



# Feasibility of Voluntary Reduction of Private Car Use

Margareta Friman, Tore Pedersen and Tommy Gärling

Faculty of Economic Sciences, Communication and IT

SAMOT

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## Sammendrag

På verdensbasis oppleves i dag en svært stor økning i privat bilhold og tilhørende privatbilisme. Selv om utstrakt privat bilbruk har åpenbare positive effekter for den individuelle bilbruker, forårsaker privatbilismen i stor grad globale negative effekter, som for eksempel høyt energiforbruk og global oppvarming. Mange land står også overfor andre alvorlige konsekvenser av privat bilbruk på grunn av overbelastning av gate- og veinettet, støy samt luftforurensning – disse effektene er spesielt tilstedeværende i storbyer. På grunn av de samlede negative effektene av utstrakt privat bilbruk implementerer samferdselsmyndighetene ofte forskjellige strategier som hver for seg består av særskilte virkemidler. Slike virkemidler som har som siktemål å forandre eller redusere privat bilbruk, blir vanligvis omtalt som Travel Demand Management (TDM).

I denne forskningsrapporten beskriver vi en klassifisering av de forskjellige TDM-virkemidlene, herunder særskilte egenskaper ved hvert enkelt virkemiddel, hva som skiller de ulike virkemidlene fra hverandre, hvordan virkemidlene potensielt kan tenkes å interagere med hverandre samt hvor effektive virkemidlene er med hensyn til å forandre eller redusere privat bilbruk. Én distinksjon mellom virkemidlene gjelder hvorvidt de benytter seg av "tvang" eller "frivillighet", det vil si hvorvidt virkemidlet tvinger bilisten til å forandre adferd (f eks fysisk sperring av enkelte områder) eller hvorvidt bilisten inviteres til å gjennomføre en frivillig adferdsforandring (f eks informasjonskampanjer). En delvis overlappende distinksjon dreier seg om hvorvidt endringsprosessen er initiert "ovenfra" (fra myndighetshold) eller "nedenfra" (fra den individuelle bilist), hvor den førstnevnte gjelder forandringer som blir påtvunget bilisten, mens den sistnevnte gjelder virkemidler som bemyndiger bilisten slik at en frivillig adferdsendring kan gjennomføres. En tredje distinksjon dreier seg om begrepet tid, det vil si hvilket tidspunkt på døgnet virkemidlet er aktivt (f eks ulike avgifter til ulike tider), mens en fjerde distinksjon angår begrepet romlig utstrekning, hvilket dreier seg om på hvilke steder virkemidlet implementeres (f eks i sentrumsområder). Forskjellen mellom markedsbaserte (f eks prismekanismer) og regulatoriske (f eks lovgivning) virkemidler utgjør en fjerde distinksjon. En siste distinksjon angår forskjellen mellom latente og manifeste behov, hvor virkemidler som tilfredsstiller latente behov kan dreie seg om, for eksempel, utvidelse av eksisterende infrastruktur for å unngå overbelastning av veinettet, mens virkemidler som har til hensikt å påvirke manifeste behov kan henseile på, for eksempel, å begrense tilgangen til bestemte soner på bestemte tider av døgnet.

Dernest foreslår forskningsrapporten et teoretisk rammeverk som gjør rede for den effekten TDM-virkemidlene kan tenkes å ha på bilistenes adferdsforandring. Rammeverket hevder at bilister formulerer mål og implementerer strategier for å oppnå endringer i sin reiseadferd (f eks fra å bruke bil til å bruke alternative reisemåter). Prinsippet om kostnadsminimering er foreslått for å forklare hvordan bilistene inkrementelt tilpasser seg til implementeringen av TDM-virkemidlene. Et viktig aspekt i

forbindelse med appliseringen av TDM-virkemidlene er å forstå hvordan de ulike virkemidlene påvirker bilistenes formulering av mål samt implementeringen av målene.

En gjennomgang av programmer som fremmer frivillige forandringer i reiseadferd (VTBC – Voluntary Travel Behaviour Change) som er implementert i Australia, Tyskland, Japan, Nederland, Sverige, Storbritannia og USA viser at disse virkemidlene på generell basis er effektive. Samtidig gjøres det rede for hvordan VTBC-programmene bemyndiger bilister ved å hjelpe dem med å planlegge, formulere mål og implementere spesifikke strategier for å oppnå målet om en forandret reiseadferd. Det er imidlertid fortsatt uklart hvorvidt disse positive effektene er av langvarig karakter. I tillegg er de positive effektene tilsynelatende kun observert for motiverte (og selv-selekterte) deltakere, og heller ikke nødvendigvis for alle disse hvis ikke spesielle betingelser er oppfylt. VTBC-virkemidlene er av en slik karakter at de både er akseptert i befolkningen, politisk gjennomførbare og kostnadseffektive. Et hovedpoeng i rapporten er spørsmålet om hvorvidt flere bilister kan bli motivert til å delta i programmer som legger vekt på frivillige adferdsforandringer (det vil si "myke" virkemidler) dersom det samtidig implementeres andre virkemidler (det vil si "harde" virkemidler) som for eksempel avgifter, fysiske sperringer eller infrastrukturinvesteringer. En viktig konklusjon med hensyn til dette er at, dersom "harde" virkemidler introduseres, vil det kunne medføre en betydelig effektøkning dersom man kombinerer disse med de teknikkene som brukes i VTBC-virkemidlene (de vil si de myke virkemidlene som inviterer til frivillig endring).

Avslutningsvis betones nødvendigheten av ytterligere forskning for å besvare spørsmålet om *når* og *hvorfor* VTBC-virkemidlene faktisk har en effekt. Overgripende spørsmål i denne sammenheng dreier seg om synergieffekter mellom de ulike virkemidlene, langtidseffekter, ulike effekter for ulike målgrupper, effekten av kollektivtransportens kvalitet, hva slags betydning det har *hvor* virkemidlene er implementert, overførbarhet til andre områder og kost-nytte analyser. I tillegg dreier forskningsbehovene seg om de spesifikke teknikkene som er anvendt i VTBC-programmene, herunder kommunisering, motivasjonsstøtte, målformulering og spesifikke planer for endret adferd, forholdet mellom tilpasset og standardisert informasjon samt kvaliteten på den "fremovermelding" (feedforward) og tilbakemelding (feedback) som gis til programdeltakerne. Utover dette er det viktig å oppnå kunnskap om hva slags spesifikke midler deltakeren selv bruker for å oppnå å redusere sin bilbruk.

Hvis en reduksjon i bilbruk betraktes som bilistenes inkrementelle tilpasning til forandringer i de reisealternativer som potensielt har konsekvenser for deres engasjement i ulike aktiviteter, er det overgripende nødvendig å forstå de forutgående faktorer som påvirker forandringen, så vel som de samfunnsmessige kostnadmessige konsekvenser av denne tilpasningsprosessen. Det å redusere bilbruk vil sjelden være en endimensjonal forandring; i så fall er det nødvendig med mer kunnskap om både de individuelle og situasjonelle faktorer som påvirker dette.

## Summary

Depletion of energy and global warming are expected future consequences of the worldwide increasing trend in ownership and use of private cars (Goodwin, 1996; Greene & Wegener, 1997). In addition many countries are today facing substantial environmental and societal costs of private car use such as congestion, noise, and air pollution. Particularly in urban areas, these consequences are urgent problems that need to be solved. Transport authorities therefore implement various policy measures that aim to modify or reduce private car use. These are generally referred to as Travel Demand Management (TDM) measures.

In this research report we propose a classification of the various TDM-measures, encompassing the specific characteristics of each, how the various measures may be distinguished from each other and to what extent they may interact, as well as how effective they are in modifying or reducing private car use. One distinction between the various TDM measures is that between coerciveness and non-coerciveness, that is whether a change is forced upon the private car users (e.g., road closures) or whether they are motivated to make a voluntary change (e.g., informational campaigns). Another partly overlapping distinction is that between top-down and bottom-up processes, where the former refers to changes that are not freely chosen, whereas the latter empowers car users to voluntarily change. A third distinction is that of time scale, that is at what times of day the measures are implemented, for instance, congestion pricing only during peak hours. The fourth distinction is spatial scale, that is where the measure is applied, for instance in the city centers. Market-based (e.g., pricing mechanisms) versus regulatory-based (e.g., legislation) measures makes up a fifth distinction. A final distinction is that between influencing latent versus manifest travel demand. Measures that aim to impact the former typically consist of, for instance, building of new roads to reduce congestion, whereas measures that aim to impact the latter is characterized by an impact on manifest travel behaviour, for instance, limiting car access to specific areas at specific times of day.

