining travel behaviour, and particularly willingness to reduce car use (e.g. Nordlund and Garvill, 2003; Eriksson et al., 2006; de Groot and Steg, 2009; Steg and de Groot, 2010). However, the TPB appears to predict car use better than the NAM (Bamberg and Rölle, 2003; Matthies and Blöbaum, 2007). Other studies also suggest that the NAM is particularly successful in explaining low-cost behaviour changes and good intentions, while the predictive power is less in situations characterized by high behavioural costs or strong constraints on behaviour, such as reducing car use (e.g. Hunecke et al., 2001; Bamberg and Rölle, 2003; Keizer et al., 2019).

The value-belief-norm (VBN) theory builds on the NAM model and proposes that problem awareness is rooted in personal values. Values are defined as general goals that transcend time and situations and that act as guiding principles in people's life (Schwartz, 1992). In general, a distinction is made between self-enhancement values, in which individuals are particularly concerned about their own interests, and self-transcendence values, in which individuals are particularly concerned with the interests of others and society (i.e. altruistic values), and nature and the environment (i.e. biospheric values). Studies have revealed that the more strongly individuals subscribe to values beyond their immediate own interests, that is, the more strongly they endorse self-transcendent, and specifically altruistic and biospheric values, the more favourably they evaluate reductions in car use and the more they are willing to do so (Nordlund and Garvill, 2003; Jakovcevic and Steg 2013; Ünal et al., 2019).

Strong biospheric and/or altruistic values are found to trigger a process of norm activation by strenghtening problem awareness (Jakovcevic and Steg, 2013; Nordlund and Garvill, 2003; Ünal et al., 2018, 2019), which in turn was found to be related to recognizing one's own contribution to these problems (i.e. outcome efficacy) and feeling a moral obligation to act sustainably (i.e. personal norms). On the other hand, strong hedonic and egoistic values (i.e. striving for pleasure and enhancing one's reserouces, respectively) were found to be either not related to problem awareness or negatively related to it (De Groot and Steg, 2007; Jakovcevic and Steg, 2013; Ünal et al., 2018, 2019). These findings indicate that values can act as a motivational source for sustainable mobility decisions and behaviours.

Affect and symbolic factors

Various studies have explicitly examined the role of affect in explaining travel behaviour, mostly in relation to car use (see Gatersleben, 2007, for a review). These studies assume that travel behaviours are motivated not only by the (anticipated) instrumental outcomes of this behaviour (e.g. 'If I drive to takes less time than taking the train'), but also the symbolic outcomes (e.g. 'If I take the bus to work my colleagues will think I am a loser') and the affective outcomes (e.g. 'Driving to work is more fun than taking the bus'). So it is assumed that three types of motives may underlie travel behaviour: instrumental, symbolic and affective motives.

A study by Steg (2003) revealed that commuter car use was most strongly related to symbolic and affective motives, while instrumental motives (such as costs) appeared less important. This suggests that, even for highly functional trips such as commuting, affective and symbolic motives play an important role; this may be even more so for leisure trips (Anable and Gatersleben, 2005). Also, most group differences were found in the evaluation of the symbolic and affective functions of car use, while people tended to agree more on the relative importance of instrumental functions of car use. More specifically, young people and low-income groups generally valued the affective function of the car more than older respondents and higher-income groups, while male drivers valued the symbolic (and some affective) functions more strongly than female drivers did (Steg et al., 2001; Steg, 2003). Also, the car is evaluated much more favourably on these aspects than public transport (e.g. Steg, 2003).

People might choose a certain transport mode or type of car to signal the uniqueness of one's own identity and status. For example, intentions to purchase an electric vehicle were better predicted by the evaluation of the symbolic and environmental aspects of the electric vehicle than by its instrumental aspects, although participants indicated that instrumental aspects were more important to them in their decision to buy an electric vehicle (Noppers et al., 2014). These findings suggest that the intention to purchase an electric vehicle is associated with the motive to enhance one's status. More generally, adoption of innovations is associated with high-status amongst early adopters (Egbue and Long, 2012).

An integrative perspective on motivations to engage in travel behaviour

The three general lines of research just described involve rather different antecedents of travel behaviour, with all three perspectives being predictive of at least some types of travel behaviour. The three theoretical perspectives are not mutually exclusive, as behaviour is likely to result from multiple motivations. Goal-framing theory (Lindenberg and Steg, 2007) postulates that goals govern or 'frame' the way people process information and act upon it. Three general goal-frames are distinguished: a hedonic goal-frame 'to feel better right now', a gain goal-frame 'to guard and improve one's resources (such as money, social recognition)' and a normative goal-frame 'to act appropriately'. When a goal is focal (that is, when it is the 'goal-frame'), it influences how people perceive and evaluate different aspects of a situation and act upon it. Goal-framing theory proposes that, typically, multiple goals are active at a given time: one goal is focal and influences information processing the most (that is, it is a goal-frame), while other goals are in the background and increase or decrease the strength of the focal goal. The three goal-frames remarkably coincide with the three theoretical frameworks described above. That is, theories and models on affect focus on hedonic goals, the TPB focuses on gain goals, while the NAM and theories on values focus on normative goals. Thus, goal-framing theory provides an integrative framework for understanding motivations underlying travel behaviour.

3.3.2 Contextual Factors

The theories discussed above focus on individual motivations influencing travel behaviour, and do not explicitly include the role of contextual factors, although the TPB considers individuals' perceptions of contextual factors, as expressed in PBC. Obviously, travel behaviour does not depend on motivation alone. Many contextual factors may facilitate or constrain travel behaviour by influencing the opportunities people face. For example, the quality of public transport or petrol price regimes can strongly affect travel behaviour (e.g. Santos, 2008; see also Sections 3.4 and 3.5). In some cases, constraints may even be so strong that motivation hardly influences travel behaviour. Therefore, it is important to consider individual motivation vis-à-vis contextual factors (as reflected in the NOA model; see Figure 3.1). The mutual influence of motivation and contextual factors can be conceptualized in four different ways. First, contextual factors may directly affect travel behaviour. For example, one cannot travel by bus when no bus service is available, while a free bus ticket may result in an increase in bus ridership (e.g. Bamberg and Rölle, 2003; Fujii and Kitamura, 2004). Second, contextual factors may affect behaviour indirectly, via motivational factors such as attitudes, affect or personal norms. For example, the introduction of a cycle path may result in more positive attitudes towards cycling (e.g. because it is safer) and positive attitudes may in turn promote cycling. Third, contextual factors may moderate the relationship between motivational factors and behaviour. For example, environmental values may only result in reductions in car use when feasible alternatives are available and cycling facilities may promote cycling only among those with strong environmental values. Fourth, related to the third point, following goal-framing theory, contextual factors may determine which type of motivation (and thus which goal) most strongly affects behaviour. For example, normative goals may be strongly related to frequency of cycling when good cycling facilities are available, while gain or hedonic goals may be prominent if cycling facilities are poor.

