

# Future urban sustainable mobility:

Implementing and understanding the impacts of policies designed to reduce private automobile usage

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*“The one thing we need to do to solve our transportation problems  
is to stop thinking that there is one thing we can do  
to solve our transportation problems.”*

Robert Liberty, Executive Director of 1001 Friends of Oregon



### Abstract

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The historically recent growth in interest in policies designed to reduce private automobile usage, policies coming under the rubric of travel demand management (TDM), is offset by a paucity of systematic research concerning the procedures by which to define and implement such TDM policies or measures, the consequences of such TDM measures and the nature of the ensuing adaptation process occurring upon implementation of any TDM measure. The present thesis' conceptual framework for understanding the effects of TDM measures extends and complements previous work in the transportation literature by drawing on psychological theories of goal setting and adaptation. The framework views travel choices as being determined by bundles of attributes characterising travel options and by goals and implementation intentions formed over time in response to evaluations of the psychological, generalised costs of current travel. Study I utilised travel diary data to demonstrate that the specific instantiation of a TDM measure (i.e., its spatial and temporal parameters) is critical to the understanding of the ways in which the travel options of various sociodemographic groups for various trip purposes are altered. Taken together, Studies II and III, which utilised focus groups and Internet-based surveys, revealed that people tend to minimise any reductions to their car use wherever possible, with any reductions being achieved in a manner minimising the psychological costs that do occur. That is, evidence consistent with a cost-minimisation principle of adaptation was obtained. Study IV demonstrated that the implementation of long-term TDM measures, assumed to have a bearing on the mobility options and adaptation alternatives available to people, is well suited to participatory planning methods involving the evaluation of future scenarios that are the result of careful analysis of present trends and plausible future developments. The methods examined are a means by which to better project potential and expected futures, and a means by which to systematically understand and communicate preferences for these futures, with reference to both scientific and non-scientific knowledge bases. In conclusion, this research presents some tentative, initial steps towards the greater theoretical understanding of the nature of TDM measures, the changes they effect, the citizens they affect and the principles underscoring citizens' adaptation process to such TDM measures, with clear and definite practical implications concerning which things to do, why and how.

Key words: Car-use reduction, Land-use planning, Public participation, Travel choice, Travel demand management

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## Preface

The thesis consists of this summary and the following four studies referred to in the text by their Roman numerals:

- I. Loukopoulos, P., Gärling, T., & Vilhelmson, B. (2005). Mapping the potential consequences of car-use reduction in urban areas. *Journal of Transport Geography*, 13, 135-150.
- II. Loukopoulos, P., Jakobsson, C., Gärling, T., Schneider, C. M., & Fujii, S. (2004). Car-user responses to travel demand management measures: goal setting and choice of adaptation alternatives. *Transportation Research D*, 9, 263-280.
- III. Loukopoulos, P., Jakobsson, C., Gärling, T., Meland, S., & Fujii, S. (2005). *Understanding the process of adaptation to car-use reduction goals*. Manuscript submitted for publication.
- IV. Loukopoulos, P., & Scholz, R. W. (2004). Sustainable future urban mobility: using 'area development negotiations' for scenario assessment and participatory strategic planning. *Environment and Planning A*, 36, 2203-2226.

The task of thanking everyone who, in their own special and unique way, has contributed to not only this thesis but to also my own personal and professional development is never a simple one. I cannot and will not simply list the many individuals who over the past four years have helped me; not only would the list be long, it would do no justice to the various forms of help I have received from those mentioned therein. So let me pay a collective tribute to the large number of colleagues, staff and friends both from within the department and from without: Thank you!

Even so, there are a few individuals that deserve special attention, the first and foremost being my supervisor, Tommy Gärling. As a supervisor Tommy has been an outstanding source of inspiration: thorough, critical, zealous, challenging, thoughtful, knowledgeable, extremely frustrating, but fair. He expected a great deal but also gave a great deal in return. Nowhere is this more evident than when we planned experiments and wrote manuscripts together. In the hope that I would receive a few days' rest, I was always relieved to send these plans and manuscripts, which had taken weeks of agonising thought and writing, off to Tommy. Of course, they were almost always returned the next day. Not to be outdone, I initially began returning the re-revisions just as quickly so as to have my few days' break. Unfortunately, this strategy never worked. All that happened was that I would receive additional suggestions the following day. In the end, I was forced to hold on to revised manuscripts for a few extra days whenever I wanted a break, because I knew full well that the day after sending them to Tommy I would receive them back, undecipherable comments and all — undecipherable even after four years of experience with his 'unique' handwriting style! Nevertheless, the benefits of all this was a fruitful, productive, learning-rich relationship that I hope will continue in the years to come.

I would also like to thank all my co-authors: Satoshi Fujii, Cecilia Jakobsson, Solveig Meland, Claudia Schneider, Roland Scholz, and Bertil Vilhelmson. These people have in

their various capacities proved invaluable to the present thesis. They have provided important input, insights and assistance at various stages of the work. They have assisted in data collection and access to already-collected data. They have provided statistical guidance and challenges and broadened my areas of expertise beyond the psychological domain.

It goes without saying that my loving family and friends merit special thanks for their support, patience, encouragement, understanding, and for being a constant source of joy, happiness, and comfort. Thank you for the long-distance phone conversations, the endless stream of e-mails, and the many parcels of Tim Tams and Vegemite. My colleagues and friends also wish to thank you for the Tim Tams (but, strangely enough, not the Vegemite).

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Peter Loukopoulos



## Contents

Introduction	1
Determinants of Automobile Use	2
<i>The appeal of automobiles</i>	3
<i>The spatial separation of activities</i>	4
<i>Attitudes, car-use dependencies, and habits</i>	6
Consequences of Automobile Use	8
<i>Economic consequences of automobile use</i>	8
<i>Social consequences of automobile use</i>	10
<i>Environmental consequences of automobile use</i>	12
Travel Demand Management (TDM) Measures	13
<i>Travel Demand Management (TDM): A definition and historical overview</i>	15
<i>TDM Measures: Attributes and impacts</i>	16
<i>Coerciveness</i>	19
<i>Behaviour change resulting from top-down or bottom-up processes</i>	20
<i>Time scale</i>	20
<i>Spatial scale</i>	21
<i>Market-based versus regulatory mechanisms</i>	22
<i>Influences on latent and manifest travel demand</i>	23
<i>Technical feasibility and costs</i>	24
Conceptual Framework	26
<i>Goal setting</i>	28
<i>The adaptation process</i>	29
<i>TDM measures and the adaptation process</i>	32
<i>Land-use planning and public participation</i>	35
Summary of Empirical Studies	38
<i>Aims and hypotheses</i>	38
<i>Study I</i>	39
<i>Study II</i>	41
<i>Study III</i>	43
<i>Study IV</i>	45
Conclusions and Discussion	48
References	55
Appendix	71



## Introduction

*“China’s Great Wall was rumoured formerly to be the only man-made structure visible from the Moon. Today a number of motorway networks easily beat it.”*

Per Otnes, sociologist

The growth and influence of the private automobile is without parallel. The number of motorised vehicles in the world grew from 75 million to 675 million in the last half of the previous century, with more than four-fifths of these vehicles being used for personal transportation (Organisation for Economic Co-operation and Development [OECD], 1996). With approximately 35 million new private automobiles being produced annually resulting in a net addition of 20 million to the world’s automobile fleet, recent estimates claim that the number of motor vehicles could reach 816 million (excluding motorised two- and three-wheel vehicles) by 2010 (World Resources Institute [WRI], 1996). Concomitantly, the energy demands of transportation have more than doubled since the 1970s; transportation is responsible for 25% of the world’s current energy use and accounts for 50% of the demand for oil (United Nations Environment Programme [UNEP], 2001). Related to the demand for energy, the United Nations Framework Convention on Climate Change (UNFCCC) has made the claim that it is likely greenhouse gas emissions will continue to increase despite the implementation of different policies to limit them (UNFCCC, 2003); according to projections, emissions are expected to increase by 11% from 2000 to 2010. One important source of emissions is motorised traffic. The transport sector increased its emissions by 20% between 1990 and 2000, and it has the highest projected increase of emissions in the current decade.

These egregious trends become even more alarming when one considers that most vehicles are concentrated in the urban areas of the world’s wealthier regions; in 1993, member countries of the OECD had 70% of the world’s automobiles (American Automobile Manufacturers Association [AAMA], 1995). Yet it is in the developing countries and the transition economies of Eastern Europe and Central Asia that the greatest increases in the number of motor vehicles are expected (WRI, 1996). The annual growth rate in passenger trips made by car in Central and Eastern European countries of 5-7% is expected to continue, if not increase, given the accession of many of these countries into the European Union (Suchorzewski, 2002). Furthermore, in all OECD countries, car ownership continues to rise steadily, and there is little sign, as was once expected, of market saturation (Organisation for Economic Co-operation and Development & the European Conference of Ministers of Transport [OECD & ECMT], 1995). Indeed, the astonishing average of more than one vehicle per licensed driver has already been reached in the United States (Southworth, 2001). Of course, car ownership is but one aspect of a larger problem. Towards the end of the previous century the then 15 members of the European Union experienced substantial growth in car travel in the form of a 40% increase in passenger kilometres (Marshall, Banister, & McLellan, 1997), and road traffic forecasts for Europe expect an increase in road traffic of up to 150% by the year 2025 (Bielli, Carotenuto, & Delle Site, 1998).

Another effect inextricably linked to the automobile but not often recognised is related to the amount of land it consumes when compared to other technological advances, such as skyscrapers or television. Furthermore, even when land use is of comparable proportions in terms of acreage, the car is still the most land intensive. For example, a road lane and railroad track are each roughly 4 metres wide but at typical

occupancy rates cars are nearly 20 times more land intensive than trains for the same capacity even before any allowance is made for car parking (Crawford, 2000). It has also been noted that habitat fragmentation due to the construction and use of infrastructure is a major cause of deterioration in the quality of the natural environment (Krisp, 2004).

This thesis summary begins by first delving into the existing research attempting to understand the pervasiveness of the influence of the car. That is, the issue of what factors determine car use is examined in the first section. Following this, a more detailed exposition of the consequences of current patterns of car use is provided, with the conclusion being drawn that restrictions are required to minimise the growing negative consequences. Various policy measures with the explicit aim of minimising the use of the private automobile are then discussed, as are various taxonomies of such measures, collectively referred to as *travel demand management (TDM)* measures. The conceptual framework of the thesis is then presented and is an account of why and how such TDM measures achieve their stated aims, as well as why such aims may not be achieved. As will be seen, the adaptation process resulting from the implementation of a TDM measure may be initiated voluntarily (e.g., through information campaigns) or coercively (e.g., increasing the costs associated with car use). This adaptation process is understood using a cost-minimisation principle and it is also noted that TDM measures may assist in making certain adaptation strategies to other TDM measures less costly and/or more effective. Finally, four studies are presented within the context of this framework. Study I investigates the sociospatial consequences of various TDM measures so as to examine how their implementation would change the travel options faced by households in different segments and for different trip purposes. Study II is an attempt at understanding the goals households set in response to various TDM measures and the determinants of these goals, as well as the adaptation process behind attempts to achieve adopted car-use reduction goals. Study III further examines the adaptation process providing evidence consistent with the proposed cost-minimisation principle. Study IV can be construed as an examination of how to implement policies that, in the long term, will have a bearing on the mobility options and adaptation alternatives available to people. It can also be considered a study of participatory planning processes. Taken together, these four studies are a first step in examining what changes are effected by TDM measures, who such measures affect, how and why those affected by TDM measures react and adapt, and how long-term TDM measures might potentially be implemented — as well as why they should be — using a participatory planning procedure.