A theoretical framework is proposed next to account for how the TDM measures impact on car users' change in travel behaviour. It takes as the point of departure that private car use primarily results from people's needs, desires or obligations to participate in various out-of-home activities. Therefore, car-use reduction may broadly be viewed as car users' adaptation to changes in travel options that may potentially have consequences for their engagement in various activities, as well as their satisfaction with these activities. The theoretical framework posits that car users if motivated to set change goals that may be difficult or easy to attain, specific or vague, complex in terms of number of outcome dimensions, and in conflict with other goals. Commitments to the set goals may furthermore vary. If a change goal is set, it is followed by forming plans to attain the set goal (e.g., to change from using the car to using alternative modes). A principle of cost-minimization is proposed that describes how car users incrementally implement plans to achieve their set goals.

A review of voluntary travel-behavior change (VTBC) programs implemented in Australia, Germany, Japan, Netherlands, Sweden, UK, and the US shows that in general these measures are effective. It is further shown that VTBC programs empower people by means of helping them to plan, set goals and implement specific means to achieve the change-goals. Yet, it is still unclear whether these positive effects are long-term. Furthermore, the positive effects are apparently only observed for motivated (and self-selected) participants and not even necessarily for all of them unless some facilitating conditions are fulfilled. VTBC measures meet with higher public acceptance, are politically feasible, and cost-effective. A main issue is whether more car users can be motivated to participate by introducing hard transport policies (pricing, legislation, infrastructure investments) that make car use less attractive. An important conclusion in this respect is that if hard transport policies are introduced, combining them with the techniques used in VTBC measures would boost the effect.

It is argued that more research is needed to answer the questions of when and why VTBC measures work. Overarching questions concerning when VTBC measures work include effects of synergies between different TDM measures, long-term effects, differential effectiveness for different target groups, the impact of public transport quality, the role of the location of an implemented program and the possibility to translate the results to other areas, and cost-benefit-analyses. Furthermore, research needs addressing why VTBC programs work focusing on the techniques and combinations of techniques that are used, including motivational support, requesting goal setting and plan formation, customized in contrast to standardised information, and the quality of feedforward and feedback information.

If car-use reduction is viewed as car users' incremental adaptation to changes in travel options that may potentially have consequences for their engagement in various activities, an overarching theoretical issue is to understand the antecedents and individual as well as societal cost consequences of the adaptation process. Reducing car use is seldom a unidimensional change. If so, theory must specify what individual and situational factors that shapes it.

## Introduction

Depletion of energy and global warming are expected future consequences of the worldwide increasing trend in ownership and use of private cars (Goodwin, 1996; Greene & Wegener, 1997). In addition many countries are today facing substantial environmental and societal costs of private car use such as congestion, noise, and air pollution. Particularly in urban areas, these consequences are urgent problems that need to be solved. This situation has resulted in suggestions of a number of transport policy measures targeted at both reducing and changing private car use. The measures are referred to as *travel demand management (TDM)* measures (Kitamura, Fujii, & Pas, 1997; Pas, 1995), although there are other names with similar meaning that are used, such as transport system management or transportation control measures (Pendyala et al., 1997), transportation demand management (Litman, 2003), and mobility management (Kristensen & Marshall, 1999; Litman, 2003; Rye, 2002).

Reducing private car use would not be difficult were it not for a number of counteracting factors. One such factor is that the versatility of the car makes it very attractive to its users (Sheller & Urry, 2000). The versatility has been strengthened by huge investments in road infrastructure in Western countries. In Sweden billions of tax money has been allocated to road infrastructure which has resulted in a society built for mass car use (Henriksson 2011). From 1950 car use increased by 40 percent to 70 percent in 2005. At the same time public transport decreased from 50 to 20 percent (Transek, 2006).

In this research report we first discuss and classify TDM measures that aim at reducing private car use. We then describe a theoretical framework that can be used to understand and forecast the success of the different TDM measures. In a third section we review empirical evaluations of a class of TDM measure referred to as voluntary travel behaviour change programs. In the final section we identify questions that need to be addressed in future research.

## A Classification of Travel Demand Measures

There are many diverse transport policy measures that may lead to a reduction in the levels of car-use related congestion, noise, and air pollution in urban areas. Some of these measures (e.g., increased capacity of road infrastructure, reduced vehicle emissions) do not necessitate a reduction in car use. A general assessment of the current state is still that measures that manage car-use demand need to be implemented (e.g., Hensher, 1998). According to this assessment, it is necessary to both reduce car use and to change car use with respect to when and where car users drive, particularly on major commuter arteries during peak hours and in city centers.

Litman (2003, p. 245) notes that TDM is “a general term for strategies and programs that encourage more efficient use of transport resources (road and parking space, vehicle capacity, funding, energy, etc)”. As noted by Taylor and Ampt (2003), TDM measures encompass any initiative that has the objective of reducing the negative

impact of car use. This definition also reflects the broader changes in policy measures, that have progressed from the 1960s, when it was common to expand road infrastructure to alleviate traffic problems such as congestion, to the 1970s, where the emphasis was on improving the management of the existing infrastructure, and to the 1980s and beyond, when policies started to target altering travel behavior (Bovy & Salomon, 2002; Pas, 1995). Even more recent manifestations are the attempts to change attitudes, norms, and values towards endorsement of a more placid lifestyle and an improved image for public transport.

Several classifications of TDM measures have been developed. Litman (2003) distinguishes five different classes: (i) improvements in transport options, (ii) provisions of incentives to switch mode, (iii) land-use management, (iv) policy and planning reforms, and (v) support programs. A partly overlapping set is proposed by May, Jopson, and Matthews (2003) who refer to land-use policies, infrastructure provision (for modes other than the private car), management and regulation, information provision, attitudinal and behavioral change measures, and pricing. Other examples of classifications are Vlek and Michon (1992) who suggest the following: physical changes such as, for instance, closing out car traffic or providing alternative transportation; law regulation; economic incentives and disincentives; information, education, and prompts; socialization and social modeling targeted at changing social norms; and institutional and organizational changes such as, for instance, flexible work hours, telecommuting, or “flexplaces.” Yet another approach is found in Louw, Maat, and Mathers (1998), who argue that car use is influenced by encouraging mode switching, destination switching, changing time of travel, linking trips, substitution of trips with technology (e.g., teleworking), and substitution of trips through trip modification (e.g., a single goods delivery in lieu of a series of shoppers’ trips). Gatersleben (2003) distinguishes measures aimed at changing behavioral opportunities from measures aimed at changing perceptions, attitudes, and norms.

Partly based on the different (and to some extent overlapping) systems of classification listed above, Loukopoulos (2007) proposed that TDM measures vary on a number of dimensions including *coerciveness, top-down versus bottom-up processes, spatial scale, time scale, market-based versus regulatory mechanisms, and impacting latent versus manifest travel demand*. These dimensions are not exhaustive but were selected on the basis of their relevance to the theoretical framework presented in the next section. The purpose is also to facilitate the evaluation of various measures. By learning from such evaluations about the strengths and weaknesses of the different measures, it would be possible to implement measures which complement each other, for instance, a mix of prohibition and voluntary travel behavior change measures.

Each dimension in Loukopoulos’ (2007) system are described and exemplified below.

## **Coerciveness**

TDM measures may vary in terms of whether the change is discretionary and within the control of the car users themselves, or whether the change is forced upon them. For instance, public transport improvements or information campaigns may be defined as non-coercive TDM measures since the decision to reduce car use is left to the car user. On the other hand, TDM measures such as road closures and prohibition in city centers are highly coercive as car users have no other choice but to reduce their car use in the designated areas. The degree of coerciveness with regard to yet other TDM measures, such as road pricing or parking fees, depends on the car users' wealth.

## **Top-Down versus Bottom-Up Processes**

Taylor and Ampt (2003) make a distinction between top-down approaches that tell people what to do and bottom-up approaches that allow people freedom in choosing to change their car use. Bottom-up approaches are also sometimes referred to as *voluntary travel behavior change (VTBC)* measures which we will focus on in a subsequent section. The goal of these measures is to empower people to change. A key principle is that individuals should define their own change goals in accordance with their needs and existing lifestyle. This is why change must be initiated as part of a bottom-up process that allows people to decide themselves whether they wish to participate (Rose & Ampt, 2001; Taylor & Ampt, 2003).