3.3.3 Habitual Behaviour

The theoretical frameworks discussed in Section 3.3.1 largely imply that individuals make reasoned choices, that is, they assume that choices are based on a careful deliberation of the pros and cons of different behavioural alternatives. However, in many cases, behaviour is habitual and guided by automated cognitive processes, rather than being preceded by elaborate reasoning, particularly if people face the same choice situation frequently. After all, we cannot possibly consider all the pros and cons of all choices that we face during a day. We simply do not have the cognitive capacity and time to do so. We just repeat the same action over and over again when we face similar choice situations. Habits are formed when behaviour results in the anticipated positive consequences over and over again. In that case, behaviour is automatically elicited by contextual cues.

Habits have three important characteristics (Aarts et al., 1998). First, habits require a goal to be achieved. Second, the same course of action is likely to be repeated when outcomes are generally satisfactory. Third, habitual responses are mediated by mental processes. When people frequently act in the same way in a particular situation, that situation will be mentally associated with the relevant goal-directed behaviour. The more frequently this occurs, the stronger and more accessible the association becomes, and the more likely it is that an individual acts accordingly. Thus, habitual behaviour is triggered by a cognitive structure that is learned and stored in and retrieved from memory when individuals perceive a particular situation.

Habits refer to the way behavioural choices are made, and not merely to the frequency of behaviour. The so-called response-frequency measure aims to measure habit strength by asking people to indicate which travel mode they will use in different situations, relying on the assumption that goals automatically activate mental representations of habitual choices. This measure is far more accurate than simply asking people how frequently they engage in a particular behaviour, as it focuses on how choices are made. The measure has been successfully employed in various studies on travel behaviour (e.g. Aarts et al., 1998; Aarts and Dijksterhuis, 2000; Klockner et al., 2003; Friedrichsmeier et al., 2013).

Habitual behaviour may involve misperceptions and selective attention: people tend to focus on information that confirms their choices, and neglect information that is not in line with their habitual behaviour. It is also possible that people change their beliefs in line with their habitual behaviour; for example, habitual car users may evaluate driving a car even more positively and travelling by public transport more negatively to rationalize their behavioural choices (i.e. cognitive dissonance reduction; Festinger, 1957), or because they adjust their beliefs based on their observed behaviour (Bem, 1972).

In many cases, habits are highly functional because they enable us to cope efficiently with limited cognitive resources and time. However, when choice circumstances have changed, people may no longer make optimal decisions when they have strong habits. In general, habits are reconsidered only when the context changes significantly. For example, temporarily forcing car drivers to use alternative travel modes induced long-term reductions in car use (Fujii et al., 2001; Fujii and Gärling, 2003). The impacts of such temporary changes were particularly strong for habitual car drivers. Lifestyle changes may also result in reconsidering habitual behaviour, for example moving to a new house, changing jobs, having children or the COVID-19 pandemic (Verplanken and Wood, 2006; Walker et al., 2014; Fujii and Gärling, 2003; Corker et al., 2022).

3.4 BEHAVIOURAL CHOICE FROM AN ECONOMIC PERSPECTIVE

In the economic discipline, models of individuals' travel behaviour share important features with models of other types of consumption behaviour. Standard economic analysis departs from the assumption that consumers base their choice on rational considerations. This means that they will make the choice from which they expect it will give them greatest overall satisfaction. The word 'expect' signals that not everything needs to be known beforehand to be able to act rationally in the economic sense, so that the *ex post* actually experienced satisfaction may deviate from the a priori expected value; and 'overall' reflects that satisfaction may very well be codetermined by personal tastes and emotions, and may thus include aspects that in daily speech may be deemed 'irrational'. Preferences of consumers are then the starting point of many analyses. These preferences mean that consumers – when they have the choice between options A, B and C – can compare these in terms of desirability; for example, B may be preferred above A, and A may be preferred above C. The classical assumption is that consumers are able to arrive at a complete and consistent ranking; in the foregoing example meaning that we can infer that B is also preferred over C (consistency), and that all pairs of alternatives can be compared (completeness); see, for example, Varian (1992). At the individual level, this is often a relatively mild assumption: most readers will find it hard to think of a counter example for their own preferences, e.g. when looking at a restaurant menu a vegetarian dish would be preferred over fish, and a fish dish over a meat meal, but the meat meal in turn looks more attractive than the vegetarian dish. Or, indeed, when a bike trip would be preferred over walking and walking over tram, but tram over cycling. Still, for social choice situations such paradoxes may more easily occur, e.g. when there is majority preferring A over B, a majority that prefers B over C, but also a majority that prefers C over A (Atkinson and Stiglitz, 2015). And, when attributes of transportation systems depend on the choices of others, as we see with frequency benefits or crowding disutility in public transport, or congestion in car traffic, individual rankings may also become dependent on other individuals' choices so that the rankings become endogenous when considering and modelling the full transportation system.

The classical economic model of consumer choice can in more advanced specifications allow for aspects such as imperfect information, endogenous habitual behaviour when the (perceived) cost and effort of information acquisition and processing make it irrational to do so at high frequency, or taste variations that may in daily speech be considered irrational. Economic science keeps exploring ways to further improve the understanding and modelling of human behaviour, often integrating elements that stem from other behavioural sciences including psychology such as discussed above. This is in particular characteristic for the – multiple Nobel Prize winning – field of 'behavioural economics'. This literature has for example given rise to concepts such as bounded rationality (Simon, 1955); underlines the importance of habitual behaviour (see Section 3.3.3 above); develops models that explain seemingly irrational behaviour from economic modelling of behaviour (e.g. Becker and Murphy, 1988); assesses how nudges in choice architecture steers behaviour (Thaler and Sunstein, 2021); and emphasizes that there may be an asymmetry in the valuation of gains and losses as in the 'prospect theory' proposed by Kahneman and Tversky (1979). For an explorative assessment on the potential applicability of behavioural economics to the study of transport behaviour, we refer to Garcia-Sierra et al. (2015).