## **Determinants of Automobile Use**

*“The living arrangements Americans now think of as normal are bankrupting us economically, socially, ecologically and spiritually.”*

James Howard Kunstler, author

The world was a markedly different place prior to the acceleration of automobile mass production and consumption. The assumption here, then, is that there is something inherently appealing about the private automobile that contributed to its rise as the dominant mode of transport in the late twentieth century. With sufficient and widespread automobile ownership, urban areas were then able to drastically change in nature. More specifically, the automobile permitted humans to travel greater distances and, as such, a

more extreme spatial separation of activities became possible. The spatial separation of activities provided, in turn, a congenial environment for the development of an automobile dependency amongst individuals and households, which in its extreme form has led to the development of car-use habits. These three major classes of determinants, the appeal of automobiles, the spatial separation of activities, and the development of car-use dependencies and driving habits, are each discussed in turn.

### *The appeal of automobiles*

*“If the automobile had followed the same development cycle as the computer, a Rolls-Royce would today cost \$100, get a million miles per gallon, and explode once a year, killing everyone inside.”*

Robert X. Cringely, InfoWorld magazine

Framing the appeal of automobiles strictly in terms of utilitarian principles and instrumental justifications is not sufficient. The attractiveness of the car is also a cultural phenomenon with symbolic and affective components independent of how it is used. There are doubtless many tangible, concrete reasons related to the appeal of the automobile but there are also less tangible, more abstract reasons. This hierarchy from tangible to less tangible bears a striking resemblance to Maslow’s (1954) hierarchy of human needs, which posits five levels. The first represents the basic requirement of subsistence such as food and water; the second is concerned with safety and security. The third level relates to social needs such as family ties, the fourth with esteem and recognition of peers, while the fifth level deals with ‘self-actualisation’ or self-expression. The car satisfies needs on all these levels (Wright & Egan, 2000).

The status and identity associated with being a car owner is one source of attraction to the car that has roots in the very early days of automobilisation. Initially, being a car owner was an envied and respected position (Sandqvist, 1997) and since then the car has continued fulfilling the role of powerful status symbol, albeit with a slightly different emphasis: the ubiquity of the car has led to it being perceived as an everyday tool, much like a refrigerator, and anyone not owning a car is perceived as being less well-off. Indeed, the norm in many parts of the developed world, particularly the United States, is for families to own more than one car; not owning a car is interpreted as a sign of deep poverty (Sandqvist, 1997). Not only does one wish to communicate status with the help of an automobile, but, additionally, driving one’s automobile allows for the expression of one’s individuality, identity and personality (Stradling, 2002). It is seen as an extension of the human body, making people more powerful and energetic, with younger car users in particular seeking enjoyment in the ability to travel at great speed. According to Wright and Egan (2000), this is why car design in recent years has emphasised horizontal lines that proclaim power and speed. While designs have changed over the years, the rationale behind them (i.e., reflecting and communicating personality and as extensions of the human body) has not, as evidenced by a quick recall of the flamboyant automobile designs of the 1960s complete with shark fins and teeth. Continuing with such less-utilitarian motivations, freedom and independence are also regarded as factors contributing to the attractiveness of automobiles. The car is linked to the notions of being able to get anywhere, anytime; door-to-door travel is possible in urban areas and access to unspoiled, natural areas is also possible outside urban areas.

The appeal of the automobile in terms of speed was alluded to above. While this can be attractive in its own right, particularly as it is the driver who controls the speed thereby

adding yet another dimension to the appeal of automobiles, the attractiveness of the automobile's speed is more likely to lie in the fact that the car assists people in overcoming the natural limitations to their speed of movement and radius of action (Vlek & Michon, 1992). This more utilitarian appeal of automobiles can be extended to include comfort, protection or safety, and autonomy or convenience (Stradling, 2002). Cars shield people from direct exposure to the elements and this shielding property also means that direct interactions with humans outside the car are limited and that the driver of the car is, therefore, safer (Vlek & Michon, 1992; Wright & Egan, 2000). New automobile designs have also minimised the weight given to speed and increased safety imagery in response to the fact that an increasing number of women are driving (Wright & Egan, 2000). The transportation of goods, the chauffeuring of others, or time and distance constraints often makes the car a most convenient tool. The importance of comfort has even been experimentally shown to predict preferences for the automobile over public transport (Joireman, van Lange, Kuhlman, van Vugt, & Shelley, 1997).

While previous research has confirmed the importance of various factors in the appeal of automobiles, an arguably more profound finding is the fact that both instrumental/utilitarian and affective/symbolic factors regarding the appeal of the automobile are not necessarily dependent upon actual car ownership and use. Jensen (1999), in a Danish survey, identified six mobility types: (i) passionate car drivers, (ii) everyday car drivers, (iii) leisure time car drivers, (iv) cyclists/public transport users of the heart, (v) cyclists/public transport users of convenience, and (vi) cyclists/public transport users of necessity. Jensen (1999) found, for example, that while the overwhelming majority of car drivers felt that the car symbolised freedom and independence, nearly 60% of cyclists and public transport users shared the same view.

### *The spatial separation of activities*

*"Suburbia is where the developer bulldozes out the trees, then names the streets after them."*

Bill Vaughan, author/journalist

Up until the middle of the nineteenth century, cities were densely populated and spatially compact. The majority of city inhabitants walked everywhere and, as a result, the only attractive building sites were those within reasonable walking distance of the city centre. With the introduction of widespread railroad and tramline construction, it became possible for people to live outside the city and commute by train or tram to the centre. Even though cars were available at the advent of the twentieth century, it was only after World War II and the subsequent spread of affluence that car ownership was brought within reach of most people so that the rail network ceased to dictate the pattern of development (Crawford, 2000; Maat, 2002). As a result of owning an automobile, people could live further away from their place of work in locations that had previously not been accessible. Suburbanisation ensued given people's preferences for low-density, single-family homes with a garden in a green setting and was accelerated by the rapid expansion of urban road networks and highways (Garreau, 1991; Maat, 2002; Morrill, 1991; Muller, 1995). Thus, the initial stages of suburbanisation increased the spatial separation between in-home and out-of-home activities.

Yet the proliferation of the automobile provides only a partial explanation of the spatial separation of activities. There were other contributing factors, notably population growth and the cost of land and construction in city centres vis-à-vis transport costs,

which were becoming increasingly cheaper even up to the end of the previous century (Gordon & H. Richardson, 1997). However, while important, population growth need not be related to the rapid expansion of urban land use, as cities with stable or declining populations have also exhibited urban sprawl (Deal & Schunk, 2004). Rather, it was often the case that cheaper land for housing, retail and industry was available on the outskirts of urban areas and, as a result, suburbanisation and urban sprawl gathered momentum. This in itself would be sufficient for increasing the spatial separation of activities: there is no reason to expect work, shopping, leisure, or home-based activities to be spatially proximal as a result of suburbanisation. Arguably, the spatial separation of activities in the United States reached such great proportions as it was spurred by a series of policies including the prohibition by banking regulators of lending in deteriorating downtown areas and the adherence to 1938 US planning guidelines explicitly forbidding traditional mixed-use development and whose adherence was a prerequisite for federal mortgage insurance (Crawford, 2000; see also Dura-Guimera, 2003, and, Paül & Tonts, 2005, for an interesting discussion of the peculiarities associated with suburbanisation in the Mediterranean context).

Whether people first moved out of cities to the suburbs because of the proliferation of affordable automobiles or whether the commercial and industrial sectors relocated outside city centres to take advantage of cheaper land is an unresolved issue. It is also, for all intents and purposes, a moot point as the result is the same: from the turn of the twentieth century a much more extreme spatial separation of activities, never before seen, has evolved. This is a crucial development as it has long been recognised that travel takes place when people need or wish to participate in activities that are at different spatial locations. That is, travel is derived from a demand for activity participation (Pas, 1998), although there are cases where people travel for the sake of travelling or travel to another destination via a more scenic route (Mokhtarian & Salomon, 2001; Mokhtarian, 2005).

The spatial separation of activities need not, however, automatically lead to greater car use. Priemus, Nijkamp, and Banister (2001) describe the BREVER law which states that, on average, people find a one-hour journey to and from work acceptable and that if the speed of the journey increases then shorter journey times are obtained in the short term but in the long term greater journey distances result<sup>1</sup>. The implications are that the spatial separation in the context of suburbanisation is most congenial to car use so long as this spatial separation does not become too extreme; very large distances may result in preferences for other modes which fulfil the requirements of the BREVER law. This is the case in, for example, Japan with its high-speed train networks where the cities of Tokyo, Kofu, Nagoya, and Osaka are within an hour's journey time from each other despite being some 500 kilometres apart (Priemus et al., 2001). Similarly, Cullinane (2003) found that it is the preference for a faster mode of transport (car or public transport) that is a major determinant of mode choice in Hong Kong. Despite these qualifications, however, it is the case that the spatial separation of activities within the context of mass suburbanisation is a major determinant of car use. Schwanen, Dieleman, and Dijst (2001) illustrated how decentralisation of urban land invariably led to palpable increases in automobile use and reductions in cycling, walking, and the use of public

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<sup>1</sup> But see Mokhtarian and Chen (2004) for a discussion of how a stable mean observed travel time budget, as embodied by the BREVER law, may mask random deviations on either side of the mean that cancel each other out across the population (i.e., individual-level interactions may be masked by a stable mean at the aggregate level).

transport. The spatial separation due to the decentralisation of activities is often too great to walk or cycle and the dispersion of humans and activities makes it difficult to plan efficient, regular, effective public transport services. Consequently, purchasing a car is seen as necessary, something which leads to a doubling in the total number of journeys with about half of the previous journeys made by public transport transferring to the car and a slight fall in the number of walking and cycling journeys (Wootton, 1999). Thus, car use increases even though the distance travelled by car may not necessarily increase: much car travel is suburb to suburb (including adjacent suburbs) and, as such, distances may be shorter than was the case with the previous car commute from the suburb to the city centre (Schwanen et al., 2001).

### *Attitudes, car-use dependencies, and habits*

*“In Houston, a person walking is someone on his way to his car.”*

Anthony Downs, writer

Many of the important determinants of car use reside within the psychological domain and include attitudes, dependencies and the formation of habits. Beginning with attitudes, an agreed-upon definition of attitude is that it is a stable evaluative response (affective, cognitive or behavioural) to some particular entity referred to as the attitude object (Eagly & Chaiken, 1993, 1998). An attitude object can be anything, abstract or concrete, that people discriminate or hold in mind. Using the automobile as an example, attitudes towards car use consist of several components: a cognitive component, reflecting knowledge of and reasoning about the positive and negative effects of car use (e.g., protection, status, congestion); an affective component, reflecting feelings towards car use; and a behavioural component, reflecting whether or not one intends to act in accord with his or her knowledge and feelings. In Ajzen's (1985, 1991) *Theory of Planned Behaviour* (TPB) the motivation to perform a behaviour, such as driving a car, is argued to be related to an attitude towards the behaviour, a subjective norm, which is defined as a judgement of significant others' (family, friends, and society) opinions of the behaviour, the individual's desire to comply with or defy the norm, and his or her perceived behavioural control, where it is assumed that if individuals lack control over factors in the environment or necessary requirements, then the relationship between attitude and behaviour is weakened. Given the previously outlined inherent appeal of the automobile, the widespread cultural acceptance of the automobile as an integral part of everyday life (related to subjective norm), and the relative high level of control one has over driving, it is not surprising that attitudes towards automobiles are significant contributors to the determinants of car use.