## **Time Scale**

The temporal nature of a TDM measure refers to its operational specifications. Congestion pricing, for example, is a measure that typically operates during peak periods or during the day but not in evenings or weekends. Prohibition measures can also operate in a similar fashion (Cambridgeshire County Council, 2003a, 2003b), although most road closures tend to be made on a permanent basis. Furthermore, TDM measures may also affect the temporal nature of the specific activity per se; for example, work hour management strategies attempt to affect the demand of vehicle trip by reducing it or by shifting it to less-congested time periods (e.g., flexible work hours, staggered work hours, modified work schedules such as a four-day week, and telecommuting services) (Golob, 2001).

## **Spatial Scale**

TDM measures' scope of influence may vary from the limited local to the broad national. Differentiated road pricing or congestion charging, for example, is a local initiative aimed at easing traffic flows in city centers to improve local air pollution levels, as well as improving the livable nature of urban areas (Banister, 2003; Foo, 1997, 1998, 2000; Goh, 2002). Road closures and pedestrianization measures are also initiatives that are local in their nature. An example of a TDM measure with a rather large spatial zone of influence is a proposed kilometer charge (Ubbels, Rietveld, & Peeters, 2002). A further

example is that of public transport discounts for certain groups in society, such as, for instance, pensioners or the unemployed.

An alternative conception of the spatial reach of TDM measures is whether or not the measures target the origin or the destination of trips. For example, it is possible in a monocentric city to make car use less attractive by means of traffic calming and access restrictions in both the city center (a typical destination) and in the residential areas (a typical origin) (Louw & Maat, 1999).

### **Market-Based versus Regulatory Mechanisms**

The range of TDM measures also vary in terms of whether they can be classified as market-based (e.g., road pricing based on pricing mechanisms) or regulatory (i.e., based on legislation, standards, and legal principles). Examples of regulatory measures include road closures, maximum parking ratios, enforced speed limits, and mandatory employer trip reduction programs. Violations of regulatory TDM measures are met with some sort of punishment. These policy measures are also referred to as command-and-control measures (Johansson-Stenman, 1999) since an authority assumes responsibility for the management of a transport system and controls it so that it functions as effectively as possible.

Examples of market-based TDM measures include road and congestion pricing (Banister, 2003; Foo, 1997, 1998, 2000; Goh, 2002), kilometer charges (Ubbels, Rietveld, & Peeters, 2002), fuel excises and parking charges (Meyer, 1999), and public transport discounts and travel vouchers (Root, 2001). Market-based TDM measures are theoretically founded in neoclassical economics; people's behavior is regulated by the principle of supply-and-demand and explicit cost-benefit analysis, such that if the price of a service (i.e., transportation) increases, the demand for this service will decrease, and vice versa. Using congestion pricing as an example, the idea is to raise costs so that the congestion externality is internalized (Emmerink, Nijkamp, & Rietveld, 1995; Rothengatter, 2003).

Market-based measures seem to have become increasingly popular in recent years, particularly among politicians who appear to have embraced a new competition paradigm emphasizing less governmental control. In line with this, many regulations have been repealed on the basis of being either outdated or unnecessarily restrictive. Although there are reasons to regulate transportation services to maintain quality, reliability, and safety, it is believed that unnecessary regulations can be reduced, and that regulation objectives can be changed to address specific problems while encouraging competition, innovation, and diversity (Klein, Moore, & Reja, 1996, 1997).

The increasing popularity among politicians has, however, been matched by an increasing skepticism amongst researchers. For road pricing to be viewed as a first-best instrument for tackling the problems of car use, there are certain requirements that must be fulfilled, two of which are that (1) households and individuals maximize utility, and (2) full information is available on all costs involved (Emmerink, Nijkamp, & Rietveld, 1995). Yet, the habitual nature of car use with its consequences of limiting pre-

decisional information search renders the second assumption suspect. The assumption of individuals' (expected) utility maximization has also been found to be violated in numerous studies (Dawes, 1998; McFadden, 1999). Furthermore, independent lines of empirical research have revealed low price elasticities to be associated with various pricing policies (at least in the short term, although some higher elasticities have been obtained in the long term) (Hensher & King, 2001; Schuitema, 2003; Sipes & Mendelsohn, 2001). Jakobsson (2004) summarizes the mainly negative outcomes of a limited number of field experiments conducted with the purpose of evaluating the effectiveness of road pricing.

Nevertheless, the popularity of market-based measures such as road pricing continues to grow amongst politicians who also regard the potential of such measures to yield additional revenues, either for other environmentally friendly transport modes or for other public services such as health and education (Johansson et al., 2003; Odeck & Bråthen, 2002; Rajé, 2003).

### **Impacting Latent versus Manifest Travel Demand**

Variations in TDM measures in terms of the nature of the actual travel demand they manage seem to be seldom taken into consideration. Latent travel demand may be defined as the demand for services or resources that goes unsatisfied for various reasons (e.g., congestion). Road construction has historically been driven by a "predict-and-provide" approach (Vigar, 2002; Whitelegg & Low, 2003), where the argument has been that latent demand should be satisfied because better and more roads were required as a matter of individual freedom (the right to use the car) and economic competitiveness (the need for efficient road links for business). However, as noted in Mogridge's (1997) review, an increase in road capacity do not yield faster or more efficient travel but, paradoxically, may actually make congestion worse. The reasons for this are argued by Downs (1992) to be due to the fact that free road space produced from marginal reductions in commuting time is consumed quickly by those traveling outside of the peak time period who would shift back in; those driving on less optimal routes who would take advantage of lowered congestion on the most popular freeways; and those on slower public transit modes who would prefer driving if there were any more space on the road. Latent demand induced by increased road capacity also includes new vehicle trips made by people who would not otherwise have made the trips, resulting from drivers who select an alternate destination (i.e., shoppers who prefer a new shopping center over the city center). In other words, the expansion of road infrastructure is self-defeating, a point that has been clearly made by Hansen and Huang (1997), who estimate that in California the five-year elasticity of vehicle travel with respect to highway lane miles is 0.6-0.7 at the county level and 0.9 at the metropolitan level. The implications of this are that most of the trips on new roads are trips that would not actually have occurred had the roads not been built.

In contrast to influencing latent travel demand, there are many TDM measures that influence manifest travel demand (i.e., actual travel). Road or congestion pricing or

kilometer-based charges are attempts aiming at changing the actual driving of many people by increasing the costs (Banister, 2003; Foo, 1997, 1998, 2000; Goh, 2002; Ubbels, Rietveld, & Peeters, 2002), or by decreasing the costs of alternative modes (Root, 2001). Road closures or prohibitions make it difficult, if not impossible for travel demand to manifest itself in certain areas or at certain times (Cambridgeshire County Council, 2003a, 2003b). The initial waves of TDM measures focused on a better management of the existing resources (Bovy & Salomon, 2002), and thus emphasized changes in manifest travel demand.

Yet, many recent TDM measures have also begun to specifically influence latent travel demand. One particularly noteworthy example is the attempt to alter human values and to change the existing mobility culture so that a less mobile society is not seen as negative (City of Zurich, 2002). Another example of such a TDM measure is land-use planning; research has demonstrated that intensities and mixtures of land use significantly influence individuals' decisions to either drive alone, to car pool, or to use public transport (Cervero, 2002). The assumptions made by proponents of such measures are that land-use patterns influence the time costs of travel and that the variations in time costs due to land use is of sufficient size to induce changes in car use (Boarnet & Crane, 2002; Boarnet & Sarmiento, 1998). Taken together, whereas the construction of road infrastructure assisted the satiation of latent travel demand by allowing it to be manifested in actual car use so that individuals could drive to their activities, land-use policies that promote, for example, mixed zoning satiate the latent travel demand by bringing the activities to the individual.

## Theoretical Framework

The potential effectiveness of Travel Demand Management (TDM) measures implemented in order to reduce private car use depends on how car users will respond to them. In conceptualizing responses to implemented TDM-measures, it is important to take into consideration that private car use primarily results from people's needs, desires or obligations to participate in various out-of-home activities (e.g., Axhausen & Gärling, 1992; Jones et al., 1983; Gärling, Kwan, & Golledge, 1994; Root & Recker, 1983; Vilhelmson, 1999). Therefore, car-use reduction may broadly be viewed as car users' adaptation to changes in travel options that may potentially have consequences for their engagement in various activities, as well as their satisfaction with these activities (Gärling, Gärling, & Johansson, 2000; Gärling, Gärling, & Loukopoulos, 2002; Kitamura & Fujii, 1998; Pendyala et al., 1997; Pendyala, Kitamura, & Reddy, 1998). In the following we offer a description of a theoretical framework (Gärling et al., 2002; Loukopoulos et al., 2007) that has been proposed with the aim of analyzing the multi-faceted nature of car users' responses to various TDM measures.