When we apply the preference-based approach to the domain of transport, the choice alternatives, may for example, be various transport modes with different scores on attributes such as price, speed and comfort. Transport behaviour entails many behavioural 'margins' than just modes. Other choices of interest include route, time of day, vehicle technology, origin, destination, speed, and driving style. Economic research often focuses on such functional and observable properties of transport modes (see also Section 3.2), for one because these form important aspects that government can affect in policies. Still, also non-observable preferences play an important role in economic modelling. These are, for instance, in discrete-choice models captured in 'alternative-specific constants', which represent the average value that travellers attach to a certain option on top of what can be explained from observed features such as the ones just mentioned; and the so-called 'idiosyncratic preferences', which capture additional preferences that are individual or even choice specific (e.g. Small et al., 2023).

In empirical work, both types of unobservable preferences can, despite their unobservability, to a meaningful extent be identified in the estimation of choice models. A relevant alternative-specific constant would show up if a constant term added to the utility function for an alternative, on top of components that capture the impact of observable attributes such as time and costs, is statistically and economically (in terms of relative size) significant (see also Chapter 16). Even though the researcher then does not yet know what it is that makes the traveller, for example, more inclined to take the car than public transport if all observable attributes were equal, it is clear that there is 'something else', on top of what can be explained for instance by travel times and monetary cost. Likewise, the importance of idiosyncratic preferences can be inferred from the relative importance of the so-called systematic part of utility, expressed in observed variables and possibly alternative-specific constants as discussed above, compared to the importance of some random term in the utility function.

The latter is, not coincidentally, also reflected in the name that has been used to indicate this type of model: random utility theory. In many statistical applications the random term is interpreted as some sort of 'error'. In contrast, in random utility models it is not an error at all, but instead reflects the specific preference that an individual has for a certain alternative and takes into consideration in her choices, but that is not directly measurable for the researcher.

Consequently, when estimating measures of benefits that travellers attach to alternatives, this random term is included as well. For the workhorse random utility model that has become known as the 'logit model', these benefits are captured in the so-called 'log-sum' measure of benefits. The interested reader will soon encounter this term when further exploring this literature (see for example, among many others, Train, 2003; and Haghani et al., 2021).

In economics, the standard way to represent the preferences of consumers is to use utility functions. The utility functions give the summary score for the alternatives, where the various attributes are weighted according to their importance. This approach is similar to computing the attitude component in the model of planned behaviour (see Section 3.3). Since people are different, it may well be that each consumer bases her choice on an individual-specific utility function. Now, a reasonably well-performing billiard player's behaviour can be described by using a model that assumes she solves the interdependent set of complex dynamic equations that describe the courses of the balls on the table, even if in reality no such mathematical operations are executed in the billiard player's mind. In the same way, utility functions are best thought of as the mathematical constructs that describe the consumer's behaviour as accurately as possible, even though in reality the consumer does not know or would not even recognize these mathematical functions. Nevertheless, the consumer's behaviour can be characterized as if she maximized that function, and for that reason it gives a natural representation of what aspects matter to which extent the consumer. Utility functions, once empirically estimated, are therefore also at the basis of much of the applied welfare analysis that underlies economic policy analysis in the field of transport. This reflects the principle of 'consumer sovereignty': the individual is the best judge of her own preferences and welfare; rather than, for example, politicians or civil servants.

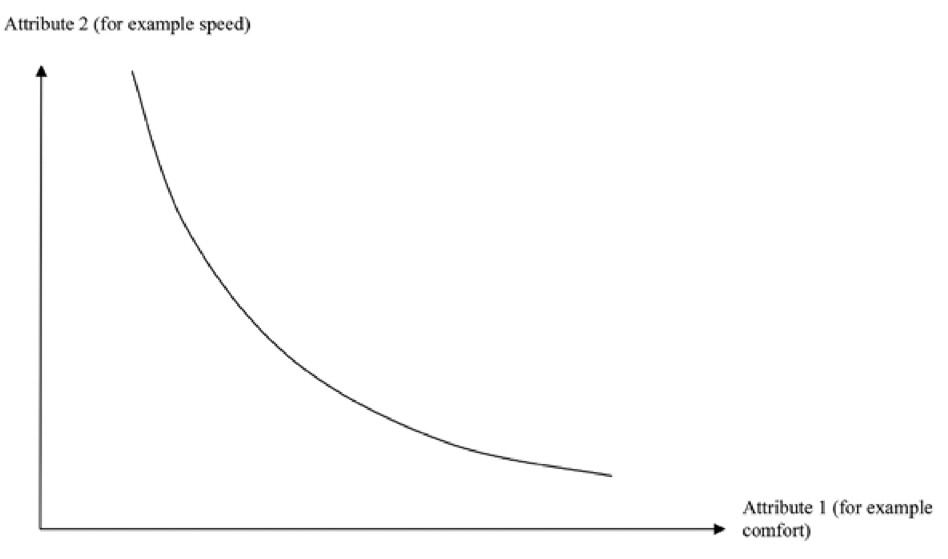

Figure 3.6 Illustration of a utility function with two attributes

Figure 3.6 shows how utility functions are typically used in graphical and analytical expositions of consumer behaviour. The figure shows the so-called indifference curve implied by the utility function: the curve that contains the set of all combinations of attributes (for example, speed and comfort) that is being valued equally by the consumer, implying that she is indifferent to these alternatives and assigns the same utility to them. The curve contains rather different combinations of attributes, some with high speed and low comfort, and other alternatives with the opposite attribute combination, but all of them are valued equally by this consumer. Of course, there will be additional relevant attributes, but for the ease of presentation we focus on these two attributes here. In graphical representations, it is common to restrict the choice set to two goods only just to keep the diagram legible, but in analytical treatments the notion is easily generalized to arbitrarily large numbers of goods.