In the same way that the many benefits of the car can translate into positive attitudes, the spatial separation of activities can lead to car dependence amongst large segments of the population. As outlined previously, a more extreme spatial separation has evolved as a result of the proliferation of the automobile, suburbanisation and the resulting difficulty in providing effective public transport services around such urbanisation trends. The result is that one needs the car to be able to function in modern society; Ryley (2001) reports research demonstrating that 80% of motorists agreed to statements of the effect that it would be difficult to adjust one's lifestyle to being without a car. E. Jones (2001) examined walkable catchments — maps showing the actual area within a five-minute walking distance from any centre, or ten minutes from any major transport stop such as a



railway station — for the Perth metropolitan area. Many suburban areas were found to have small walkable catchments, partly due to suburbs being designed around a curvilinear system and cul-de-sacs making direct walking distances much longer and contributing to car dependency for travel to various activities. Adding to such dependency is the fact that public transport systems have not sufficiently evolved, or been able to evolve, to deal with suburbanisation and the greater dispersion of activities. Using Los Angeles as an example, Modarres (2003) illustrates how the city centre area is well served by public transport as are various work sub-centres located outside the city centre area. However, while the public transport system is good at connecting workplaces, it is poor at connecting employees to their place of work (particularly if it is located outside the city centre). Aarhus (2000), examining the Norwegian context, found that the suburbanisation of jobs was associated with increases in commuting by automobile, presumably because suburbanisation is associated with improved access to (free) parking, poorer access to public transport and a smaller share of employees living near enough to work to be able to walk or cycle. Thus, car use dependency is an important determinant of car use amongst people.

Indeed, attitudes and car dependency may, in combination, act as an even greater determinant of car use or, at the very least, may hinder any attempts to reduce car use. For example, Tertoolen, van Kreveld, and Verstraten (1998) observed that when the discrepancy between attitude (environmental awareness) and behaviour (car use) was pointed out to experimental participants (car drivers), then the response was to alter the attitude (e.g., automobile use was not so bad for the environment) rather than alter the behaviour. Both car dependency and attitude result in repeated, continued use of the automobile for a variety of reasons and purposes with many consequent benefits to the individual. This leads to the development of habitual behaviour.

Habits can be defined as goal-directed actions that may or may not be consciously instigated (Bargh, 1989). Goal-directedness distinguishes habits from other automatic behaviours, such as reflexes (Verplanken, Aarts, & van Knippenberg, 1997). While one may be conscious of choices to perform a habit, the actual performance of the habit involves little thinking because the actual behaviour has been automatised to a large extent (Jager, 2003). Anderson (1982) has distinguished three stages in the development of a habit: (i) the declarative stage, which involves cognitive processing of information so as to guide behaviour; (ii) the knowledge compilation stage, where people convert the information into a procedural form, and (iii) the procedural stage, where the habit has been formed, although changes may still occur insofar as the process may continue to be sped up with continued practice. An important prerequisite for the development of a habit is that the behaviour is rewarding, repeated under stable circumstances, and that an individual is motivated and able to repeat the earlier behaviour (Ouellette & Wood, 1998); conditions applying to car use. Attitudes and the appeal of the automobile contribute to the instigation of driving, often acting as its own reward. Furthermore, the urban environment in which one lives changes very slowly (in terms of road networks, one's place of residence and work) and, as such, the context in which the driving behaviour occurs is stable. Also, for the reasons outlined above, travel by modes other than the private car is likely to be less rewarding (or even impossible due to car dependency) given the nature of the spatial separation of activities. Thus, car use is likely to be repeated and, more importantly, the cognitive processing of information that

occurred on the initial occasions of driving to various activities is likely to be compiled such that the need to participate in an activity automatically activates a driving script (T. Gärling, Eek et al., 2002; T. Gärling, Fujii, & Boe, 2001). That is, it is not frequency of performance or repetition per se that determines whether or not car use is habitual, but whether or not it occurs automatically. It can, therefore, be concluded that habits are important determinants of automobile use. Indeed, habitual driving is arguably a much more important determinant of car use in the long run, because a general finding is that attitudes and intentions are not enacted if they are interfered with by habits (Verplanken & Faes, 1999). Should the situation in which the habit was formed change (e.g., better, quicker public transport), then there is no guarantee that car use will decrease. As habit strength increases, depth of predecisional information search decreases and people will continue to drive despite the fact that driving is no longer the optimal, or most rewarding, mode of transport.

Consistent with this and emphasising the key role played by habits, Klöckner and Matthies (2004) found that habit strength moderated the relation between personal norm and travel behaviour with the implication being that those with strong habits, as opposed to weak habits, would not be influenced by norm-based information campaigns, such as commitment strategies or environmental education, to reduce car use. Furthermore, Cullinane and Cullinane (2003) showed that, despite its small size (50 × 40 kilometres), the fact that very few drivers have permits to drive into mainland China, and the fact that public transport accounts for 90% of all motorised journeys, the average length driven per car per day in Hong Kong is 35 kilometres. That is, once a car has been acquired it quickly becomes considered less of a luxury and more of a necessity and, in turn, car use becomes habitual.

### **Consequences of Automobile Use**

*“A rat who gnaws at a cat’s tail invites destruction.”*

Chinese proverb

The consequences of automobile use are hotly debated and there is little agreement amongst the academic and political community and, indeed, the general community at large. Despite such disagreements there are, nevertheless, discernible and agreed upon impacts of car use that can be broadly grouped into three key impact areas: the economic, the social, and the environmental. While many consequences may seem small and inconsequential it is maintained that the sum of all these small consequences, as well as the larger more noticeable consequences, cannot be ignored. To do so would be reckless, much like the proverbial rat mentioned above.

#### *Economic consequences of automobile use*

*“Economics is extremely useful as a form of employment for economists.”*

John Kenneth Galbraith, economist

Historically, economic growth and transport growth have gone hand in hand. For example, it has been concluded that more than half the economic growth of the then West Germany during the period 1950-1990 could be attributed to growth in transport activity (European Conference of Ministers of Transport [ECMT], 2002). The argument stating

that transport growth, which includes automobile use, has positive economic consequences is based on the claims that (i) transport investment acts as a stimulus to large sectors of industry involved in construction and transport and (ii) infrastructure improvements (typically road network expansion and improvement) reduce the costs of transporting goods (for freight transport) and of accessing goods and services and the labour and leisure/tourism markets (for private transport) (Holvad & Leleur, 2003; Low, 2003; Marott Larsen, Pilegaard, van Ommeren, in press). However, it may also be the case that economic growth stimulates transport growth. Meersman and van de Voorde (2002) argue that freight transport is almost a direct consequence of economic activity: Goods are transported from one region to another because production requires a supply of raw materials and the removal of intermediate or finished products. Of course, private transport is also affected by economic activity: Freight transport brings the good to the consumer whereas private transport takes the consumer to the good. Therefore, increasing economic growth can also lead to increases in transport growth, and with it automobile use.

While the debates concerning the direction of causation between transport and economic growth continue, it is generally accepted that the positive correlation between economic activity and transport is a statistical fact (Koppen, 1995). However, this does not mean that the relationship is a given. It merely indicates that the trends over the past century have almost always yielded a positive relationship between economic and transport growth. Black (2001) labels the notion that investment in transportation infrastructure will lead to economic development of manufacturing industries a myth; it is possible for transport investment and growth to result in negative, neutral and positive economic impacts. Negative impacts arise, for example, when the investment takes capital away from other sectors, when it leads to external industries capturing local markets before the area has had a chance to develop local markets (see also Marott Larsen et al., in press), and when the economic growth is a result of goods being moved further rather than more goods being moved, as has been the case in Europe (Whitelegg, 1997). Neutral impacts, as the name suggests, is the situation where positive and negative impacts of transport project investment cancel each other out. Finally, according to Black (2001), for positive impacts to be experienced, there must be some economic activity that is prevented due to lack of transportation. He furthermore argues that while such situations may exist in the developing world, it is highly unlikely that these exist in the developed world. To further emphasise this point, one merely needs to consider Böge's (1995) study of yoghurt production at a particular factory in Stuttgart, which is cited by Whitelegg (2003) to underscore the, at times, gross economic inefficiencies of transport. Böge's appraisal showed that, as a result of the many different products and sub-products that contributed to the final product, the final product was so transport intensive that each 150 gram package of yoghurt was responsible for moving a truck 9.2 metres.

The economic consequences of car traffic are also reflected at levels other than the societal level. There are onerous consequences at the household level, for example, felt in terms of the costs of running and owning an automobile, as well as at the company level, felt in terms of congestion (defined as the duration of a trip that is additional to that which would be required in free flow conditions), employee or goods traffic delays, and the greater absenteeism associated with employees who drive to work than with those who cycle (European Partners for the Environment [EPE], 1999). While estimates of the

costs of congestion vary greatly, American data show that traffic conditions have worsened nearly every year in nearly every metropolitan area for two decades (B. Taylor, 2004). This is not to say that congestion should be eliminated; uncongested, isolated areas are also inefficient (Small, Winston, & Evans, 1989) and, as such, it might not be desirable to significantly reduce congestion even if one were to assume that this were possible (Stopher, 2004). Rather, the argument being made is that congestion levels are far from the optimal levels targeted by most transportation economists. Finally, the economic consequences of car traffic can also be felt at the state and local authority level in terms of building and maintaining road networks and even subsidising vehicle manufacture, as well as in terms of welfare costs (estimated at 2% of gross domestic product for OECD countries) resulting from accidents or from general health impacts (EPE, 1999).

The above discussion, therefore, suggests that even if transport, which includes automobile use, has positive effects through the exchanges that it allows and for the activities that it makes possible, it entails an enormous cost for society (even if this were historically not the case). This is why recent research on the issue of whether or not it is possible to, in practice, decouple transport and economic growth has gathered momentum (e.g., Standing Advisory Committee on Trunk Road Assessment [SACTRA], 1999; Stead & Banister, 2002). In any case, the economic consequences of transport appear to be tending towards the negative. At best, the positive correlation between transport and economic activity is no longer taken to be an inevitable statistical fact.

### *Social consequences of automobile use*

*“Walking is the best possible exercise. Habituate yourself to walk very far.”*

Thomas Jefferson, Third President of the United States of America

Many social benefits have been associated with the automobile. Freedom and independence, as well as the increase in one’s spatial radius, have already been discussed in connection with the appeal of the automobile. Similarly, benefits arising from the ability to participate in spatially separated activities such as employment, shopping, and leisure activities have already been touched upon in the previous sections dealing with the increasing spatial separation of activities due to the proliferation of the automobile within the context of suburbanisation and the economic consequences of automobile use. There are also, however, many negative social consequences linked with automobile use.

Often overlooked as a result of the assumption that most people can become accustomed to noise, which for the most part is claimed to be but a minor annoyance, road traffic noise creates significant health and social problems. Noise causes raised blood pressure, cardiovascular disease, sleep disturbance, and it prohibits undisturbed outdoor recreation and damages the learning and reading abilities of school-age children (Berglund & Lindvall, 1995; Vlek & Michon, 1992). According to Whitelegg (2003), who reviews the United Kingdom context, the impacts of car use on children are extremely serious when the long term is taken into consideration: children are often driven to school resulting in a loss of independent mobility and physical activity, which in turn leads to a sedentary lifestyle, greater obesity and greater health risks.