Figure 1 shows the theoretical framework. The various travel options are defined as bundles of attributes that describe trip chains (including trip purposes, departure and arrival times, travel times, monetary costs of trips, uncertainty, and inconveniences). Individuals' choices of the various travel options are influenced by these bundles of

attributes. Another important determinant is the specific goals that individuals set. According to self-regulation theory in social psychology (Carver & Scheier, 1998), such goals form a hierarchy from the concrete (programs) to the abstract levels (principles). The goals function as reference values in negative feedback loops that regulate ongoing behaviour or changes in behaviour. If a discrepancy between the present state and the goal arises, some specific action is carried out with the aim of minimizing the discrepancy. After implementing, for instance, a road pricing scheme, a car-use reduction goal may be set if individuals experience an increased monetary travel cost (Loukopoulos, Gärling, & Vilhelmson, 2005). On the other hand, if various other changes are encountered, such as for instance decreased travel times by car (due to less congestion) or perhaps decreased living costs (e.g., children moving out, salary raises), no such goal may be set. In effect, there exists no simple relationship between increasing, for instance, the costs of driving and individuals' setting of car-use reduction goals. A similar line of reasoning may be applied to changes in destinations, departure times, or routes.

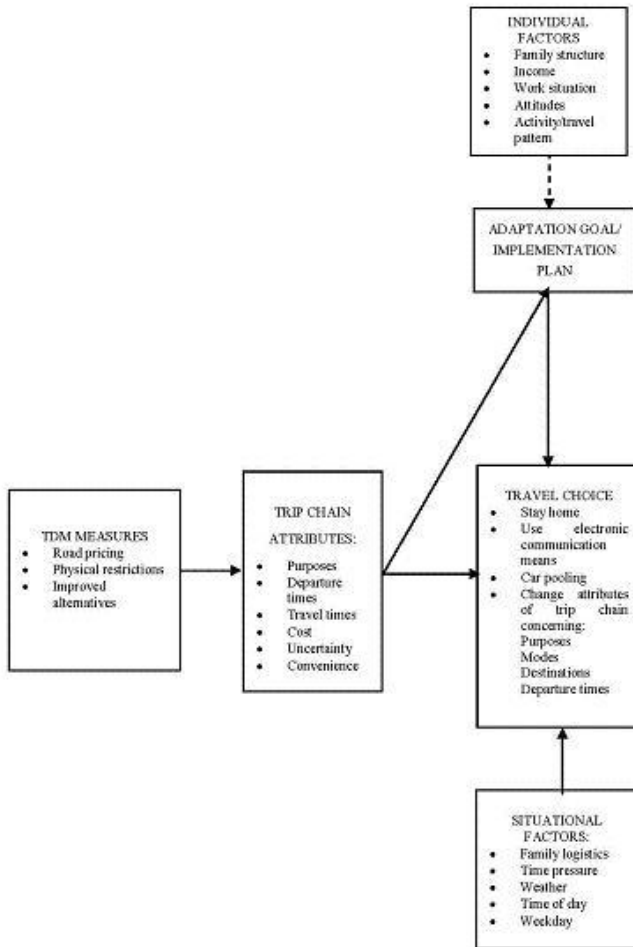


Figure 1. Theoretical framework. (After Gärling et al., 2002)

A broad range of needs, desires, attitudes, norms, and values influence the goals that individuals set and which they strive to attain (Austin & Vancouver, 1996). Goals are assumed to have the two primary attributes content and intensity (Locke & Latham, 1984, 1990). Goal content in turn has four separate parts: difficulty, specificity, complexity, and conflict. Difficulty is related to the degree of impediments to obtain the goal, specificity to whether or not the goal is easy or difficult to evaluate, complexity to the number of different evaluation dimensions, and conflict to the degree to which the achievement of one goal inhibits achievement of another goal. The second primary attribute, intensity, entails commitment, perception of goal importance, and the processes engaged by goal attainment. Previous research on goal setting and attainment

(e.g., Lee, Locke, & Latham, 1989) has shown that specific, more difficult goals may increase the likelihood that they are attained, provided that this is not beyond people's skill. Commitment to the goal and immediate clear feedback about goal attainment are moderating factors.

After having set a car-use reduction goal, individuals are assumed to form a plan for how to achieve this goal and to make commitments to execute the formed plan. In social psychology this process is referred to as the formation of implementation intentions (Gärling & Fujii, 2002; Gollwitzer, 1993). The plan that is formed consists of predetermined choices that are contingent on specified conditions (Hayes-Roth & Hayes-Roth, 1979). In making plans for how to reduce their car use, individuals may consider a wide range of options such as staying at home, suppressing trips and activities or using electronic communications means instead of driving, or they may car pool or change the effective choice set of travel options with regard to purposes, destinations, modes, or departure times. Eventually, they may also consider longer-term strategic changes, such as, for instance, moving to another residence or to change work place or work hours.

It is hypothesized that individuals to a large extent seek and select options that lead to the achievement of the goal they have set, although it is not assumed that this process necessarily entails a simultaneous optimal choice among all available options. Consistent with the notion of satisficing (Gigerenzer, Todd, & the ABC Research Group, 1999; Simon, 1990), it is instead assumed that options are chosen and evaluated in sequence. Experimental laboratory-based research (Payne, Bettman, & Johnson, 1993) has shown that people make optimal tradeoffs between accuracy and (mental and tangible) costs. This is an important difference to microeconomic utility-maximization theories (McFadden, 2001) that assume that people invariably invest the maximal degree of effort; whether people actually invest effort or not is in the proposed theoretical framework dependent on properties of the set goal (e.g., if it is vague or specific). Furthermore, if the costs of an effective adaptation are regarded to be too high, even a very small and specific reduction goal to which an individual is committed may be abandoned or reduced.

A second important difference to utility-maximization theories is that individuals' choices are made sequentially over time. This implies that a change-process is prolonged and thus fails to instantaneously result in outcomes that are beneficial to society. Furthermore, both benefits (effectiveness) as well as costs of the chosen alternatives are evaluated. If such evaluations indicate that there is a discrepancy compared to the goal, more costly changes may be chosen. Even though it has been shown that people make optimal accuracy-effort tradeoffs in laboratory experiments, we do not know whether they do so in real life when they are making complex travel choices. Actually, much speak to the fact that they do not. It is well-documented that habitual car use and other daily habits and routines cause choice inertia (Fujii & Gärling, 2007; Verplanken et al, 1999), and research has also demonstrated that a status quo bias exists such that the current state is overvalued (e.g., Samuelson & Zeckhausen, 1988) making changes less attractive. Particularly if a car-use reduction goal is vague, evaluations of whether or not

a change-option is effective may possibly be biased towards confirming the expectation that it is not (e.g., Einhorn & Hogarth, 1978; Klayman & Ha, 1987). Furthermore, previous research has demonstrated that an immediate and clear feedback is essential (e.g., Brehmer, 1995). A system for changing current car use that does not provide feedback is likely to fail.

On the basis of the theoretical framework, the existence of a hierarchy of change options that vary in effectiveness and costs is posited. In Table 1, an operationalization is displayed by specifying three distinctly different categories of potential change options together with the costs associated with each. It is further assumed that an inverse relationship exists between effectiveness and costs for these change options. Below a description with reference to the table is given of each of the options.

| <b>Choice options</b>   | <b>Possible costs</b>  |
|---|--|
| More efficient car use <ul style="list-style-type: none"> <li>• Trip chaining</li> <li>• Car pooling</li> <li>• Choosing closer destinations</li> </ul> | Additional planning  |
| More efficient car use<br>Trip suppression  | Additional planning<br>Activity suppression  |
| More efficient car use<br>Trip suppression<br>Mode switching  | Additional planning<br>Activity suppression<br>Increased time pressure<br>Inconveniences |

Table 1. Sequential choices of travel options and their possible cost.

As may be seen in Table 1, a first stage involves making car use more efficient by chaining car trips, by car pooling, or by choosing closer destinations. The costs are an increased need to plan ahead. The resulting change in car use may however not be sufficient to achieve the car-use reduction goal that is set.