Preferences are defined here in a way that is different from the NOA model (Figure 3.1). The NOA model focuses on fundamental needs such as safety and health, while economic models deal with ‘wants’. Wants relate to preferences for ways to satisfy needs. Economic models are usually based on the assumption that wants are not fully satisfied in the ranges where the model is applied: more consumption of a good is better, and so is less consumption of a bad. In other words, economic models typically consider goods or bads for which a change in the quantity or quality matters to the individual. This has much to do with the nature of economic science: to study individual and collective decisions under conditions of scarcity. If, in the observed situation, wants are exhausted, there is no more scarcity for that feature and the choice problem in that dimension is no longer economic in nature. Still, sometimes economic research addresses satiation phenomena. For example, people value an extra hour of sleep positively, but this value decreases as people sleep longer, and the valuation of an extra hour of sleep may even become negative if waking up is not under direct control.

An important observation is that wants, in an economic sense, cannot always be fulfilled, since the consumer lacks the financial means or the required time. Many people in the world would like to travel by car, but a considerable number do not have the money to purchase one. In a free market, only the wants that are accompanied by sufficient purchasing power determine which transport services will be supplied, not the needs of the consumer. If so desired, governments can help to satisfy fundamental needs, for example, by subsidies for public transport in order to guarantee that long-distance trips can also be made by people with a low income.

A central theme in the economic study of consumer and traveller behaviour concerns the allocation of monetary and time budgets over alternative possible uses. In classic economic modelling of a consumer this involves the analysis of how a consumer creates a bundle of consumption items that maximize her utility, given her income level and the prices of these various consumption items; and, given her preferences as represented by the utility function. In mobility research, analysts pay attention not only to income constraints but also to time constraints. This means that consumers consider not only the price of goods, but also the time needed for consumption. For travel behaviour this means that consumers consider not only the price per kilometre, but also speed (see, for example, Becker, 1965; Golob et al., 1981; Small et al., 2023). The trade-offs that individuals then make between time and money reflect their so-called value of time, to which we will turn in more detail below. In brief, it reflects the ratio of marginal utilities of time and money, and thus implies which simultaneous compensating changes in travel time and monetary travel cost would leave the traveller exactly equally well off as she is initially.

The optimization of utility by the consumer, as a function of attributes of trips, implies a so-called demand function for kilometres travelled: the function that shows how the size of travel demand depends on the price per kilometre and the time needed to travel a kilometre, taking as given factors such as income and prices of other goods. Knowing the demand function is of great use when one wants to predict what will happen when the price per kilometre or income changes. Often, the researcher observes combinations of quantities demanded and these determining factors. Then, the same relation between utility and demand functions is established but then in the reverse direction. The utility function is then derived from the observed demand function, as that utility function for which it is true that its maximization leads to the observed demand function.

There are various ways to express the results of economic analysis for practical purposes. We will now turn to the ones that we believe the analyst is most likely to encounter in practice: valuation of travel time, price elasticity, time elasticity and income elasticity.

3.4.1 Value of Travel Time

An often-used indicator of consumer preferences in travel is the so-called value of time (VOT) or value of travel time savings (VTTS). In the present chapter, we confine ourselves to a short introduction. The value of time is the core of the trade-off consumers make between price and speed when they compare various travel alternatives (Small et al., 2023). Estimations of the value of travel time for the Netherlands usually range from 5 to 25 euros per hour. A valuation of travel time of 25 euros per hour means that, when a consumer compares a railway trip that takes 6 hours with a flight that takes only 3 hours, she will prefer the train as long as it is 75 euros cheaper than the flight and the two alternatives are considered equally attractive in all other relevant aspects. Note, however, that other attributes such as comfort, access and egress times, or perceived sustainability – think of 'flight shame' – will for most travellers also play a role in this trade-off. Knowledge of the value of travel time is an important tool when one wants to predict travel choices.

Different travellers will have different values of time; and the same traveller will have different values of time at different moments and in different circumstances. The value of time will obviously depend on what people would do with their time when they save travel time. If they would use this time to work more hours, that would of course lead to higher income. People with a higher wage rate per hour will therefore have a higher value of time, all else being equal. The VOT also depends on the trip purpose. Business trips have the highest values of time, followed by commuting and finally other trip purposes. Situational conditions also play a role here. Someone who has an important appointment and who faces the risk of being late because of a delay will have a high value of time under those circumstances.

In more sophisticated economic models of travel time valuation, values of travel time are separated from values of schedule delays (meaning, the value attached to arriving too early or too late), and also from values of travel time uncertainty, to better represent such situations (see for example Kouwenhoven et al., 2014). In the given example, the individual's value of leaving another 5 minutes earlier will be lower than the valuation of arriving 5 minutes too late, even though in both cases the travel time becomes 5 minutes longer. The values of schedule delay represent this. Note also that the VOT will depend on the time that is already used for travel. Someone who already travels a lot for his work will probably have less time for other activities, so that she will be prepared to pay higher amounts for trip alternatives that will save time. The value of time may also depend on the duration of the trip: travellers may be inclined to judge an extra 30 minutes travelling differently when it is in a relative sense a smaller or bigger part of the total travel time – imagine a trip that is expected to take 10 minutes versus one that is expected to take 6 hours – and may also have prepared to undertake different activities during a longer trip which makes extension less of nuisance – think of working on a presentation or report.

Another important concept in transport economics is that of generalized costs of a trip (see Chapter 6). The generalized costs are the sum of the monetary costs and the time-related costs (see, for example, Bruinsma et al., 2000). As people become richer, they will be prepared to pay more to save travel time. Hence, one may expect a tendency for the share of time costs in generalized transport costs to show an increasing trend. This also means that the behavioural relevance of financial attributes such as fares or tolls of a given size may be expected to gradually decrease as people get richer (see also Chapter 6), and consumers will increasingly pay attention to attributes like quality, speed, reliability and comfort. At the same, the increase in the value of time will also make congestion costs more important, so that the optimal levels of financial incentives such as tolls also increase. In the end, financial incentives may then very well become even more relevant than in a world with very low incomes.

3.4.2 Price Elasticity

The price elasticity of demand for kilometres is the usual way to express the sensitivity of demand with respect to prices, and has the great advantage of being expressed in a unit-free way, namely as the percentage change in demand (q) when the price per kilometre (p) increases by 1%:

Price elasticity of demand = [Dq/q]/[Dp/p]

For example, when the fuel price elasticity of demand for car kilometres is −0.2, this means that when the fuel price increases by 10%, the number of kilometres driven will decrease by 2%. The price elasticity of demand for public transport is usually considerably closer to −1. This means that the demand for public transport is much more sensitive to price changes than is car transport to fuel price changes. One of the explanations for this is that the fuel costs have a rather limited share in total costs.