Indeed, there is a burgeoning literature associated with the public health impacts of both car use and of the urban environment created by a car-dominated society; notably the effects on physical activity. This is no surprise given that one in three American

adults is obese (Larkin, 2003) and that estimates of up to 300 000 premature deaths occur each year in the United States because of physical inactivity (Brownson et al., 2004). Canadian and American data show that access to physical fitness facilities and urban design factors, such as traffic lighting and footpath maintenance, are associated with greater levels of physical activity (e.g., Brownson, Baker, Housemann, Brennan, & Bacak, 2001; Craig, Brownson, Cragg, & Dunn, 2002). The realisation that car use and car-friendly environments can be related to negative public health consequences has seen the recent increase in cooperation between two distinct research fields: the physical activity and health fields, and the transportation and urban planning fields. A recurrent theme is to turn cities into activity-friendly environments that are built (or re-built) on a human scale, as opposed to an automotive scale; the Pedestrian and Cyclists Equity Act introduced into US congress in 2003, for example, earmarks funding for strategies (e.g., building safe routes to schools) that provide incentives for people to become physically more active (Larkin, 2003).

It is perhaps of health risks associated with greater automobile use that most people are aware. However, the extent of such impacts has often been grossly underestimated given the preoccupation with road deaths and serious injuries resulting from accidents. Whitelegg (2003), citing recent findings from Germany, illustrated how cars were not only responsible for 47 000 deaths and 495 000 injuries (serious and light) per year but also for a range of other, less severe, health impacts including chronic bronchitis, hospitalisation due to breathing problems, asthma attacks, and an incapacity for work. More conventional statistics on the social impacts of traffic accidents are available from the World Health Organization and World Bank (2004): the cost of road crash injuries is estimated to be 2% of the gross national income in high-income countries and road traffic injuries have been shown to place a heavy burden on global, national and even household economies.

Automobile use also has discernible, but seldom researched, effects on community life, social interaction and liveability, all of which are important components of psychological and physical well being and quality of (urban) life. Appleyard (1981), for example, found that residents of heavily trafficked streets had much less social contact and fewer friends and acquaintances than residents on lightly trafficked streets. That is, an important social consequence of car traffic is the way in which it impedes social interaction within communities amongst residents.

A recent trend in transportation research is concerned with the way in which certain individuals are excluded from society. Social exclusion is a multidimensional concept that is independent of poverty, social isolation or physical distance, and that is often defined as a regular physical and social exclusion from the resources of a dignified existence, such as an active labour market, quality health care, consumption opportunities, and integration into civic life (Rajé, 2003; Schönfelder & Axhausen, 2003). Research into social exclusion does not presume negative social consequences due to the car. Rather, it is more concerned with the issue of accessibility to various activities and aspects of society and how social inclusion may be improved given the various factors influencing accessibility such as, for example, information and communication technologies, mobility, land-use management and planning (G. Lyons, 2003). In fact, given the urbanisation trends of the previous century together with the associated increase in car dependency, many researchers are hesitant of endorsing policy measures limiting

car use (insofar as such measures may add to the exclusion of already isolated groups) when such measures are introduced with no other steps being taken to reduce exclusion, such as improving public transport possibly through the hypothecation of revenues from road pricing TDM measures (Hine & Grieco, 2003; Rajé, 2003). An important insight from research is that exclusion is related to both physical location and life-stage, with the implied social consequences being that a society faced with increasing car use also runs the risk of further marginalising, for example, the elderly, the unemployed, the handicapped, women and children (EPE, 1999; Hine & Grieco, 2003).

### *Environmental consequences of automobile use*

*“Hell is a city much like London — A populous and a smoky city.”*

Percy Byssche Shelley, poet

Whereas the putative consequences associated with the automobile may be both positive and negative in economic and social terms, it is argued that the environmental consequences of automobile use can only be negative (or neutral) but not positive. The reasoning behind this position is typified by Low (2003) who describes the global biosphere as a closed system, which itself is composed of a variety of natural ecosystems of different scales, with essentially one energy input (solar radiation) and no output for waste. Therefore, human beings’ use of automobiles either affects the balance of this closed system of ecosystems, which by definition is a negative phenomenon, or it does not, which at best can be defined as a neutral phenomenon insofar as the global system is, for example, capable of absorbing certain levels of emissions.

The environmental consequences of transport relate both to the provision of infrastructure and to the operation of vehicles which use that infrastructure. These consequences include visual pollution, non-renewable resource depletion, air pollution and congestion<sup>2</sup>. While most methods of transport result in some form of negative environmental consequence(s), automobile use is widely considered to be more damaging to the environment than other travel modes, excepting perhaps the aeroplane, and automobiles are typically less efficient than forms of mass transit both in terms of individual journeys and in terms of the energy used in their manufacture and maintenance (Vigar, 2002).

The environmental consequences of car use on the land include soil (and even water) pollution resulting from lead emissions, brake- and tyre-wear, oil and fuel contamination and even the spreading of salt on roads during the winter season (EPE, 1999). However, perhaps the main land-use-related consequence has to do with the sheer amounts required by the automobile, an observation made all the worse by the fact that even when land use is of comparable proportions in terms of acreage, the car is still the most land intensive (Crawford, 2000). The amount of land required by the automobile, the spatial separation of activities and the typical pattern of segregated land use, as already described, have given rise to urban sprawl. While there is considerable diversity in definitions of urban sprawl in the literature, accepted indicators include an outward extension of new

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<sup>2</sup> Noise pollution or barrier effects of infrastructure and traffic on human movement have been covered in the subsection on the social consequences of automobile use. Although such consequences could be included in the present subsection, the emphasis is on consequences on the natural environment. Congestion is included here insofar as it contributes to emissions and visual pollution, even though it could be considered a barrier or as having an adverse impact on liveability.

development, low-density residential developments in new areas some distance from the central city, leapfrog or scattered development, transport networks dominated by the car, road networks characterised by large blocks, and the rigid separation of homes, services and workplaces (Paül & Tonts, 2005; Robinson, Newell, & Marzluff, 2005). The environmental impacts of urban sprawl have been summarised by Johnson (2001) and include habitat and ecosystem fragmentation, reduced regional open space, greater air pollution, higher energy consumption, decreased aesthetic appeal of the landscape, increased stormwater runoff and risk of flooding, and reduced biodiversity. Road construction, particularly of flyovers, is also considered to be an eyesore and a form of visual pollution. Flyovers often worsen the environmental consequences of car use insofar as (i) vehicles travelling at a higher level and speed aggravate the noise and air pollution of adjoining residential buildings and (ii) public transport cannot use flyovers, which are typically built at intersections, and so must pass through the congested intersection along the main road as this is where public transport stops are located (Banerjee-Guha, 2003). That is, flyovers cause visual pollution while at the same time worsening air pollution by reducing the attractiveness of public transport and increasing the space available to cars.

The intensive resource use required by automobiles is not limited to land. Not only does transportation account for half of the world's oil demand (UNEP, 2001), it is also the case that, with respect to petroleum products, the ratio of energy efficiency for the car compared to public transport is 1:2.5 (EPE, 1999). Furthermore, the use of conventional petrol-powered automobiles contributes to air pollution and global warming through the emission of carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), sulphur dioxides (SO<sub>2</sub>) and volatile organic compounds (VOCs) (B. Johansson, 1999; Pickrell, 1999). Cars cause nearly two-thirds of all CO emissions, one-third of CO<sub>2</sub> emissions, more than a third of NO<sub>2</sub> emissions, and slightly more than one-quarter of emissions of VOCs (T. Gärling, A. Gärling, & Loukopoulos, 2002). The environmental consequences of car use, therefore, are both global (resource depletion, effects of emissions) and local (visual pollution, local air pollution, congestion). Finally, while technological advances have both minimised emissions (e.g., heavy particulates, lead) and resource use (e.g., more efficient motors), the net effects of such improvements are not felt as a result of the increasing trends in automobile production and use (Vlek & Michon, 1992; OECD & ECMT, 1995; WRI, 1996).

### **Travel Demand Management (TDM) Measures**

*“Humans simply cannot exist in the natural world without exerting some impact. Nevertheless, while we cannot hope to have no impact, we can hope to have less impact.”*

Raymond F. Dasmann, conservation biologist

A wide variety of policies have been proposed with the aims of alleviating the increasingly negative consequences of automobile use and, ultimately, of guiding society towards a sustainable future. Some policies have directly tackled the automobile per se, either by restricting sales and ownership as has been the case in Singapore (Foo, 1998) or by de-marketing the car as a status symbol and convenient accessory of modern life (Wright & Egan, 2000). Such policies, however, at best affect the determinants of car use, specifically the appeal of the automobile, although ownership restrictions can be

argued to not change this either. Other policies have attempted to promote technological advances, such as alternative catalysts and cleaner fuels (Borgwardt, 2001; T. Gärling, A. Gärling et al., 2002). Yet, such policies typically affect the consequences of car use (e.g., fewer emissions, environmentally friendly tyres). Furthermore, it is generally accepted that car-ownership restrictions are exceptions to the rule and not likely to be implemented elsewhere in political climates somewhat different to Singapore and that technological advances alone are insufficient. For example, Borgwardt (2001) makes the case that technological advances such as fuel cell vehicles, while effective at the level of the individual vehicle, are ineffective at the fleet level due to low market penetration (but see Spiegel, 2004, for a counterargument with respect to the specific case of platinum). Even in cases of large market penetration, the results of technological advances may be offset by greater driving amongst individuals who feel they can drive more given the fact that their driving is not as harmful or fuel consuming as was once the case; a phenomenon referred to as the ‘rebound effect’ (Berkhout, Muskens, Velthuisen, 2000; Schuitema, 2003). Furthermore, as described in the previous section, emissions are only one aspect of many as regards the consequences of automobile use and, as noted for the UK context by Begg and Gray (2004), a government may meet emissions targets in the short term — even with the expansion of infrastructure — without the need to manage demand due to improvements in engine technology. Nevertheless, the demand for road use must eventually be dealt with because carbon dioxide emissions will begin to rise and because even in the essentially hypothetical case of no emissions many social consequences remain, such as the decreasing levels of human physical activity, as may even congestion. Himanen, Lee-Gosselin, and Perrels (2004) also maintain that one cannot rely on technological solutions alone and the oil dependence of the transport sector is here to stay for at least another decade.

It is partly for these reasons that it is argued that demand for car use must be reduced (Hensher, 1998). That is, people’s travel behaviour needs to be modified and, as such, any reference to the effectiveness of a TDM measure in this thesis necessarily implies a behavioural change among users of the automobile<sup>3</sup>. These policies will be referred to as *travel demand management (TDM) measures*, although they are often referred to by other names with similar meanings including, but not limited to, transport system management or transportation control measures (Pendyala, Kitamura, Chen, & Pas, 1997), transportation system management (Southworth, 2001), transportation demand management (Litman, 2003), and mobility management (Kristensen & Marshall, 1999; Litman, 2003; Rye, 2002).

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<sup>3</sup> Of course, it can be argued that policies increasing the positive environmental attitudes of people with respect to travel are effective. Indeed, proponents of the Transtheoretical Model of Change (Prochaska & DiClemente, 1984; Prochaska, Norcross & DiClemente, 1995) have identified that people who successfully make a change must progress, and even cycle, through the stages of precontemplation, contemplation, preparation, action, maintenance, and termination. As such an attitude-change or awareness campaign may succeed in assisting people move from the precontemplation stage to the contemplation stage (i.e., not thinking of using, or even knowing about the existence of, public transport to possibly considering testing an alternative mode to the car such as public transport). Much research and work in the now-completed EU TAPESTRY project “Travel Awareness Publicity and Education supporting a Sustainable Transport Strategy in Europe” (<http://www.eu-tapestry.org>) was underpinned by the Transactional Model; see also P. Jones and Sloman (2003). While important and equally valid as an outcome, the present thesis’ focus is behavioural and not attitudinal change; however, some mention is given to the latter (see Figure 1).