In a second stage, trips may also be suppressed in order to achieve a larger reduction in car-use. In addition to increased planning, trip suppression also implies changes in activities but perhaps only the suppression of some isolated (e.g. shopping) trips. With regard to activity change, leisure activities seem to be the next most likely to be removed from the activity agenda or substituted by in-home activities, whereas more consequential changes in work hours or changes of job are the least likely.

If the car-use reduction goal is still not attained, other travel modes (than the car) are chosen. For instance, since work-activities cannot easily be suppressed, public transport may be chosen for these trips. The costs associated with switching mode include additional planning, increased time pressure, and inconveniences. Thus, in order to alleviate the effects of a potentially harmful increased time pressure (Gärling, Gillholm, & Montgomery, 1999; Koslovsky, 1997; Novaco, Kliewer, & Broquet, 1991;

Novaco, Stokols, & Milanese, 1990), suppression of some minor leisure activities and shopping may still be necessary.

It should be noted that Table 1 describes only one possible operationalization of the principle of sequential cost-minimization of choices of change options, as survey results suggest that the hypothesized hierarchy may vary with trip purpose and household, and also with individual characteristics (Gärling, Gärling, & Johansson, 2000; Loukopoulos et al., 2004). Furthermore, it may not always be the case that costs vary inversely with effectiveness; TDM measures may be applied, or other changes (e.g., residential relocation) may occur, that either singly or in combination, facilitates less costly changes that are effective.

In order to understand how TDM measures affect individuals' car use, the theoretical framework posits that two processes need to be examined further. The first is how the type and size of the measure affect the size and type of the car-use reduction goals that are set by individuals with different characteristics? The second regards which of the properties listed above for describing TDM measures are related to the goal-setting process? Coercive TDM measures may have a better effect than non-coercive TDM measures.

If an implemented TDM measure does not lead to the setting of car-use reduction or change goals, it will not have the intended effect. However, even if a change goal is set, it may still not have the intended effect, something which follows from the likely fallibility of the second process that needs to be examined: the formation and implementation of a plan to achieve the car-use reduction or change goal. It is substantially documented that attitudes and intentions do not always have a strong correspondence with individuals' actual behavior (Eagly & Chaiken, 1993; Fujii & Gärling, 2003; Gärling, Gillholm, & Gärling, 1998). Several reasons for this have been identified. We assert that the principle of cost-minimization (where cost is broadly defined) is important for understanding how households and individuals try to attain the set car-use reduction goals. If the cost is perceived as too high for its given strength and size, the case may be that the goal is abandoned or changed. Evaluation of feedback about effectiveness (goal attainment) is another essential element. If delayed and/or vague, suboptimal adaptation alternatives may continue to be chosen.

Coercive measures, including also road-user charges, presumably only affect the motivation to change. Additional TDM measures need to be implemented in order to reduce the cost of effective change alternatives so that these are perceived as more attractive. Such measures include those focusing on latent travel demand, that is, increased accessibility without the use of the car. Additionally, choices of appropriate spatial and time scales may also be important.

## **Evaluations of Voluntary Travel Behaviour Change Measures**

Voluntary travel behaviour change (VTBC) measures aim at empowering car users to make a voluntarily switch towards a more sustainable travel mode (Cairns et al., 2008; Jones & Sloman, 2006; Taylor & Ampt, 2003). In Japan these measures are

referred to as *travel feedback* (TFP) *programs* implemented as small-scale experiments (Fujii & Taniguchi, 2006). Both in Australia and in the UK, and increasingly in other countries, implementations of such VTBC measures target a large number of households, usually as part of broader programs that aim to encourage sustainable behaviour changes (Taylor, 2007). Such large-scale implementations are typically commissioned by the local governments and implemented by various consultant companies. Two examples are “Individualised Marketing” (IndiMark) developed by SocialData (Brög et al., 2009) and “TravelBlending” developed by the Monash University and Steer Davies Gleave (Rose & Ampt, 2003). The latter of these has been consistently modified and is currently also labelled “Living Neighbourhoods” or “Living Change” (Cairns et al., 2004).

An important issue regarding the VTBC programs is (1) whether they are effective in attaining their goal and (2) whether they are cost-effective relative to other transport policy measures. Several evaluations have been carried out, mainly in Australia, the UK, and Germany. These were reviewed in Richter et al. (2010, 2011) and Redman et al. (2012). Friman et al. (2012) reviewed several VTBC programs that have been conducted in Sweden. However, it has been difficult to find documentation of these programs, partly because they have been implemented by different principals and partly because adequate descriptions have not been published in accessible sources or made available in some other way. Of 50 reports found, only 32 contained sufficient information to be analysed. Not more than two programs were documented according to a standardized method including objective, procedure, and results at different levels. In the following review of the results of evaluations, we are for this reason leaving out the Swedish evaluations.

A summary of the reviews in Richter et al. (2010, 2011) and Redman et al. (2012) follows. A general conclusion from these reviews is that VTBC measures are effective. Nevertheless, as noted by Richter et al. (2011) and as will be discussed in the next section, a number of issues remain to be resolved. The summary addresses first results concerning *when* the measures work and then results concerning *why* the measures work.

## **When VTBC Measures Work**

***Long-Term Effects.*** Although there is substantial empirical evidence indicating that VTBC programs have positive effects (Richter et al., 2010), the issue of whether these effects are long-term remains to be addressed. Long-term changes in travel are naturally the goal of VTBC measures as well as of hard transport policy measures such as pricing, prohibition, and infrastructure investments. At the face it appears to be more questionable whether a long-term goal is achieved with the implementation of VTBC measures, relying as they do on car users’ voluntary changes in travel. Still, Taylor and Ampt (2003) argue that there is evidence showing that behaviour changes do persist and may even increase over time.

Taylor (2007) reviews diverse research that shows evidence for long-term effects. For an implementation of IndiMark in Perth, Australia, it is suggested that the initial

changes were not only sustained after 12 months, but also that there were additional increases in walking trips and a corresponding reduction in car-driver trips. In South Perth, the impacts of pilot projects that were monitored for three years (1997-2000) also showed that increases in public transport use and walking and cycling shares were maintained (Ker, 2003). The increases that were achieved in a program conducted in South Perth were also reported to be maintained. Similar results exist for programs conducted in Adelaide. Brög and Schädler (1999) reported that for the German large-scale implementations of IndiMark, changes in travel were stable at least two years after the termination of the program. In a similar vein, Ker (2003) reports that there were long-term effects both in Kassel and in Nürnberg, Germany. In Kassel four years after the initial implementation of IndiMark, only a minor reduction was observed of the large immediate increases in the public transport share due to the program. Although no comparison with a control group was made in Nürnberg, the results suggest similar stability up to as much as two years.

Fujii and Taniguchi (2006) also report various long-term effects in Japan. In a TFP program implemented in the city of Suita, bus use remained at an equally high level one year after implementation, and in the city of Sapporo in 2001, participants' car use was still reduced one year after the program was finished. Long-term effects of TFP programs were also found in the city of Kawanishi in 2003.

The apparent stability of these reported effects justifies the conclusion that VTBC measures change individuals' travel behaviour over the longer term. Yet, in Taylor's (2007) review of VTBC measures implemented in Nottingham, Leeds, and Santiago de Chile, changes were not found to last. Comprehensive reports of less successful VTBC implementations are unfortunately difficult to obtain, possibly because researchers are reluctant to publish or encounter difficulties in publishing negative results.

The long-term effects of VTBC programs and the associated time-scale of behavioural responses still remain issues that need to be further investigated. Although this kind of research takes a long time to conduct, it is obviously of paramount importance. The mixed results may also warrant a more detailed review or meta-analysis of the existing findings. One problem that needs to be adequately addressed with regard to this is that long-term effects are reported in many different ways, something which makes it more difficult to infer their effectiveness.

### ***Synergies Between VTBC Measures and Hard Transport Policy Measures.***

Gärling and Schuitema (2007) argue that, with regard to the effects of VTBC measures, these seem likely to be strengthened if combined with hard transport policy measures. Similarly, it may be argued that the public acceptance of hard transport policy measures such as road pricing (Jones, 2003; Steg & Schuitema, 2007), as well as their effectiveness (Cairns et al., 2008; Stopher, 2004), would increase if combined with VTBC measures.

In support of synergy effects resulting from a combination of hard policy measures and VTBC measures, Cairns et al. (2008) quote studies conducted in the Netherlands and in the US which report car-use reductions of as much as 20-25% if VTBC measures are

combined with measures such as parking management and bus subsidy. If VTBC measures are not combined with such measures, the reductions remain at 5-15%.