The elasticity as defined above is often called the 'own' price elasticity, since it gives the sensitivity to the price of the good or service itself. A related elasticity concept is the cross-price elasticity, implying the percentage change in the demand for the one good after a change in the price of another good. Often the cross-price elasticity is positive. For example, a higher ticket price for rail would mean that the demand for car use will increase. This is an example of substitution between travel modes. However, negative cross-price elasticities cannot be ruled out. For example, when the price of railway tickets decreases this may mean that more people will travel by train and hence also more people will travel by bus to go to the railway station. This would be an example of complementarity, a result one may expect in the case of multimodal transport chains.

3.4.3 Travel Time Elasticity

The demand function for transport reflects that travel behaviour depends on the duration – and hence the speed – of trips. This can be expressed by the travel time elasticity. It appears that the speed does indeed have a strong influence on the demand for transport. The long-term travel time elasticity of the demand for transport is close to −1. This means that a decrease in the average travel time per unit of distance by a certain percentage will lead to a similar percentage increase in the total distance travelled. This elasticity of −1 would thus imply that the total time that is used for travelling is about constant over the course of time (Zahavi, 1979) (see also Chapter 6). Van Wee et al. (2006) even find indications that there is a gradual increase in the total time spent travelling.

An aggregate elasticity of −1 for an individual, meaning that she has a constant daily amount of travelling, does not mean she has that same elasticity for every individual travel option. The improvement of a certain option does not mean she will use that option more frequently to keep the total time spent in it constant, but may instead well mean that she starts making trips to other (further) destinations. In the context of time elasticities, cross-travel time elasticities may also be relevant. Consider for example a multimodal trip chain with train as the main transport mode. Access modes bringing passengers to the railway station are often slow, hence the demand for rail transport may well be rather sensitive to the speed of access modes.

3.4.4 Income Elasticity

The last factor we discuss here in the context of the demand function is the impact of income on the demand for transport. This can be expressed by the income elasticity. Consumer goods are defined as luxury goods when the income elasticity is higher than 1. In that case, consumers spend an increasing part of their income on these particular goods when income rises. Another category of goods has an income elasticity of between 0 and 1: consumption of these goods increases with income, but at a decreasing rate. A last category of goods has a negative income elasticity: as people get richer they will consume it less and less (so-called inferior goods).

Aviation has a high-income elasticity, clearly higher than 1. This is one of the reasons why aviation has grown so rapidly over the last few decades, at least up until the COVID-19 crisis. The immediate consequence is that aviation is also a sector that will be hurt particularly strongly in the case of an economic recession, also when excluding business travel. Cycling and walking are transport modes with a very low-income elasticity (close to zero). At the same time there is also a relationship between people's income and the trip purposes for which they would use certain transport modes. For example, people with high incomes may use

Table 3.1 Relationship between annual income and distance travelled per person per day, the Netherlands, 2019

Annual income (standardized)	Distance travelled per person per day, as car driver (km and % of all modes)	Distance travelled per person per day, all modes (km)
First 20%-group	7.96 (32%)	25.09
Second 20%-group	11.34 (42%)	26.71
Third 20%-group	17.32 (48%)	35.74
Fourth 20%-group	20.85 (53%)	39.61
Fifth 20%-group	28.14 (59%)	47.61

Source: CBS (2022); www.cbs.nl/nl-nl/cijfers/detail/84709NED

the bicycle mainly for recreational activities when the weather is good, instead of using it as a transport mode for daily purposes (Rietveld, 2001).

As people have higher incomes they tend to travel more kilometres. For example, in the Netherlands, people in the lower income brackets travel about 25 kilometres daily. People in the high-income brackets travel nearly 50 kilometres per day (see Table 3.1). Furthermore, people with higher incomes choose transport modes that are relatively expensive and fast, and within a given transport mode they choose the more expensive versions (for example, first- versus second-class seats on the train).

When we consider household expenditure, the 30% of the population with the lowest incomes spend about 7.3% of their income on travel. For the next 30% this is about 11.1% (CBS, 2015). This jump can mainly be explained by the difference in car ownership between these two income groups. A remarkable relationship is found between income and the use of public transport. The use of bus, tram and metro decreases (or stabilizes) when income increases. According to the definition given above, so in terms of income elasticity, these are thus inferior goods. For the train a different pattern is found. It is high for low-income groups (in particular students, who enjoy free public transport in the Netherlands), then for median incomes it is much lower and finally it clearly increases again for higher incomes. Thus, railway trips tend to be considered luxury goods in the higher part of the income distribution.

3.5 BEHAVIOURAL CHOICES FROM A GEOGRAPHICAL PERSPECTIVE

Geographers study behavioural choices from three perspectives: behavioural geography, utility theory and time geography. Behavioural geography focuses on the cognitive processes underlying decision-making. As such it relies heavily on psychological concepts and mechanisms (see Sections 3.2 and 3.3). Utility theories are based on the economic discipline (see Section 3.4). In this section we focus on time geography, since it is the theory which is most unique to the geographical perspective. This theory and perspective also explain the links between needs and desires, location choices and accessibility in Figure 2.1. First, in Sections 3.5.1–3.5.4

classical time geography as developed in the former century will be presented and thereafter in Section 3.5.5 methodological and theoretical innovations of the last 20 years will be discussed.

3.5.1 Classical Time Geography

Until the 1960s transport problems were studied using a trip-based approach (see also Chapter 16). This means that the basis of the analysis is the trips, which are studied independently of each other. Connections with activities and with the behaviour of other people were rarely the subject of study in this approach (Jones, 1979; Delhoum et al., 2020). Time geographer Hägerstrand (1970: 9), in his legendary paper 'What about people in regional science?', wrote the following words on these selective approaches in social sciences:

> It is common to study all sorts of segments in the population mass, such as labour force, commuters, migrants, shoppers, tourists, viewers of television, members of organizations, etc., each segment being analysed very much in isolation from the others … we regard the population as made up of 'dividuals' instead of individuals.

In the 1970s, as a reaction to the shortcomings of the trip-based approach, the activity-based approach was developed. 'Activity-based approach' is a collective term for a range of studies on the trips people (want to) make. Goodwin (1983) describes this approach as a way in which observed behaviour depends on the activity patterns of people and households within their constraints in time and place. In this integral approach emphasis is put on people's needs or preferences as well as on constraints for individual choices (see also Miller, 2021, and Chapter 16 for activity-based models).