*Travel demand management (TDM): A definition and historical overview*

*“Little by little, one travels far.”*

J. R. R. Tolkien, author

While perhaps taking Tolkien out of context, it is nevertheless true that humans travel more and more, longer and longer, and further and further than ever before (e.g., Cameron, T. Lyons, & Kenworthy, 2004; Stead, 2001). Furthermore, while the number of short trips is decreasing, the number of short trips conducted by car is on the increase (Mackett, 2001). A plethora of policies has been proposed to reverse or constrain these trends. In his review of online resources, Litman (2003) distinguishes between five categories of TDM measures: improvements in transport options; provisions of incentives to switch mode; land-use management; policy and planning reforms; and support programmes. May, Jopson, and Matthews (2003) distinguish six categories of intervention: land-use policies; infrastructure provision (for modes other than the private automobile); management and regulation; information provision; attitudinal and behavioural measures; and pricing. Vlek and Michon (1992) suggest that the following TDM measures are feasible ways of implementing car-use reduction policies: physical changes such as, for instance, closing out car traffic or providing alternative transportation; law regulation; economic incentives and disincentives; information, education, and prompts; socialisation and social modelling targeted at changing social norms; and institutional and organisational changes such as, for instance, flexible work hours, telecommuting, or ‘flexplaces’. Louw, Maat, and Mathers (1998) argued that travel by car could be influenced by policies 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 between ‘hard measures’, which aim to change behavioural opportunities and ‘soft measures’, which aim to change norms, motivations, and perceptions. May et al. (2003) also make this distinction and go further by claiming that attitudinal TDM measures empower individuals to make choices (in contrast to imposing restrictions on them). A rather different conceptualisation is proffered by Marshall and Banister (2000), who distinguish ten categories of TDM measures — capacity management; pricing; land-use planning; communications and technology; city/company travel policies; physical and priority measures; subsidies; access and parking restrictions; goods deliveries; public awareness — placing heavy emphasis on the mechanisms through which these categories work: a switching mechanism (of mode, destination, or time) and a substitution mechanism (through linking trips, technology, or modification).

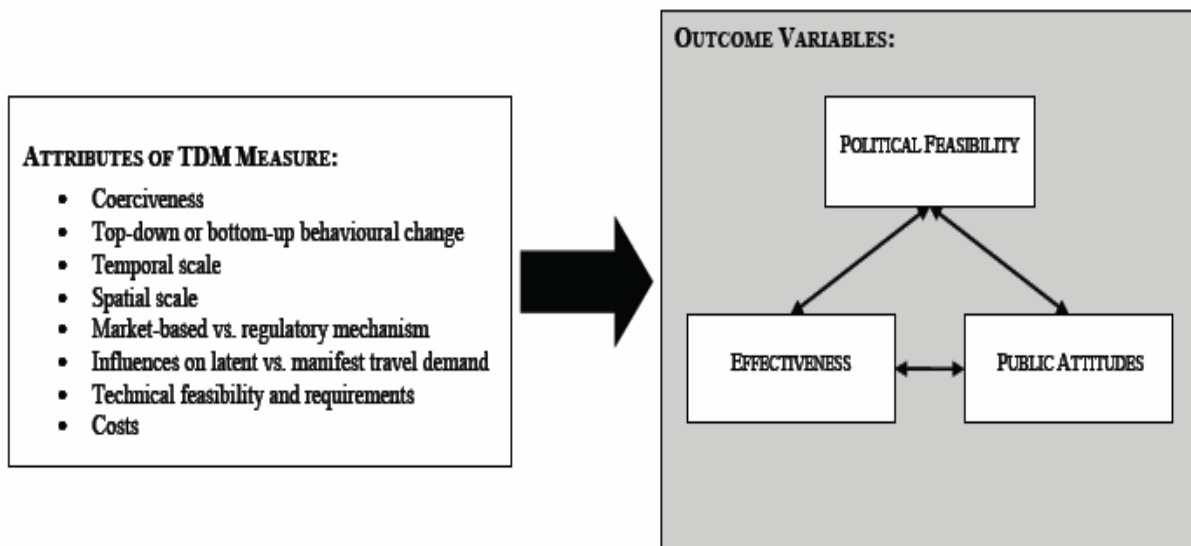
From the above brief overview, it is clear that TDM measures are broadly defined. As seen above, some definitions even focus on the adaptation mechanisms assumed to be triggered in response to the TDM measure; a distinction the present thesis maintains, discussing the adaptation process at a later point. However, there exists one key commonality among all the various categories of TDM measures outlined above, and it is this commonality that Litman (2003, p. 245) emphasises in defining TDM as “a general term for strategies and programmes that encourage more efficient use of transport resources (road and parking space, vehicle capacity, funding, energy, etc)”. This definition is broad reflecting the historical progression away from an initial focus on convincing people to reduce their usage of the private car by changing modes of transport

or by driving less. As M. Taylor and Ampt (2003) note, the term TDM measure now encompasses any initiative with the objective of reducing the negative impact of the car; among the benefits accruing from a reduction in car use within a community, they include less crime and children being allowed to walk or ride alone to a greater extent. This historical development of TDM can also be dealt with using Litman's (2003) definition. It should also be said that the definition of TDM reflects the broader evolutionary changes in policy measures, which have progressed from the 1960s when increasing infrastructure to alleviate traffic problems such as congestion was commonplace, to the 1970s where the emphasis was on improving management of existing infrastructure, to the 1980s and beyond when policies began to target altering human behaviour (Bovy & Salomon, 2002). An even more recent manifestation is the attempt to alter human values and change mobility culture as has occurred in, for example, some parts of Switzerland with administrations marketing a slower lifestyle and better image for public transport (City of Zurich, 2002). The policies of the 1960s are incompatible with the definition of TDM.

*TDM measures: Attributes and impacts*

*“Results! Why, man, I have gotten a lot of results. I know several thousand things that won't work.”*  
 Thomas A. Edison, inventor

Given that TDM is a multifaceted, umbrella term for the collection of policies seeking to minimise the negative consequences of automobile use, it is to be expected that TDM measures may vary on several attributes or dimensions (e.g., coerciveness, technical feasibility, political feasibility, cost). Presented in Figure 1 is a schematic of various attributes or dimensions and their resulting impacts on the key outcomes of public attitudes, political feasibility and effectiveness (i.e., behavioural responses to a TDM measure). The various dimensions, which are by no means exhaustive but are selected on the basis of relevance to the present thesis' focus on behavioural change and the adaptation process, are then examined in greater detail.



*Figure 1.* Schematic of the effects of TDM-measure attributes on key outcome variables and the interrelationships between these outcome variables.

Clearly, Figure 1 implies both that researchers may choose to examine any or all of effectiveness, political feasibility or public attitudes as outcome variables and that it is theoretically possible for two different TDM measures with differing attribute patterns to achieve the same level of effectiveness (in terms of trip reduction or emissions reductions or any other index of effectiveness) but to have very different levels of political feasibility or to result in different public attitudes. The effectiveness of a TDM measure, in terms of resulting behavioural changes, can be related to the measure's attribute composition. For example, it is generally the case that TDM measures covering a larger area will affect a greater number of trips (see Study I). Similarly, the less coercive a measure (e.g., building new public transport routes), the less effective it tends to be in terms of encouraging behavioural change; the previous discussion on habits is one reason as to why this is the case. Regarding public attitudes, however, it has generally been found that the more voluntary TDM measures allowing people to choose to change are more positively received than the more coercive measures (e.g., Ison, 2000; Loukopoulos, Jakobsson, T. Gärling, Schneider, & Fujii, 2005; M. Taylor & Ampt, 2003; Thorpe, Hills, & Jaensirisak, 2000). Similarly, coercive market-based measures, such as road pricing, tend to be less popular than regulations, such as prohibition or road closures, because people do not like paying for things that were once free as it impinges on their perceived freedoms and because, from a social equity viewpoint, they disapprove of the fact that some groups are potentially disadvantaged by coercive market-based measures (Jakobsson, Fujii, & T. Gärling, 2000; P. Jones, 2003; Oberholzer-Gee & Weck-Hannemann, 2002).

Referring to recent literature showing the importance of symbolic and affective motives for travel — travel liking or the positive utility of travel (see Mokhtarian, 2005) — TDM measures that directly or indirectly affect the non-instrumental reasons for travel may meet great resistance from large segments of the community. Furthermore, it should not be assumed that such motives are confined to leisure trips. Steg (2005) demonstrated that they also played a vital role even for the peak hour car commute of Rotterdam residents. Clearly, then, TDM measures that may in some way affect the symbolic and affective reasons of travel are likely to be less popular. However, the irony is that they may be less popular *and* less effective in that those with a greater positive utility of travel are more likely to continue driving; a conceptual distinction can thus be made between coercive policies that are less popular but more effective. The implications are important as seen by reconsidering the car commute mentioned above. A road pricing TDM measure may be unpopular and less effective with respect to the commute to work than entry restrictions or prohibition in that the positive utility of travel may reduce the effectiveness of the former but not the latter TDM measure.

TDM measures covering a greater spatial region or in operation for longer periods of time during the day are more likely to be less well received because of the greater difficulty in avoiding such TDM measures. Furthermore, with respect to attitudes, a distinction can also be made between acceptability, which refers to the attitudes before the implementation of a potential future TDM measure, and acceptance, which refers to the attitudes held after the implementation of a measure (Schade & Schlag, 2003a, 2003b; Schlag & Teubel, 1997).

As regards political feasibility, many TDM measures restricting the use of the car by individuals can be difficult to implement partly because many governments consider the

freedom of movement of citizens a right and consider the car an instrument of such freedom and equality (Docherty, Shaw, & Gather, 2004; Sandqvist, 1997). Additionally, more costly TDM measures are less feasible given the fiscal and budgetary difficulties facing many governments, particularly if the perceived returns on an investment in a TDM measure are seen to be relatively small. Indeed, such cost effectiveness is often an argument for many voluntary change programmes, which require little capital investment compared to, for example, the extension of existing public transport systems (Brög, Erl, & Mense, in press; Department of Transport Western Australia, 2000). Rose and Ampt (2003) further argue that, in addition to cost-benefit<sup>4</sup> ratios of up to 10:1, the evidence from such programmes is that their effects are relatively stable even a year after the programme's end. Furthermore, as noted by M. Taylor and Ampt (2003), protagonists of restrictive TDM measures may be dismissed through the democratic process and, as such, less-restrictive TDM measures are a safer option.

Yet, it is not only the case that the various TDM attributes can independently affect effectiveness, public attitudes and political feasibility. A further, more critical implication of Figure 1 is that the various outcomes themselves are interrelated. For example, Figure 1 implies that effectiveness is related to both the public attitudes generated by a TDM measure and the political feasibility of implementing the TDM measure; indeed all outcome variables are argued to be related to each other. Clearly, when attempting to minimise the negative consequences of growing car use, the more effective a measure the greater the political feasibility. However, more effective measures are also those that require greater change in behaviour and which, in turn, may be less popular amongst the voting public. This, in turn, has consequences on the political will to implement such measures. Nor should it be assumed that the more effective a TDM measure in terms of reducing car use, the more negative the prevailing public attitudes are towards the measure. For example, because of the presumed unfairness of differential treatment of various citizen groups (e.g., the poor compared to the wealthy) as opposed to treating everyone identically, various forms of road pricing are less popular than prohibition or road closures preventing access by car to the city centre (P. Jones, 1995, 2003). In this case, the more effective TDM measure is preferred to the less effective TDM measure. Additionally, even in the case when there is sufficient political will to implement a highly effective TDM measure there is the potential for negative attitudes and reactions amongst the public potentially leading to reactance, which, in turn, decreases the effectiveness of the implemented TDM measure. In brief, according to reactance theory (Brehm & Brehm, 1981), whenever one's freedom to choose is threatened or eliminated, individuals strive to regain a feeling of autonomy, something which often results in attitudes being changed in the opposite direction to that being suggested such that individuals want the thing they are deprived of even more (Brehm, 1966; Brehm & Sensenig, 1966).