Some research has failed to show that there is a lasting effect of a free monthly public transport ticket offered to frequent car users (Fujii & Kitamura, 2003; Thøgersen, 2009; Thøgersen & Møller, 2008) or that of increased car use costs (Jakobsson et al., 2002). When taking these limited results together with the extensive research described above showing that there are lasting effects, it may be appropriate to ask whether adding techniques used in VTBC programs would make the effects of economic incentives and disincentives more lasting. In a recently conducted field experiment, Thøgersen (2009) failed to find such an effect. Similarly, Brög and Schädler (1999) compared the effects of free public transport tickets in an IndiMark program with the effect of the distribution of free public transport tickets in a German city, where no further action (e.g. information or motivation) was taken. In these programs, comparisons made before and after the study period revealed no differences in modal shift.

Further research seems warranted both of the effects of hard transport policy measures on the effectiveness of VTBC measures as well as of the reverse effects. This research may be guided by Loukopoulos' (2007) proposed classification of transport policy measures (see above) with the aim of identifying possible synergies in their implementation. The research may also test the theoretical propositions by Bamberg et al. (2011) and Gärling et al. (2002), that changes in travel options (travel times, costs) are important in order to make car users set reduction goals. However, if such reduction goals are too difficult to implement, for instance, due to lack of high-quality travel alternatives, the goals may either be reduced or all-together abandoned.

***Availability of High-Quality Travel Alternatives.*** Low quality of travel alternatives may both be perceived as a barrier and is sometimes also an actual barrier to a reduction in car use. Consequently, the effectiveness of VTBC measures may be reduced. Even though the walking and biking modes are popular sustainable alternatives to using the car, they are nevertheless restricted to some user groups, to short trips and to good weather conditions. Therefore, public transport should generally be considered to be the one most important sustainable alternative. Findings from research carried out in Auckland, New Zealand show accordingly that good quality public transport is a very important condition for the effectiveness of the soft transport policy measures (Taylor, 2007). Unfortunately, it is not clear what constitutes good quality. A research review (Redman et al., 2012) reveals that one key quality attribute of PT service is reliability, with frequency, fare prices, and speed also being generally important. The relative importance of the various quality attributes in affecting public transport demand is, however, largely contingent on other factors, such as user demographics, individual situations and previous experiences with the public transport services.

It is generally agreed that public transport services should be made as attractive as possible to the users, although there may often be a discrepancy between the perceived

quality and the objective quality of public transport services (Friman & Felleesson, 2009). It is reported that reliability, frequency, travel time, and fare level (Hensher et al., 2003), comfort and cleanliness (Swanson, Ampt & Jones, 1997) as well as security (Smith & Clarke, 2000) are all important factors in the users' evaluations of the quality of public transport services. Furthermore, Friman and Gärling (2001) emphasized the importance of providing clear and simple information. The question then arises how improvements made in the quality of public transport services would impact on, or interact with, the effectiveness of VTBC measures.

In Ker's (2003) analysis of large-scale implementations of IndiMark in six German cities, which were accompanied by improvements made in the public transport services, ranging from minor increases in frequency of service to extension of a subway line to the target area, the mean increase of public transport use in these six cities was 25 trips per person per year compared to the control groups. In three other German cities where no improvements were made to the public transport services, the increase was 17 trips. The combination of quality improvements made in the public transport system and the IndiMark approach, thus resulted in a 47% larger increase in public transport trips compared to the cities in which IndiMark was implemented without quality improvements of the public transport services. In cities that had low initial public transport mode shares, the increase in PT mode share after improvements was even higher.

Thus, it is suggested that particularly in areas that has low initial public transport mode shares, quality improvements of public transport would indeed be of additional benefit. In Ker (2003) it is reported a notable increase in satisfaction with public transport for the large-scale applications of the IndiMark programs conducted in Germany. It is also suggested that simultaneous improvements in the quality of public transport services would most likely enhance this increase in satisfaction. The increase in positive evaluations made by those individuals who participated in the programs has also been identified in the application of IndiMark in Australia. Somewhat paradoxically, in South Perth Brög, Erl and Mense (2002) reported that despite no improvements of public transport services, the number of people judging the public transport service to have a higher quality after than before the implementation increased from 23% to 38%. Similarly, the number of people judging the public transport service to have a worse quality after than before the implementation actually decreased from 23% to 8%. The number of people reporting to be satisfied with the public transport service increased from 31% to 47%, whereas the number of people reporting dissatisfaction with the public transport services actually decreased from 55% to 39%. In the same vein, a well-controlled field experiment that was conducted in Sweden (Pedersen, Friman, & Kristensson, 2011) showed that an observed initial gap between car users' perceptions of low quality in public transport services and the higher quality experienced by frequent users of the service was notably reduced when the car users started to use the service, implying that there is an initial bias in reporting satisfaction by non-frequent PT users (car users). In this area it seems that important synergy effects may exist, which additional research should attempt to disentangle.

***Definition of Target Populations.*** In choosing a specific travel mode people are influenced by different factors. They also respond differently to VTBC measures. Therefore, it is important to undertake a systematic investigation of such differences. Knowledge about how different target groups may differ in their responses would help make the future VTBC measures customized and therefore more effective.

A related issue that has been addressed is whether effects of VTBC measures obtained from a self-selected sample can be generalised to the population at large. Doing so requires knowledge of how participants differ from non-participants (Ampt, 2004). Taylor (2007) found such differences between participants and non-participants in sustainability concerns related to car use. Socio-demographic information about people who had been contacted during an Australian program is reported by Seethaler and Rose (2005). They showed that household members who already use public transport were 6.5 times more likely to participate. An obstacle is the difficulty to obtain information from non-participants. New methods may need to be developed to accomplish this. A possibility would be to invite random samples to participate in a survey, then later recruit them to the VTBC program when socio-demographic and other relevant information has already been obtained. Comparisons would then be possible between self-selected participants and non-participants. Randomized untreated control groups should also be included. It is, for instance, possible that participants in control groups increase car use more than a general trend would forecast if the effectiveness of the program reduces congestion.

Fujii and Taniguchi (2006) report results from a Japanese TFB program in the city of Suita, indicating that VTBC measures may be more effective in promoting public transport to non-frequent than to frequent public transport users. Furthermore, the same program yielded higher increases in public transport use for new residents than for old residents. It was believed that the former were less likely to have developed habitual car use and would therefore more easily change. In a similar vein, Ampt (2004) reports that individuals and households are more likely to change their travel after having encountered some significant changes in their lives such as taking up a new job, birth of a child, or moving house. Taniguchi, Suzuki and Fujii (2007) conclude that if a strong habitual car use prevails, VTBC measures may not work. Fujii and Gärling (2003) stress that in a change program targeting people's travel mode choice, one should recognize that because choices are habitual they are often made without much deliberation. It is therefore essential to consider how to break an existing habit.

***Targeted Locations and Translation to Other Locations.*** In the UK evaluations of VTBC measures have revealed significant differences between urban and rural areas (Cairns et al., 2004), whereas in Australia location has not been identified to be a significant moderator of effectiveness (Taylor, 2007). The reason may be that all Australian implementations have been made in similar major cities. Yet, Ker (2003) reports that for an IndiMark implementation in the Town of Cambridge, Australia neighbourhoods with higher incomes, higher car ownership and car use, and worse

public transport services had a larger reduction in car-driver trips. However, most of this change went to car as a passenger. Ker (2003) therefore notes that IndiMark may not be as effective in increasing public transport use in high-income or high car-owning and car-using neighbourhoods.

Taylor and Ampt (2003) identify as an important research issue the degree to which translations of research results are possible from one location to another. Although some VTBC programs distinguish between different locations and explicitly suggest that the outcomes may differ, few explicit comparisons have been made. The results of existing comparisons are furthermore not consistent. Location sometimes refers to the type of program (e.g. workplace versus school travel feedback programs, see Fujii and Taniguchi, 2006), sometimes to the neighbourhood, or sometimes to the region in which the VTBC program is implemented.

***Cost-Benefit Analyses.*** Cost-benefit analyses of VTBC measures have been reported in the UK (Cairns et al., 2004, 2008) as well as for IndiMark conducted in Adelaide and South Perth (Taylor, 2007). Ker and James (1999) report that for the IndiMark program in South Perth in 1997, benefits would exceed costs by a factor of between 11 and 13 over ten years. Initial costs of A\$ 1.3 million would be outweighed by benefits of A\$ 16.8 million (e.g. due to decreases in air pollution, travel time, greenhouse gas emissions, and road congestion). Brög and Schädler (1999) claim that IndiMark can be financed by the additional revenues for public transport alone. Similarly, Ker (2003) concludes that the level of travel change observed in Australian IndiMark and TravelBlending programs (15 to 40 additional public transport trips per person per year) would typically generate sufficient additional fare revenues to cover the full cost of the program in two to five years. He concludes that VTBC measures are highly cost-effective means of achieving progress towards an increase in public-transport use and the use of other sustainable travel modes.