Time geography was originally developed by Hägerstrand (1970). This theory is based on the idea that the life of an individual, but also of other organisms and material objects, describes an uninterrupted 'path' through time and across space. The timescale of these paths can vary from a day to the whole lifespan. Every organism or thing is constantly in movement, even when it is itself at rest. In this manner one can see a society as being built up from a large number of webs or networks composed of uninterrupted paths that have been drawn by people, other organisms and non-living elements through time and space (Dijst, 2020). In this theory, participation in activities is not a matter of choice, but subject to three types of constraints:

1. **Capability constraints**: biological, mental and instrumental limitations. For example, people sleep on average seven to eight hours a night at home, need to eat at regular moments, have a certain level of skills to carry out activities, and have transport modes at their disposal which enable them to travel through time and across space at various speeds.
2. **Coupling constraints**: people need to meet or access equipment and other materials at certain times and locations, in order to carry out joint activities like attending a lecture at a university or doing the groceries in a supermarket. Different time schedules and the different locations of people can complicate this coupling of individual paths.
3. **Authority constraints**: these regulate the access of individuals to activity places through social rules, laws, financial barriers and power relationships. Business hours, the price of admission and the timetable of public transport are some examples of these regulatory constraints.

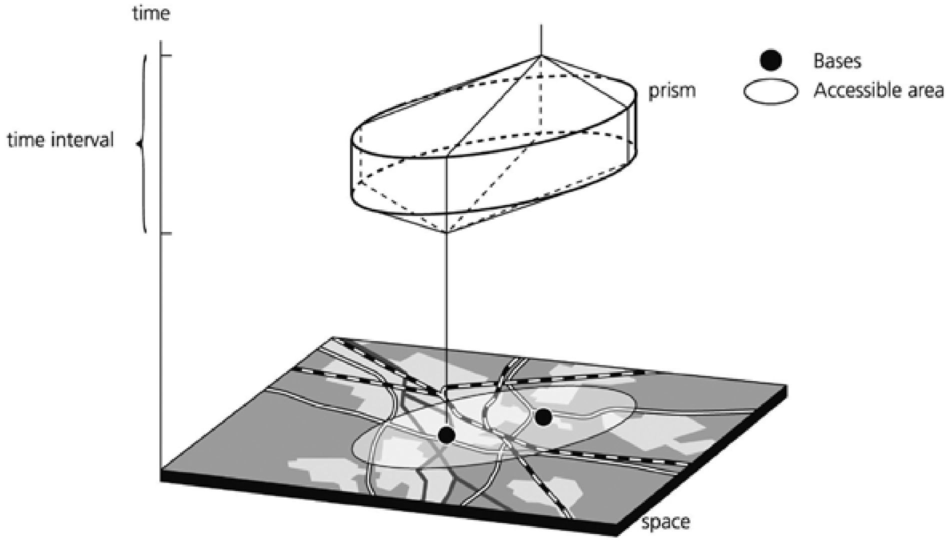

Figure 3.7 Prism and potential action space

In time geography, it is assumed that some activities such as work and home activities are fixed in time and in locations called 'bases'. These base locations, like fixed work and home locations, determine the opportunities to conduct more flexible activities such as buying the groceries and attending the theatre. These flexible activities can be pursued in 'time intervals', also called 'time windows', which represent blocks of time in which travel and relatively flexible activities can be carried out.

The capability, coupling and authority constraints define, for a certain time interval, a three-dimensional 'prism', which embraces the set of opportunities for travelling to activity places and to participate in activities (Figure 3.7). The projection of a prism in a three-dimensional space designates the 'potential action space'. This area contains all the activity places that can be visited within a certain time window: in other words, it represents the accessible area (Dijst, 2020).

Within this theoretical approach two behavioural rules can be distinguished which influence travel behaviour: fixation in time and space, and travel time ratio.

3.5.2 Fixation in Time and Space

As mentioned before, it is assumed that some activities are fixed in time and base locations. In Section 3.2, we called choices for these base locations mid-term choices. Why are these base locations so important? According to Cullen and Godson (1975: 9), 'Activities to which the individual is strongly committed and which are both space and time fixed tend to act as pegs around which the ordering of other activities are arranged and shuffled according to their flexibility ratings.' As explained above, these flexible activities, like daily shopping, can be pursued in 'time intervals', also called 'time windows', which represent blocks of time in which travel and relatively flexible activities can be carried out. In general, people have shorter than longer intervals. In a working day, typical time intervals are: before the commuting trip at home, while commuting to work, during the lunch break at work, while commuting to home, after dinner. On non-working days people may use fewer but larger time intervals.

Fixations in time have meaning for the type of activity places people attend. Empirical research (e.g. Kitamura and Kermanshah, 1983; Dijst and Vidakovic, 2000; Hafezi et al., 2019) has shown that similar activities take place in the same time intervals. Mandatory activities, like daily shopping and taking children to school or day care centres, usually take place in relatively short intervals of a maximum of 1.5 hours. However, for leisure activities like social visits and attending performances in theatres or exhibitions in museums people usually need large time intervals. One of the arguments for this temporal sorting of activities is that people want to secure scarce intervals for compulsory activities as much as possible. Dual-income households, especially, apply this strategy to avoid fragmentation of their leisure time.

Although time regimes show increasing levels of flexibility these can also lead to a temporal sorting of activities. For example, parents usually have to chauffeur their children two to four times a day to or from school. Often theatres cannot be visited during the daytime, and shops also have limited business hours. The duration of films, plays and sports matches are also often prescribed. Finally, the length of a time interval offers the option to take a longer time to travel to visit activity places that are at a relatively greater distance geographically.

3.5.3 Travel Time Ratio

The prism concept (Figure 3.7) makes it clear that individuals are constrained in their trade-offs between travel time and activity duration. Capability, coupling and authority constraints restrict the set of opportunities individuals have for travelling to activity places and to participate in activities. An individual has, in principle, three temporal choices without violating the constraints:

1. to spend the entire available time budget on travel without spending any time in an activity place;
2. to stay in a base location without travelling outside; or
3. to spend time on travel as well as on activities in one or more activity places.