This short discussion should clearly demonstrate that the nature of the relationships between the various outcome variables in Figure 1 is neither simple nor straightforward. Nor is it the focus of this thesis. It is, however, a topic worthy of more dedicated research and emphasises the importance of understanding and delineating just what it is about a TDM measure that is crucial to each of effectiveness, public attitudes and political feasibility and how the various attributes of TDM measures may have positive effects on

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<sup>4</sup> Benefits include travel time changes for individuals or for the network, vehicle operating costs, pollution costs, accident and road trauma costs, health and fitness (Rose & Ampt, 2003).

one outcome variable but negative effects on another. That is, while the interrelationships between the various outcome variables are important, so, too, are the actual TDM attributes feeding into these relationships, as seen in Figure 1. As such, the following sections, borrowing from Loukopoulos, T. Gärling, Jakobsson, and Fujii (in press), examine the various attributes or dimensions that can be used to distinguish amongst TDM measures in greater detail.

*Coerciveness.* TDM measures vary in terms of whether the behavioural change is discretionary and within the control of automobile users or whether the change is forced upon automobile users in some way. For example, public transport improvements or information campaigns are non-coercive TDM measures as the decision to reduce car use is left to the individual. On the other hand, TDM measures such as road closures and prohibition within city centres are highly coercive as individuals have no choice but to reduce car use within the designated areas. The coerciveness of other TDM measures such as congestion charging, increases in parking fees and parking restrictions may depend on factors such as individual and household wealth.

P. Jones (2003), Schuitema (2003), Steg and Vlek, (1997), Stradling, Meadows, and Beatty (2000), and Thorpe et al. (2000) distinguish between *push* and *pull* measures. Push measures discourage car use by making it (or car ownership) less attractive. Coercive measures tend to be classified as push measures. Pull measures encourage the use of alternative modes to the car by making such modes more attractive. As such, the less coercive measures, such as cheaper public transport or new bike lanes or even car pooling subsidies, tend to be classified as pull measures. There is a close correspondence between push and pull measures and between TDM measures encouraging attitude change and those forcing behavioural change. For example, the idea underpinning the Individualised Marketing Programme, also referred to as IndiMark (Brög et al., in press), is that much opposition to public transport is due to lack of information and motivation. By bringing such information to the individual and by showing when public transport can be of benefit to the individual, the expectation is that attitudes change such that individuals become more willing to reduce the use of the car for certain trips and purposes. Forced behaviour change, on the other hand, disregards individual attitudes and imposes restrictions.

As Vlek and Michon (1992) and T. Gärling, A. Gärling et al. (2002) point out, forced changes may have negative side effects outweighing the expected benefits, such as costs or sacrifices that households will not accept as well as potential negative health impacts arising from increases in time pressure and stress. Additionally, the less coercive strategies (attitude change or pull measures) may be based on untenable assumptions about how much households are willing and able to change their car use, particularly in the light of car use habits. Such habits interfere with information search and processing (related to new public transport services, for example) so that car use is not reduced. There appears to be a consensus that a package of measures needs to be introduced consisting of coercive measures that break a habit (by, for example, making car use no longer possible or making it prohibitively expensive) and non-coercive measures (such as increased public transport services or new routes) encouraging the use of other modes (T. Gärling, Eek et al., 2002; Meyer, 1999).

*Behaviour change resulting from top-down or bottom-up processes.* A recently made distinction between various TDM measures has been described by M. Taylor and Ampt (2003). They distinguish between traditional, top-down approaches, which tell people what to do, and bottom-up approaches, which allow people to choose to change their travel behaviour. The term given to such bottom-up approaches for the reduction of automobile use is *voluntary travel behaviour change approaches* (M. Taylor & Ampt, 2003); voluntary in the sense that nothing is changed in the transport system and that people are provided with better information concerning their transport options (Stopher, Alsnih, & Ampt, 2005). Although the distinction between voluntary travel behaviour change approaches and pull measures is not clear cut<sup>5</sup>, the goal of the former is to empower people to change travel behaviour as opposed to expecting or forcing a response to external stimuli or pressures (coercive or otherwise). A key principle of voluntary travel behaviour change approaches is that each individual should define his or her own goals, in accordance with his or her own needs and existing lifestyle. This is why change must be initiated as part of a bottom-up process, with households deciding whether or not they wish to participate in a voluntary behaviour change programme (Rose & Ampt, 2001; M. Taylor & Ampt, 2003).

Empowerment implies providing options and permitting individuals or households to choose to change. As such, one can consider land-use planning TDM measures as being a bottom-up process. Consider the effect of neighbourhood or city design on physical activity. While the possibility of engaging in physical activity for leisure purposes is available in any built environment, there is a clear difference between car-oriented and pedestrian-oriented environments in terms of providing choices for physical activity associated with daily life (e.g., commuting or shopping), with only the latter providing such possibilities (King, Stokols, Talen, Brassington, & Killingsworth, 2002). Going even further, Handy (1996a), reviewing urban form and design research, states that research ought to shift from searching for strategies to change behaviour to searching for strategies to provide choices.

*Time scale.* A somewhat forgotten aspect is the variation in time scale required for both the implementation of TDM measures and for responses to various TDM measures. Goodwin (1998) noted that while many effects can be realised immediately, the cumulative effects of policies may not be felt for up to 50 years or more. For example, prioritising public transport and new fares policies have impacts on demand within the first year of implementation, with longer term elasticities being twice as great after 5-10 years. Road pricing schemes and changes in the costs of petrol are argued to yield small responses within the first year with a build-up of effects on car use and car ownership over the next 5-10 years or more. Perhaps the most obvious example of a TDM measure requiring long-term planning and with long-term consequences is that of land-use planning. Goodwin (1998) claims that the short-term effects of land-use planning to reduce travel distances are small, with the larger cumulative effects being felt only after 20 years. Related to land-use planning is pedestrianisation, which Goodwin (1998) claims

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<sup>5</sup> For example, as discussed later, land-use planning (e.g., mixed zoning) can be considered to be a long-term, pull measure even though it may arguably be excluded from the definition of voluntary behaviour change approach if one considers land-use planning to involve a change to the transport system. The key issue, in a sense, is where the transport system ends and land-use system begins.

has an immediate effect on traffic and with effects on pedestrians and retailers being felt after 5 years. This is consistent with the work of Gemzoe (2001) who examined the 30-year process of pedestrianisation and bicycle promotion in central Copenhagen. He argues that the whole concept and use of public space in the city has changed, as has traffic culture as evidenced by the fact that more people travel to work by cycle than by car.

The temporal nature of a TDM measure can also refer to its operational specifications. Congestion pricing, for example, typically operates during peak periods or during the day but not at evenings or at the weekend. Prohibition measures can also operate in similar fashion (Cambridgeshire County Council, 2005), although most road closures tend to be permanent. TDM measures can also affect the temporal nature of the activity per se: work-hour management strategies attempt to affect vehicle trip demand by reducing that demand or 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). Such strategies have been shown to be effective, but it is also known that any savings often generate new, longer trips for non-commuting purposes such as leisure activities or maintenance activities, many of which were previously linked via chaining to the commuting trip (Black, 2001).

*Spatial scale.* TDM measures' scope of influence may vary from the local to the national. Road pricing or congestion charging, for example, is a local initiative aimed at easing traffic flows in urban areas and at improving local air pollution levels, as well as at improving the liveability of urban areas (Banister, 2003; Foo, 1997, 2000; Goh, 2002). Road closures and pedestrianisation measures are also local initiatives. An example of a TDM measure with a large spatial zone of influence is kilometre charges for road transport involving the payment of a certain charge for each kilometre driven by the vehicle user (Ubbels, Rietveld, & Peeters, 2002). A further example is that of public transport discounts for certain groups, typically those outside the employment market (e.g., pensioners, unemployed).

TDM measures may be initiated nationally but have local, even company-specific, impacts. An example is legislation requiring employers to implement strategies to reduce transportation impacts of employees, suppliers, visitors, and customers (Enoch & Potter, 2003; Rye, 2002). Such strategies vary from employer to employer but may include car-pooling schemes, coordination of specific transport routes with local public transport providers, and parking restrictions. Methods aimed at specifically encouraging the commercial sector to minimise the travel of its employees has been a growing TDM area (Enoch & Potter, 2003). In Sweden, for example, local traffic authorities have begun assisting companies to establish a successful, efficient car-sharing scheme for company vehicles by detailing, in the form of a manual, all the steps — bureaucratic, taxation, administrative, legal and so on — required in the tendering process (Norefjäll, 2004). Another employer-based TDM measure is proximate commuting where large decentralised employers (e.g., a bank with many geographically dispersed branches) reassign willing employees to job locations closer to the worker's residence so as to reduce commuting (Rodríguez, 2002).

Finally, an alternative conception of the spatial reach of TDM measures is whether or not they target the origin or 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 centre (i.e., a common destination) and residential areas (i.e., the typical origin). Such a policy has been implemented in the city of Enschede, the Netherlands (Louw & Maat, 1999).

*Market-based versus regulatory mechanisms.* TDM measures also vary in terms of whether they can be classified as market-based (i.e., based on economic principles and pricing mechanisms) or regulatory in nature (i.e., based on legislation, standards, and legal principles). Examples of the latter include road closures, maximum parking ratios, enforced speed limits, and mandatory employer trip-reduction programmes (Meyer, 1999). Violations of such TDM measures are met with some form of punishment, fine or disapproval and the assumption is that such regulations or laws are internalised under the threat of punishment (Vlek & Michon, 1992). Such policy measures are also referred to as command-and-control measures (Johansson-Stenman, 1999) insofar as an authority assumes responsibility for the management of a transport system and controls it so that it, in principle, functions effectively. In contrast, examples of TDM measures based on market-based mechanisms include road and congestion pricing (Banister, 2003; Foo, 1997, 2000; Goh, 2002), kilometre charges (Ubbels et al., 2002), fuel excises and parking charges (Meyer, 1999), public transport discounts and travel vouchers (Root, 2001), and job tickets, which are special season tickets for commuters based on a contract between the employer and a local transport company (these offer cheaper public transport system usage because the contract is a form of bulk buying of public transport tickets) (Gronau & Kagermeier, 2004).

The principles underlying market-based mechanisms can be found in classical economics: people's behaviour is based on the principle of supply-and-demand and explicit cost-benefit analysis, such that if the price of a product (i.e., transportation) increases, the demand for this product will decrease, and vice versa (Schuitema, 2003). Using congestion pricing as an example, the idea is to raise costs so that the congestion externality is internalised (Emmerink, Nijkamp, & Rietveld, 1995). In fact, this principle is clearly seen in Singapore where prices are increased or decreased dependent on the level of road utilisation (Foo, 1997, 2000; Goh, 2002). Furthermore, market-based mechanisms have become increasingly popular in recent years, particularly amongst politicians who appear to have embraced a new competition paradigm emphasising less governmental control. In line with this, many regulations have been repealed on the basis of being outdated or unnecessarily restrictive. Although there are reasons to regulate transportation services to maintain quality, predictability and safety, unnecessary regulations can be reduced, and regulation objectives can be changed to address specific problems while encouraging competition, innovation and diversity (Klein, Moore, & Reja, 1996, 1997).