It should also be recognized that cost-benefit analyses have limited value when costs or benefits cannot be quantified. As examples, non-economic and non-transport benefits including changes in land-use, increased social interaction, economic development, and certain health indicators are reported by Ampt (2001). Interviews with participants in South Perth indicated that health was a significant motivator for increases in walking. To recognize and assess these additional benefits is a challenging future task.

### **Why VBTC Measures Work: Techniques That Have Been Used**

In this subsection we focus on the different techniques used as part of VTBC measures that are key to an understanding of why the measures work. The techniques differ in whether they include (1) motivational support to set a goal to change travel, (2) request that plans for how to change travel are formed, and (3) provide customized information facilitating plan execution. For instance, both IndiMark (Brög et al., 2009) and TravelBlending (Rose and Ampt, 2003) provide customized information. In addition

TravelBlending provides motivational support without however directly requesting goals to be set. Only Japanese TFB programs (Fujii and Taniguchi, 2006) have requested that goals are set and that plans are formed.

Procedural differences also exist. IndiMark involves two or three contacts to conduct a travel survey as well as measuring intentions to change travel, to provide customized information, and to provide further customized information if necessary (Brög et al., 2009). Travel blending involves four contacts (Rose & Ampt, 2003), with the purpose to motivate a travel change, to conduct a travel survey, to provide customized comments, and to provide additional customized comments. A single contact is entailed by less elaborated programs, for instance the program implemented in Obihiro, Japan (Taniguchi et al., 2007).

The question may be raised concerning how participants should be contacted. If non-individualized information reaches larger samples at lower costs, why do VTBC measures typically use individual contacts? Fujii and Taniguchi (2006) report a less effective TFB program that only used internet communication. They concluded that communication featuring face-to-face contacts and personal mails are likely to be more effective. In support of this, experiences of European travel surveys indicate that personal contacts at the door step or over phone increase response rates (Seethaler & Rose, 2005). In the Melbourne suburb of Darebin, establishing a personal contact at delivery of before-survey forms made it 2.4 times more likely that households responded. A motivational call on the evening before the survey made a response 2.7 times more likely. For the after-survey forms a motivational call was again the most significant factor, while a personal contact during the delivery of the forms did not matter. It is clear that the evidence is insufficient and that more research needs to address whether and why in the context of VTBC measures face-to-face communication would be more effective. A related issue is how more cost-effective telecommunication may be designed to become equally effective.

For the selection and development of techniques that change travel, we refer to the theoretical framework presented above. Likewise Bamberg et al. (2011) argue that it is necessary to understand the *process* of voluntarily changing travel. As was illustrated in Figure 1, it is hypothesized that the process starts with the setting of a change goal (car use reduction or increase in public transport use) followed by the formation of a plan for achieving this goal. Setting a change goal is equivalent to forming a behavioural intention (Gollwitzer & Sheeran, 2006). According to other theories in social psychology (Ajzen, 1991; Bamberg & Möser, 2007), behavioural intentions are influenced by anticipated positive consequences of changing the current travel (or avoiding negative consequences of not changing the current travel) (attitude); perceived feasibility of attaining the goal, primarily the perception of feasible alternative travel options; social pressure; and felt obligations (personal norm) to travel more in line with important self-relevant standards. Following goal setting and the formation of a plan, plan execution is hypothesized to be regulated by negative feedback. Techniques that provide feed-forward information should target goal setting, either directly or indirectly by influencing its determinants (attitude, perceived feasibility, social pressure, and moral

obligation), and plan formation. What should behaviour change goals look like? As shown by research in several other areas (e.g. health promotion and work performance), specific and difficult goals lead to larger changes when compared with no goals or vague “do your best” goals (Locke & Latham, 1990, 2006).

Taniguchi et al. (2007) showed that public-transport use increased by 76% for TFB programs directly requesting goal setting compared to 25% with no request of goal setting. Evidence for motivational support inducing a positive attitude is not available since in almost all TFB programs (26 out of 31) reported in Taniguchi et al. (2007), this was provided for change in car use. Most of them (24) used environmental damages as arguments for change, but also health (15) and the availability of specific public transport resources (9) were used to motivate changes. Providing feedback is also essential and may likewise be conceived of as motivational support. It is however often unclear what kind of feedback should be given and how it works. For instance, some people may set a goal to lose weight and consider feedback on weight loss to be essential. Other participants set goals to reduce car use because they cannot any longer afford using their cars as much as before. They would presumably be motivated by feedback on how much money they save. Research needs to look deeper into the interrelated questions of what change goals people set, what motivates them to set these goals, and what types of feedback that are effective.

Because a general car-use-reduction goal is not sufficient to guide changes in travel, a detailed plan (e.g. using the bus instead of the car for work trips) needs to be formed to reach the goal (Gärling & Fujii, 2002; Gollwitzer, 1993). Fujii and Taniguchi (2006) conclude in their review of Japanese TFB programs that requesting a plan to be formed has a strong effect on travel behaviour changes. Such programs yielded the largest reduction in CO<sub>2</sub> (35%), the largest reduction in car use (25%), and the largest increase in public transport use (100%). In a meta-analysis of the results of 14 TFB programs (Taniguchi et al., 2007), it was shown that car-use reductions were mainly achieved in 11 programs which requested participants to form a plan for how to change their travel. In seven of the 14 programs participants were asked to set a change goal before forming a plan, by stating the percentage by which they would reduce their car use and increase their public-transport use, respectively. The average car-use reduction for the goal setting programs was 20% compared to 10% for the programs with no goal setting. Yet, the results are inconclusive because at least four of the latter programs also featured a request to form a plan.

Customized information about alternative travel modes would facilitate the formation of a plan to change travel. Consistent with this, Brög and Schädler (1999) claim that people frequently lack knowledge of public transport alternatives. During an implementation of IndiMark in Leipzig-Grünau, Germany an increase in public transport use from 53% to 64% was observed for those who had been informed about public transport alternatives but no change for those who had not been informed.

It may be possible to inform people about public transport alternatives through non-customized information if the information attracts sufficient attention, for instance in times of increasing gas prices. However, drawing on parallels to customer-oriented

marketing, Brög (2000) argue against this by noting that, instead of being flooded by useless information, people should receive only the information they need. In support, Brög and Schädler (1999) report a study where an Austrian public transport operator send out standardised information packages. Simultaneously, another group took part in the IndiMark program that uses customized information packages. A control group received no information. The results showed that the public transport shares in the group with standardised information was the same as in the control group, while in the IndiMark group the public transport shares were 17% larger.

Providing customized information is not invariably used. Taniguchi and Fujii (2007) report a TFB program providing non-customized information on how to use bus services. Additionally, participants were asked to form a plan for how to use these services. This program resulted in a strong increase in the frequency of bus use. Yet, customized feed-forward information, for instance an individually designed map for public transport may have had an even stronger impact. Because customized information minimizes the cognitive costs of processing the information, it should be more effective in facilitating a behavioural change. But it may not be necessary in case participants are requested to form a plan (Fujii & Taniguchi, 2006). A program using the latter technique is perhaps successful because it forces participants to consider travel alternatives and acquire the needed information themselves. Thus, while forming a plan, participants invest the cognitive costs they would not choose to do if they were not requested to form a plan. In a field experiment by Fujii and Taniguchi (2005), the effectiveness of a TFB program that requested participants to form plans (the planning group) was compared to a TFB program that provided customized information (the advice group). The results showed that the planning group reduced the number of days of car use more than the advice group.

The quality of customized information delivered by a VTBC measure is important in determining its effectiveness. Thus, Fujii and Taniguchi (2006) found that the degree of reduced CO<sub>2</sub> emissions and car use depended on the length of a preceding travel diary. If customized information was based on a 7-day travel diary, it was more effective than if it was based on a 1-day travel diary. Information thus seems to be more effective if it is based on more travel data. One may however question this conclusion because of the possibility of pre-existing differences in commitments between those willing to complete a 7-day diary and those willing to complete a 1-day diary. A question this raises is whether technologies such as GPS (Stopher et al., 2009) could be implemented to obtain more accurate travel diaries with less response burden on participants.