To study the relationship between travel time and activity duration empirically Dijst and Vidakovic (2000) proposed the travel time ratio concept, which is defined as the ratio obtained by dividing the travel time to a particular activity place by the sum of travel time and activity duration for the same activity location. Schwanen and Dijst (2002) have shown that Dutch workers spend on average 10.5% of their time available for work and travel on commuting. This corresponds to 28 minutes for an eight-hour work day. The travel time ratio for work varies systematically with socio-demographics. For example, a household type defined by the presence of a partner and children and employment status accounts for almost one-tenth of the variation. On average, daily shopping has a ratio of 0.40 and for social leisure activities 0.25 (Susilo and Dijst, 2010). The concept is used in various studies, like on spatial planning (He et al., 2020), transportation networks (Irshaid et al., 2021), daily mobility patterns (Su et al., 2021) and health studies (Tan and Arcaya, 2020).

3.5.4 Model Applications of Classical Time Geography

Based on the time geographical perspective for planning purposes, simulation models have been developed to assess the effects of planning measures on the choice opportunities that individuals of various types have. PESASP (programme evaluating the set of alternative sample path) and its improved version MASTIC (model of action spaces in time intervals and clusters) are good representatives of this type of model. These models facilitate the assessment of the potential impact of time policies (for example, the business hours of shops, flexible working hours and adjusted public transport schedules), transport policies (for example, new road construction and new bus stops) and spatial policies (for example, changes in the density or mixture of activity places) on the opportunities offered to people to participate in their desired activities (Dijst et al., 2002).

3.5.5 Beyond Classical Time Geography

Due to theoretical, methodological and technological developments, classical time geography as framed by Hägerstrand has been enriched and transformed into a more comprehensive theory. The supply and use of Information and Communication Technologies (ICTs) in daily life offer tremendous new opportunities to (re)organize activities, which are less bounded in time and space. The widespread use of smartphones and the internet stimulate online shopping, teleworking, digital learning, navigation, on-demand transport services and other e-activities. These opportunities became even more important during the COVID-19 pandemic.

At the same time, these new technologies produce large volumes of real-time and high-resolution georeferenced Big Data (Kitchin and McArdle, 2016). The availability of these data in combination with an increase in the power of personal computers stimulated the development of geocomputation in Geographical Information Systems (GIS). Geocomputation refers to a set of computer-based techniques, such as data mining, genetic algorithms, cellular automata, fractal modelling and visualization. Algorithms have been developed to refine the analysis of the spatio-temporal opportunities available for individuals and their behaviours in time and across space. Miller and Goodchild (2015) are convinced that data and methodological developments could lead to significant discoveries in geography on the meaning of geographical contexts and spatial modelling.

Based on geocomputation techniques, Kwan (2000, 2004) has developed several algorithms to visualize concepts from time geography. Her three-dimensional figures offer realistic representations of urban environments, showing individual time–space paths and the location of activity places (see: http://meipokwan.org/Gallery/STPaths.htm). Navigation tools such as fly-through, zooming, panning and dynamic rotation, together with multimedia capabilities, allow the users of this visualization to create their own virtual images of the urban world.

Kwan (2008) was also one of the first geographers to visualize in GIS the emotional experiences along time–space paths (see also Huang et al., 2020). In recent years, GIS-based geocomputation is increasingly used to measure and visualize exposures to air pollution along mobility routes which are important for health (Richardson et al., 2013; Wang et al., 2021).

The conceptual and geometric time geographic framework is supplemented by Harvey Miller's measurement theory (Miller, 2005a). This theory consists of a series of analytical formulations for basic concepts and relationships of time geography. With this analytical framework, it is possible to infer time geographic entities and relationships from high-resolution measurement of mobile objects in space and time. As such it meets the analytical demands of location-aware technologies (LATs), like GPS tracking, and location-based services (LBS), such as navigation and social network services. Miller's theory has been extended to virtual interactions and velocity fields. To include virtual interaction he introduced two concepts. First, the concept of the (wired or wireless) 'portal', which is a station where actors can have access to appropriate communication services. Second, the 'message window' that defines the time interval when actors interact with portals (Miller, 2005b). Measurement theory has been supplemented with a field-based theory which addresses continuous changing travel velocities across space. In contrast, classical time geography is based on an uniform velocity assumption (Miller and Bridwell, 2009).

In time geography the prism represents the space–time volume of potential paths or opportunities actors have to participate in joint activities. For some social problems in time and space, it is important to know what the chances are of finding a person in a particular area or to determine the likelihood that two persons meet each other. To that purpose, a probabilistic approach to time geography is developed (Winter and Yin, 2011). This approach relies on knowledge about the behaviours of people in time and space, which are dependent on the variety of behaviours leading to different probability distributions.

By embracing and integrating other theoretical perspectives, for example, theories from social psychology, sociology and philosophy, it is possible to include concepts like emotions, perceptions and attitudes in time geography. Unlike in classical time geography, in a relational interpretation of time geography space and time are constructed within relational networks of humans and non-humans and not as pre-given dimensions of a container as in classical time geography. It also emphasizes the relevance of embodied experiences, intentions and meanings. This relational perspective allows studying existential feelings and relational needs of people in daily interactions in geographical environments (Dijst, 2018). This can increase the understanding of health and health-related behaviours and social issues, such as social integration and cohesion. This perspective leads for example to a reinterpretation of the concept 'authority constraint'. Not only an external authority but also the individual herself can act as an authority who can impose constraints on contact with others. Based on perceived or presumed negative appreciation and acceptance of another's biological and cultural appearance and behaviour a person could avoid specific places and disapproving gazes (McQuoid and Dijst, 2012).

3.6 CONCLUSIONS AND SYNTHESIS

Below we summarize the most important conclusions of this chapter and give a synthesis of the links between the discussed disciplines. Before presenting this synthesis it might be good to mention that in this chapter we have put a strong emphasis on three individual behavioural perspectives. However, research and policy making is often particularly interested in patterns at the aggregate levels rather than the choices or behaviours of individuals (see also Figure 3.2). Various multivariate models, some of them have been briefly mentioned in this chapter, are used to identify these patterns. There are also models available, such as micro-simulation or agent-based models, which makes use of behavioural rules to make predictions about future aggregate behaviours.