However, the increasing popularity amongst politicians has been matched by an increasing scepticism amongst researchers with regards to the claimed first-best nature of congestion pricing and market-based TDM measures in general. For a TDM measure to be viewed as a first-best instrument for tackling the problems of automobile usage, certain requirements must be fulfilled, two of which are that (i) individual behaviour must be rational, based on utility maximisation, and (ii) full information is available on all costs involved (Emmerink et al., 1995). However, the previous discussion on the habitual



nature of automobile use and the consequences for predecisional information search renders these two assumptions suspect, even though Emmerink et al. (1995) have demonstrated that congestion pricing, for example, can be considered to be a second-best strategy with some advantages over other second-best strategies (but also some problems). Furthermore, independent lines of 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, 1997; Schuitema, 2003; Sipes & Mendelsohn, 2001). Many researchers even argue for greater regulation and re-engagement of government authorities in the transport sector (e.g., Docherty et al., 2004), with many even arguing for what has been termed within public transport the *controlled competition model* (Örn, 2003): a planning authority is responsible for designing a coordinated network with each route or section being tendered to different companies in a competition setting.

In any case, the popularity of some form of market-based measure continues to grow amongst politicians who also see the potential of such measures to yield additional revenues, either for other environmentally friendly transport modes or for other services such as health and education (L. –O. Johansson, Gustafsson, Falkemark, T. Gärling, Johansson-Stenman, 2003; Odeck & Bråthen, 2002; Rajé, 2003). It is also known that hypothecating revenues from market-based measures is one method to increase the acceptability and feasibility of implementation for any given TDM measure (e.g., Oberholzer-Gee & Weck-Hannemann, 2002)

*Influences on latent and manifest travel demand.* Variations in TDM measures in terms of the nature of the demand they manage is seldom taken into consideration. Yet, there are clear and important distinctions between various types of demand. Latent demand can be defined as the demand for services or resources that goes unsatisfied for various reasons (e.g., slow travel times or congestion, in the case of travel by car). Road construction has historically been driven by a “predict-and-provide” approach (SACTRA, 1994; Vigar, 2002; Whitelegg & Low, 2003), where the argument was that latent demand should be satisfied because better and more roads were required as a matter of individual freedom (the right to use the automobile) and economic competitiveness (the need for efficient road links for business)<sup>6</sup>. However, as cogently reviewed by Mogridge (1997) and Noland and Lem (2002), increases in urban capacity do not yield faster or more efficient travel times but rather, counterintuitively, make congestion worse. The reasons for this are summarised by Downs (1992) as being due to the fact that free road space produced from marginal reductions in commuting time (or from expansion of road capacity) is consumed quickly by (i) those travelling just outside of the peak time period who would shift back in; (ii) those driving on less optimal routes who would take advantage of lowered congestion on the most popular freeways; and (iii) those on slower public transit modes who would prefer driving if there were any more space on the road. Outside of commuting, demand induced by newly opened road capacity could include new vehicle

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<sup>6</sup> The use of the “predict-and-provide” approach has also been criticised on the grounds that, more often than not, simple forecasting techniques have been used whereby recent demand history for each mode is extrapolated to estimate future demand (Vigar, 2001). Given the factors outlined previously that have aided in the increase of automobile use and the decrease in the use of alternative modes (e.g., the extreme spatial separation of activities), then the predict-and-provide approach can be argued to have exacerbated trends such as increasing automobile use and decreasing use of alternative modes (public transport, cycle, walking).

trips by people who would not have otherwise made the trip or trips resulting from drivers who select an alternative destination (i.e., shoppers who prefer a new out-of-town retail development over the city centre). Noland and Lem (2002) even point out that new transportation capacity induces long-run changes in land-use development patterns. In short, road infrastructure provision and expansion is self-defeating (Mogridge, 1997), a point clearly made by Hansen and Huang (1997) who estimate that 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 in California. The implications are that most of the trips using a new road in California are trips that would not have occurred had the road not been built. That is, the 'predicted' traffic growth generally used to justify new roads will not exist if the road is not built (Hansen & Huang, 1997; Noland & Lem, 2002).

In contrast to influencing latent travel demand, many TDM measures influence manifest travel demand (i.e., observable behaviour). Road or congestion pricing or kilometre-based charges are attempts at changing the observed driving behaviour of many people by increasing the cost of driving (Banister, 2003; Foo, 1997, 2000; Goh, 2002; Ubbels et al., 2002) or, in the case of public transport rebates and discounts, by decreasing the costs of alternative modes (Root, 2001). Road closures or prohibition make it impossible for a behaviour or demand to manifest itself in certain areas or at certain times (Cambridgeshire County Council, 2005). The initial waves of TDM measures focused on better management of existing resources (Bovy & Salomon, 2002) and, as such, emphasised influencing manifest travel demand.

Yet many recent TDM measures have also begun to specifically influence latent travel demand. One example is the attempt to alter human values and change mobility culture so that a less mobile society is not seen as a negative (Vlek & Michon, 1992; see also City of Zurich, 2002). Another example is the increasing use of information technology systems (e.g., Internet shopping, telecommuting) (Golob, 2001). Yet another example of such a TDM measure is land-use planning. Research has demonstrated that intensities and mixtures of land use significantly influence decisions to drive alone, car pool, or use public transport (Cervero, 2002). The assumptions made by proponents of such measures are that land-use patterns influence the time cost of travel and that the variations in time cost due to land use are of sufficient size to induce changes in travel behaviour (Boarnet & Crane, 2001; Boarnet & Sarmiento, 1998). In summary, therefore, 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 activity, land-use policies promoting, for example, mixed zoning satiate latent travel demand by bringing the activity to the individual.

*Technical feasibility and costs.* Needless to say there are many other attributes that may affect the influence of a TDM measure on any or all of the outcome variables illustrated in Figure 1. However, it is argued that these other attributes tend to affect the feasibility of implementation of a TDM measure or the public attitudes towards it. Nevertheless, there are two attributes that are worthy of particular mention: technical feasibility and costs.

The technical feasibility and requirements of TDM measures often play a key role in the achievement of sustainable transportation. Having said this, however, technological development in transportation is notoriously slow due to the scale and costs of projects,

the long periods required for research and development, and the long life expectancy of infrastructure and mobile equipment (Shiftan, Kaplan, & Hakkert, 2003). Additionally, technical feasibility and requirements often play a larger role in the success of the more coercive TDM measures as opposed to TDM measures espousing voluntary behaviour change. The greatest concern has been, put simply, whether or not the technology will work, whether the technology will reliably detect vehicles so that drivers do not escape without paying or so that they are not wrongly charged, and whether high levels of non-compliance will overwhelm the system causing it to lose credibility (P. Jones, 2003). Evidence from successfully implemented road pricing schemes is testimony to the possibility that the technological requirements can be met; lack of appropriate technology is not likely to be a constraint in the near future (Blythe, 2004). If anything, privacy issues are a greater concern: The failure of the proposed electronic road pricing scheme in Hong Kong has been attributed to public disquiet at an authority having access to the private movements of its citizens (Hau, 1990). Nevertheless, privacy concerns seem to play a lesser role now even with the possibility of anonymous registration (P. Jones, 2003).

As already mentioned, technical feasibility and requirements have been most extensively examined with respect to road pricing schemes. Foo (1997) highlighted the technical features of the then Area Licensing Scheme in Singapore and noted that pre-payment is necessary to avoid the creation of congestion at entry points. Also important is the clear demarcation of a payment area with relatively few entry points for ease of enforcement, proper training of enforcement officers, and the provision of alternative bypass or escape routes so that motorists are not accidentally forced into a payment area. If anything, it is possible to argue that the technical feasibility of the majority of TDM measures that are likely to be implemented is within reach and, therefore, not an important influence on effectiveness. Indeed, the failure to take full advantage of the available technology can severely limit the long-term effectiveness of a TDM measure, bringing its entire viability into question. Nowhere is this more evident than in London. Congestion charging in London has not been able to deliver the anticipated revenue for reinvestment in transport infrastructure, a shortfall due to (i) the greater than expected reductions in traffic and (ii) the higher operational costs associated with the manually intensive process of call-centre registrations of licence plates (due to the use of video/photo technology to trace vehicles in and/or entering the charging zone) and follow-up activities (i.e., those related to enforcement and penalty notices processes) (Murray-Clarke, 2004). A fully electronic scheme (as in Singapore or in several Norwegian cities), taking full advantage of the available technology, would not only drastically minimise such operational costs but also potentially increase effectiveness both by making it more difficult to cheat the system and by allowing scarce resources to be wisely devoted elsewhere (e.g., enforcement).

As is no doubt evident from the above discussion, the implementation and operational costs of a TDM measure are of considerable importance. However, bearing the present thesis' focus on effectiveness in mind, it is difficult to see how the costs of a TDM measure are necessarily related to effectiveness. The operational costs described previously with respect to the London congestion charging scheme are a potential example, although these are argued to be more related to the issue of technical feasibility. Rather, the relationship between costs of a TDM measure and the benefits resulting from

the TDM measure (a cost-benefit ratio) need not be related to the effectiveness of a TDM measure in reducing car use and is argued to be more important for political feasibility and possibly for public attitudes (May et al., 2003). Indeed, the very notion of cost-benefit ratio is not an uncontroversial one with respect to the evaluation of TDM measures. This is nowhere more evident with respect to voluntary behaviour change programmes where, firstly, any obtained benefits are unlikely to be directly transferable because participants in such programmes are unlikely to represent the entire community and, secondly, the cost-benefit ratio is possibly a biased measure for such measures because of their low implementation and running costs. Nevertheless, the costs of a TDM measure are important given the impacts on the two outcome variables of feasibility and attitudes (Figure 1).

### **Conceptual Framework**

*“The sound principle of a topsy-turvy lifestyle in the framework of an upside-down world order has stood every test.”*

Karl Kraus, writer

Having delineated the reasons for and the consequences of automobile use, along with the various measures for reducing current societal levels of automobile use, attention is turned to describing the way in which such TDM measures exert their influence on users of the automobile. The conceptual framework, first described in T. Gärling, Eek et al. (2002), is presented in Figure 2.

Travel options are defined as bundles of attributes describing trip chains: number and type of purposes, departure and arrival times, travel times, monetary costs, uncertainty, and convenience. It is generally assumed that trip chains rather than trips constitute travel choice options (Axhausen & T. Gärling, 1992) and that car users’ subjective definition of a trip chain — subjective in the sense that it is the user who perceives and defines his or her trip chain — reflects the process of forming choice sets (Thill, 1992). In the conceptual framework, choices of travel options are hypothesised to have two classes of determinants: (i) the bundles of attributes characterising the travel options included in the formed choice set, and (ii) the goals and implementation intentions formed over time in response to evaluations of monetary costs, time, and convenience of current travel. The goals determining choices of travel options may (or may not, for example, in the case of falling petrol prices or newly opened road infrastructure) take the form of a specified desired reduction in travel cost and/or car use. Such goals, and the implementation intentions contingent on them, are assumed to be partly determined by several relatively static factors including income, family structure, work situation, activity/travel pattern, and attitudes (e.g., environmental concern). Another important aspect of the conceptual framework concerns the effects of other users of the transportation system who also respond to the TDM measures. This is important since these other users are likely to respond in such a way that the travel options for a target user are changed over and above the effects that a particular TDM measure (or combination of measures) would otherwise have. Finally, the conceptual framework also allows for the possibility that situational factors (e.g., poor weather, time pressure, family logistics) influence travel choice. For example, torrential rain may cause even the most dedicated cyclist to drive to work for the day, and the time pressure arising from needing to pick up one’s children from school