The available evidence appears to support that the techniques of motivational support to set goals of changing travel, requests to form plans for how to change travel, and providing customized information of how to make changes are effective ingredients in VTBC measure. However, too few systematic comparisons have been made at a large scale, allowing the relative cost-effectiveness of each technique to be determined. On the other hand, this may not constitute the appropriate approach since evidence suggests that the techniques overlap in affecting the different components of the process of voluntarily changing travel. Evaluating techniques that according to theoretical analyses

are optimally combined appears to be more needed. The role of theories of behavioural change (e.g. Bamberg et al., 2011; Gärling and Fujii, 2009) should become more prominent in the implementation and evaluation of VTBC measures.

VTBC measures have been developed to motivate individuals to voluntarily reduce car use. These measures often meet with more public approval and are more politically feasible than (hard) transport policy measures forcing a travel change on the individual (Gärling & Schuitema, 2007). Further research is therefore motivated to develop VCTB measures to become even more cost-effective measures. The next section highlights future research needs on VTBC measures based on the foregoing review of the results of the evaluations.

### Research Needs

In this section we summarize the research needs that were discussed above (see also Richter et al., 2011, and Table 2).

| Identified research needs   |
|---|
| Long term effects and the associated time scale of behavioural responses, including what other factors may account for long term effects.   |
| How hard transport policy measures, in particular improvements in public transport services, impact on the effectiveness of voluntary travel-behavior change measures as well as possible effects in the reverse direction.   |
| Assessments of impacts on different target groups.  |
| Comparing determinants of participation and changes in travel behaviour   |
| Generalizability of the results   |
| Determine cost effectiveness of techniques (motivational support to set goals of changing travel, requests to form plans for how to change travel, and providing customized information of how to make changes) by voluntary travel-behavior change measures used and synergies from their combinations |

Table 2. Summary of identified research needs (adopted from Richter et al., 2011).

Addressing the question of when VTBC measures are effective, the development of useful programs requires priority of longitudinal panel studies that examine travel behaviour changes. Panel studies many times provide a better statistical basis for drawing valid conclusions about effectiveness (Stopher et al., 2009). Given the contradictory findings, further research is also needed to clarify what factors may account for long-term effects.

Another priority for research is to investigate how hard transport policy measures, in particular improvements in public transport services, increase the effectiveness of VTBC measures. Evidence shows that effectiveness increases if the measures have been accompanied by improvements of the quality of public transport. In particular, future research needs to address what kinds of quality improvements increase changes in travel, and why people evaluate public transport worse than it actually is.

The review shows that VCTB measures have different impacts on different target groups. The promotion of public transport appears to be particularly successful among people who have experienced major changes in their lives. Their stronger willingness to change is probably related to that they have not yet developed new travel habits. In a similar vein, people with strong habitual car use seem to be less likely to participate. The benefits people receive from car use and the barriers they experience to change travel behaviour need to be further researched and ways to overcome the barriers developed.

Does participating in programs have the same determinants as does change in travel? An example of an issue to be resolved by more research is that VTBC measures are more effective in promoting public transport to non-frequent public-transport users than to frequent public-transport users (Fujii & Taniguchi, 2006), whereas the latter are more likely to participate in the programs (Seethaler & Rose, 2005).

Translation and generalization of research results from one location to another is only possible if the conditions are clearly defined. Current evaluations therefore fail to disentangle location effects. Sometimes location-dependent differences between urban and rural areas are discussed, sometimes more content-related issues such as differences in work and school TFP programs (e.g. Fujii & Taniguchi, 2006). Socio-demographic factors may also be drawn on to explain regional effects. Available data on these differences should be prioritized in research and thoroughly reviewed in order to draw valid conclusions and provide suggestions.

Addressing the question of why VTBC measures are effective requires assessments of techniques and combinations of different techniques. Goal setting and plans for travel change have been successfully implemented in small-scale experiments (Fujii & Taniguchi, 2006). Goal setting appears to be one of the most useful methods (Fujii et al., 2009) to improve VTBC measures and should therefore probably be prioritized. Is it possible to translate the results from research on goal setting (Locke & Latham, 1990, 2006) and plan formation (Gärling & Fujii, 2002)? What are the best ways of supporting people in forming plans for travel change (Gollwitzer, 1993; Gollwitzer & Sheeran, 2006)?

Yet another prioritized research task is to determine the cost-effectiveness of techniques (motivational support to set goals of changing travel, requests to form plans for how to change travel, and providing customized information of how to make changes) and synergies from their combinations. During all stages of communication it seems more fruitful to establish personal contacts. Given the costs of face-to-face contacts, research still needs to address the question of how VTBC programs excluding or reducing personal contacts can be made more effective. For the same costs reasons, the currently predominant individualised approach during all stages should be further refined.

Closely related is the question of what is the best way of customizing feed-forward and feed-back information. It is true that customized information has proven to be effective compared to standardized information (Brög & Schädler, 1999). Yet, to collect customized information is time-consuming, expensive, and sometimes difficult. The introduction of the technique of requesting plans to be formed has shown that people

themselves will retrieve the necessary information about travel alternatives. In fact, doing this has appeared to be even more successful. Future research should examine this innovation. If shown to be successful, it may lead to a change from customized information to customized support.

It is important to know what means participants use to achieve car-use reduction. Did they use the bicycle instead of the car for a few short trips to the grocery store or did they use the train instead of the car for one longer journey? A closer look is necessary in order to reward participants' accomplished travel behaviour changes and to determine where a program does not fulfil its expectations. Newly developed GPS-based surveys offer a means of simplifying the collection of detailed data (Stopher et al., 2009).

## **Summary and Conclusions**

Private car use is expected to continue to increase in the future. Although there are many efforts at developing clean fuels and cars, at the moment it is not believed this will fully solve the problem with increasing car use. Various measures to reduce private car use have therefore been developed. We reviewed and classified these, commonly referred to as travel demand management (TDM) measures. In order to understand their effects, a theoretical framework was presented. This theoretical framework is broader than others such as, for instance, economic demand theory. It provides an analysis of the components of travel-behaviour change and is therefore useful in theoretically grounding voluntary travel-behaviour change (VTBC) measures. The remaining of the report provides a summary of empirical evaluations of VTBC programs followed by a summary of important unresolved research problems.

It is concluded that VTBC programs are effective in reaching set goals of car-use reduction. Yet, it is still unclear whether these positive effects are long-term. Furthermore, the positive effects are apparently only observed for motivated (self-selected) participants and not necessarily for all of them unless some facilitating conditions are fulfilled. On the positive side, VTBC measures meet with public acceptance, are political feasible, and cost-effective. A main issue is whether more car users can be motivated to participate by introducing hard transport policies that make car use less attractive. An important conclusion in this respect is that if hard transport policies are introduced, combining them with the techniques used in VTBC measures would boost the effect. VTBC measures would also make hard transport policy measures more effective.

If car-use reduction is viewed as car users' incremental adaptation to changes in travel options that may potentially have consequences for their engagement in various activities, an overarching theoretical issue is to understand the antecedents and individual as well as societal cost consequences of the adaptation process. Reducing car use is seldom a unidimensional change. For this reason, theory must specify what individual and situational factors that shape it.

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# Feasibility of Voluntary Reduction of Private Car Use

Many countries are facing substantial environmental costs of private car use such as congestion, noise, and air pollution. Transport authorities implement various policy measures that aim to modify or reduce private car use; these are generally referred to as Travel Demand Management (TDM) measures.

In this research report we propose a classification of various TDM measures, encompassing the specific characteristics of each, how the various measures may be distinguished from each other and to what extent they may interact, as well as how effective they are in modifying or reducing private car use.

A theoretical framework is proposed next, to account for how the TDM measures impact on car users' change in travel behaviour. The theoretical framework posits that, if a change goal is set, it is followed by forming plans to attain the set goal (e.g., to change from using the car to using alternative modes). A principle of cost-minimization is proposed that describes how car users incrementally implement plans to achieve their set goals.

A review of voluntary travel-behavior change (VTBC) programs shows that in general the VTBC-related TDM measures are effective. Yet, it is still unclear whether the positive effects are long-term. Furthermore, the positive effects are apparently only observed for motivated participants and not even necessarily for all of them unless some facilitating conditions are fulfilled. However, VTBC measures meet with higher public acceptance, are politically feasible, and cost-effective.

It is argued that more research is needed to answer the questions of when and why VTBC measures work, including also a closer investigation into which individual and situational factors that generate the positive effect.

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