1. The three disciplines discussed in this chapter differ in the concepts they use, the identification of relevant determinants and behavioural mechanisms. However, each discipline focuses on and explains only a part of the reality of behavioural choices. The combination of these disciplinary perspectives can therefore lead to a more comprehensive understanding of travel behaviour and there is no 'competition' between disciplines as to which offers the 'best' way to study behaviour. The best strategy is to benefit from the insights that each discipline has to offer, and to combine these as well as possible in the integrative conceptual framework on this chapter.
2. A comparison of economics and psychology shows that psychology explicitly describes a wider range of behavioural aspects than economics. Economic studies typically assume that people make rational choices in the economic sense. This means that people do not systematically choose options for which they know or expect that alternatives are available that would provide higher satisfaction against the same cost, or the same satisfaction against lower cost. Determinants of that satisfaction include, also in economic models, many hard-to-observe features of individuals, including tastes and preferences that in daily speech could be called 'irrational' (but are not seen as such in the economic perspective), as well as unobserved characteristics of choice alternatives.
3. Psychology explicitly analyses a wider range of factors, including emotions, morality and habits than the economic approach. Psychologists also analyse the impact of other people on behavioural choices in different ways than economists do, who tend to focus on market failures such as the reciprocal impacts of congestion, crowding, traffic safety, pollution, noise or consumer externalities. Finally, economists put more emphasis on financial and temporal opportunities and constraints. They treat some of the aspects that psychologists focus on such as abilities and skills as exogenous in the short run, while longer-run models in, for example, labour and spatial economics explicitly consider choices on education, learning and knowledge spillovers. Likewise, what psychologists call perceived opportunities is in economics often reflected in choice set generation, in the degree of completeness of information, and becomes endogenous when information acquisition is modelled explicitly.
4. In comparison with psychology and geography, economics has a stronger focus on quantitative analyses that offer opportunities to predict the impact of economic, technological and other societal trends on travel choices from the long-run equilibrium perspective, taking into account the effects of feedbacks and interactions in travel and spatial behaviour. The effectiveness of economic policy measures can also be assessed in such modelling

frameworks. Examples are changes in prices, impacts of investments in new infrastructure, or the planning of new residential areas. However, owing to the previously discussed limitations, these predictions are never certain, and sensitivity analyses are an important tool to deal with this.

5. The geographical approach is largely comparable with economics utility maximization theory. However, in this chapter we have focused on the spatio-temporal constraints people experience in daily life. This geographical approach is complementary to a psychological and economic approach. Geographers also study short-term daily activity and travel behaviour in conjunction with the mid-term (e.g. choices of work and residential location and transport and communication modes) and long-term decisions (e.g. lifestyle choices) in the life course of individuals. In addition, a relational approach of time geography is increasingly integrating perspectives from psychology.
6. The different disciplines study the same phenomena from different angles and with different emphases. Terminology and jargon may differ as we have seen above, but this is bridgeable. More intrinsically, where emphases that disciplines place diverge, it is usually the case that the one discipline studies what the other – often implicitly – takes as given. An important synergy from interdisciplinary behavioural study in transport sciences is that it helps identifying such implicit assumptions, and brings on board the expertise that is needed to oversee and understand the potential implications of this, as well as knowledge of and experience with the theories and tools needed to remedy the associated shortcomings whenever deemed desirable.

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ANNEX 1 SOME KEY INDICATORS OF TRAVEL BEHAVIOUR FOR THE UNITED KINGDOM AND THE NETHERLANDS

The data in both tables are taken from the National Travel Surveys of the United Kingdom (NTS) and the Netherlands (ODiN). Comparing both countries should be done with caution. The travel surveys differ in sample size and composition, survey methods and operationalization of variables. The data refer to the year 2019, which is the most recent year not influenced by the changes in travel behaviour caused by the COVID-19 pandemic.

Table A3.1 Holders of car-driving licences and car ownership in the United Kingdom and the Netherlands by socio-demographics in 2019

Socio-demographics		United Kingdom (%)	The Netherlands (%)
Car-driving licence holders:			
Gender			
Men		80.0	84.6
Women		71.0	75.3
Age UK in years	Age Netherlands in years		
17–20	18–19	35.0	43.7
	20–24		70.7
21–29	25–29	62.0	77.8
30–39	30–39	79.0	81.4
40–49	40–49	86.0	86.9
50–59	50–59	86.0	88.3
	60–64		87.7
60–69	65–69	85.0	85.1
≥70	≥70	67.0	68.4
Car ownership:			
Gender			
Men		64.0[a]	82.1[b]
Women		54.0[a]	79.0[b]
Household income:	Household income:		
Netherlands	UK		
First 20%	Lowest level	55.0	73.6
Second 20%	Second level	72.0	78.6
Third 20%	Third level	82.0	81.2
Fourth 20%	Fourth level	85.0	82.4
Fifth 20%	Highest level	87.0	82.7

Notes:

[a] For main driver

[b] Member of household with ≥ 1 car

Source: UK-NTS (2019); NL-ODiN (2019).

Table A3.2 Travel attributes in the United Kingdom and the Netherlands by socio-demographics in 2019

Socio-demographics		No. of trips per day		Kilometres per day	
		United Kingdom	The Netherlands	United Kingdom	The Netherlands
Gender					
Men		2.5	2.6	30.7	40.7
Women		2.7	2.8	26.3	31.3
Age UK in years	Age Netherlands in years				
17–20	18–24	2.3	2.6	23.0	41.6
21–29	25–34	2.4	2.8	27.8	45.5
30–39	35–49	2.9	3.2	35.0	44.1
40–49	50–64	3.1	2.8	36.5	40.5
50–59	65–74	2.8	2.3	36.6	29.7
60–69	≥75	2.7	1.6	32.0	18.2
≥70		2.2		20.7	
Household income:	Household income:				
UK	Netherlands				
Lowest level	First 20%	2.4	2.3	18.1	25.1
Second level	Second 20%	2.5	2.4	22.3	26.7
Third level	Third 20%	2.7	2.8	26.4	35.7
Fourth level	Fourth 20%	2.8	3.0	35.1	39.6
Highest level	Fifth 20%	2.7	3.0	40.5	47.6
Car ownership[a]					
No	No	2.0	2.8	12.5	34.6
1	Yes	2.6	2.9	25.7	43.5
≥2		2.9		37.3	

Note: [a] UK including vans; NL only for driving licence holders
Source: UK-NTS (2019); CBS Statline (2019).