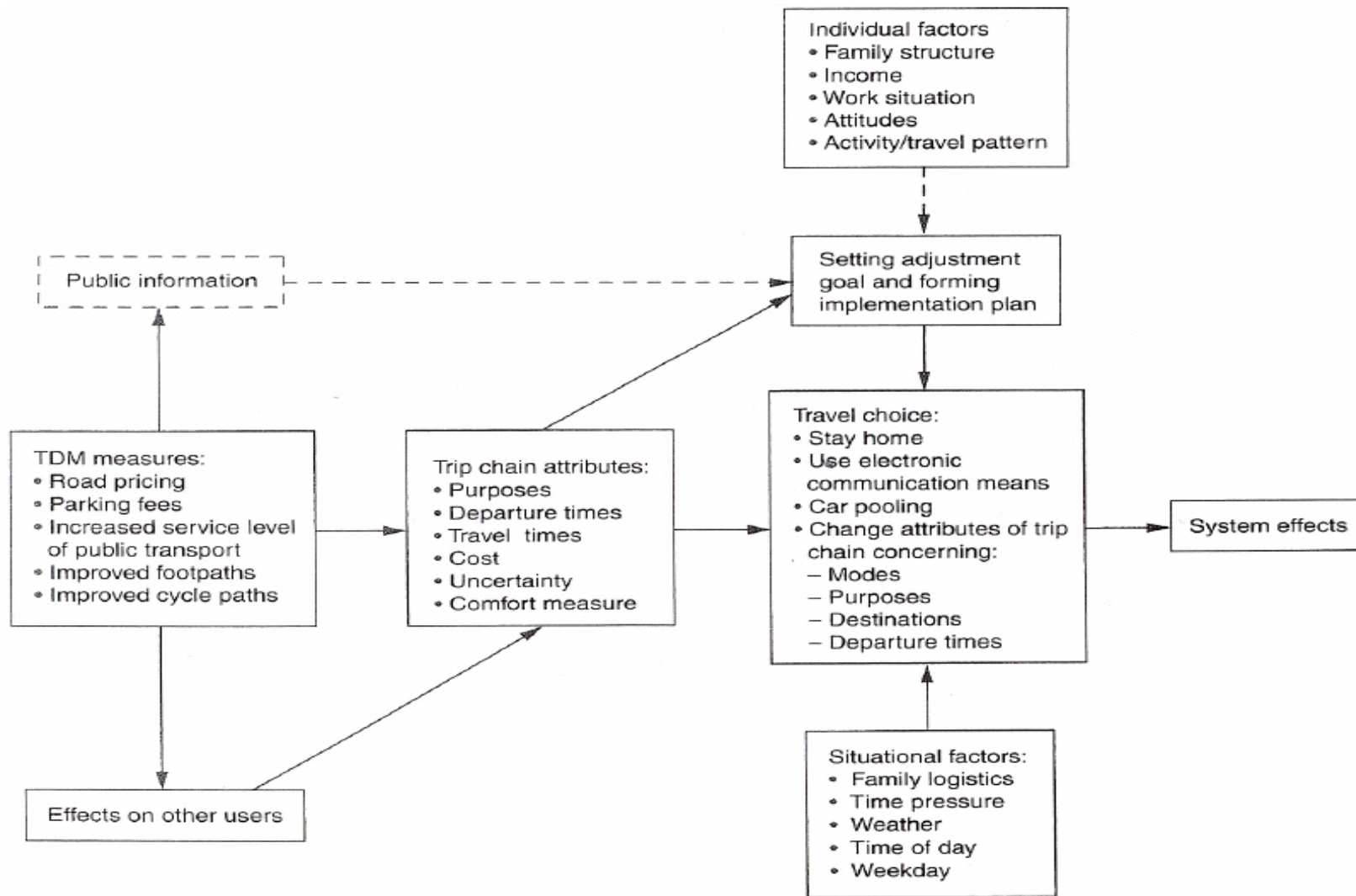


Figure 2. Proposed conceptual framework (Source: T. Gärling, Eek et al., 2002, p. 61)

directly after work may also lead to a choice being made to use the automobile.

As implied in the previous discussion and as illustrated in Figure 2, TDM measures most often directly influence the bundles of attributes characterising travel options by, for example, prohibiting car use in certain areas or by increasing the costs of driving or by lowering fares for public transport. In these cases, the TDM measures in question change the objective characteristics of trip chain attributes. However, as also implied in the previous discussion and as also illustrated in Figure 2, certain TDM measures do not change the objective characteristics of trip chain attributes. Instead, such information and awareness campaigns rely entirely on changing attitudes and, in turn, on encouraging the setting of goals to reduce unwanted travel.

### *Goal setting*

*“Our plans miscarry because they have no aim. When a man does not know what harbour he is making for, no wind is the right wind”.*

Seneca, philosopher

The needs (e.g., Alderfer, 1969; Maslow, 1954) and desires (e.g., Pinder, 1984; Vroom, 1964) that people are assumed to have in various theories of motivation can be conceptualised as choice outcomes or goals (e.g., Locke, 1968; Locke & Latham, 1984, 1990; see also Heath, Larrick, & Wu, 1999). Goals are assumed to have two primary attributes: content and intensity. Lee, Locke, and Latham (1989) divide goal content into four separate parts: (i) difficulty, which refers to the skills required to obtain the goal, (ii) specificity, referring to whether or not the goal is quantitative, (iii) complexity, which refers to the number of different outcome dimensions and (iv) conflict, which refers 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.

An important research finding is that more difficult goals lead to better performance than goals that are easier to attain, provided that the difficulty level is not too great since then there will be less commitment to the goal and the positive relationship will level off or even become negative. Individuals having multiple and distal goals choose to invest effort in attaining those goals from which they can expect to obtain more positive outcomes (Yearta, Maitlis, & Briner, 1995) and they prefer goals that can be achieved at a higher rate of progress so that they experience positive rather than negative affect (Carver & Scheier, 1990). A second finding is that a specified goal leads to better performance than an unspecified (“do-your-best”) goal. These findings are robust and have been replicated in many different settings (Lee et al., 1989; Locke, Shaw, Saari, & Latham, 1981). There are, however, several factors that moderate the effects of goal setting. One such factor is feedback about progress. A difficult, specific goal leads to better performance if the person receives feedback about how well he or she is doing. Another facilitating factor is goal commitment. A goal is a motivator only if one is committed to it. The source of the goal (e.g., whether the person participates in setting the goal or the goal is provided) does not seem to be important (Locke, Latham, & Erez, 1988).

Goal setting theory (Locke & Latham, 1984, 1990) suggests that a set goal directs people’s attention and actions towards activities that are relevant to that goal. Furthermore, goals mobilise effort to work towards goal attainment, with the mobilised

effort being proportional to goal difficulty. More difficult goals, therefore, lead to more sustained effort or persistence than more easily attained goals. Direction, effort, and persistence are assumed to be activated automatically based on past experience. In summary, the achievement of any goal is influenced by a variety of factors including goal commitment, goal difficulty, goal specificity, and information about progress.

In the conceptual framework presented in Figure 2, TDM measures are assumed to affect specific trip-chain attributes (e.g., increased travel costs and/or travel times). These attribute changes are proposed to affect people's travel choices both directly and indirectly, through setting a goal of adjusting to the attribute changes. For instance, if road pricing is introduced, a person will experience increased travel cost. Individual factors, such as income, are assumed to affect whether or not a goal is set to reduce travel costs (i.e., those who can afford to pay the increased travel costs are less likely to set the goal of reducing them than are those who cannot afford the costs). Thus, provided that the increased travel costs are perceived as necessary to reduce, the person will set the goal of reducing them. Furthermore, TDM measures can directly lead to a car-use reduction goal being set without affecting trip-chain attributes, instead relying entirely on changing attitudes as is the case with public information. In addition, travel choices may be determined more immediately by public information concerning situational factors and expectations of adverse consequences. For example, information about temporary road closures may result in a choice to leave the car at home for as long as the road closures remain in place. Alternatively, reports of public transport delays due to poor weather or strikes may lead to the decision to utilise the car. In summary, the goals or travel choice outcomes in the proposed conceptual framework are determined by (i) changes in the objective characteristics of trip chain attributes (direct effect on travel choice), (ii) the goals one sets as a result of changes in trip chain attributes (effect on travel choice of trip chain characteristics mediated via goal), and (iii) the goals one adopts as a result of public information and attitude change campaigns (effect on travel choice mediated via goal, which is not adopted as a result of changes in trip chain characteristics).

### *The adaptation process*

*“Change is inevitable – except from a vending machine”*

Robert C. Gallagher, author

Assuming that a goal has been set and further assuming that this is a car-use reduction goal adopted as a result of the implementation of a TDM measure, the question then remains as to how the adaptation process proceeds. This process consists of implementation intentions entailing a commitment to a plan for how to attain the car-use reduction goal (T. Gärling & Fujii, 2002; Gollwitzer, 1993, 1996). Such a plan consists of sets of predetermined choices contingent on specified conditions. In making plans for how to reduce car use, households may choose among a wide range of options such as staying at home and thereby suppressing trips to out-of-home activities, perhaps using electronic communication means instead of driving, car pooling, travelling to closer destinations, or using other travel modes. Households may also choose longer-term strategic changes such as moving to another residence, changing work place, or changing work hours (e.g., compressing the work week).

Individuals and households are hypothesised to seek and select adaptation alternatives that lead to the achievement of their goals. It is not assumed, however, that this process

necessarily entails a simultaneous optimal choice among all options. Experimental laboratory-based research (e.g., Payne, Bettman, & Johnson, 1993) has shown that people make tradeoffs between accuracy and (mental and tangible) costs and that these tradeoffs are frequently optimal. Furthermore, two key differences to microeconomic utility-maximisation theories (e.g., McFadden, 2001) are posited. Firstly, it is not assumed that people invariably invest the required degree of effort; in the present paper's theoretical framework this is assumed to depend on properties of the set goal. For example, whether a goal is vague or specific may play a role as research has demonstrated that a bias exists such that the current state is overvalued (e.g., Samuelson & Zeckhausen, 1988), thus making changes less attractive. In particular if the car-use reduction goal is vague, evaluating whether or not a change is effective may be biased towards confirming the expectation that it is (e.g., Einhorn & Hogarth, 1978; Klayman & Ha, 1987), with the result being that the required degree of effort is not invested. Secondly, consistent with the notion of bounded rationality (Gigerenzer, Todd, & the ABC Research Group, 1999; Simon, 1990), choices are made sequentially over time. This implies that the change process is prolonged and fails to instantaneously result in outcomes beneficial to society. Additionally, while the costs of chosen adaptation alternatives and their benefits (effectiveness or goal achievement) are evaluated, costs are assumed to be evaluated first as it is these that are generally felt immediately. Effectiveness is evaluated over time on the basis of negative feedback (cf. Carver & Scheier, 1998). If such evaluations indicate a discrepancy with the goal, more costly changes are chosen. Thus, a sequential cost-minimising principle that dictates the choices of change or adaptation alternatives is proposed. Even though it has been shown that people make optimal accuracy-cost tradeoffs in laboratory experiments, it is not known whether they do so in real life when making complex travel choices. Indeed, several observations speak to the contrary, particularly those related to habitual car use and related habitual and routine activities, all of which cause inertia (T. Gärling & Axhausen, 2003). In sum, both the benefits (effectiveness in achieving a reduction goal) and costs of chosen change options are assumed to be evaluated, with more costly changes being chosen only if evaluations of effectiveness indicate a discrepancy with the goal.

On the basis of the aforementioned theoretical framework, the existence of a nested hierarchy of change options varying in terms of costs is posited. As indicated in Table 1, the first stage is to make car use more efficient by chaining trips, car pooling, or choosing closer destinations. The cost is an increased need to plan ahead. The resulting change in car-use efficiency may, however, not be sufficient to achieve the set car-use reduction goal. In a second stage trips may also be suppressed in order to achieve greater car-use reduction. In addition to increased planning, trip suppression implies changes in activities. Although in extreme cases this may necessitate changes in lifestyles, the required changes are generally likely to be minor, perhaps solely involving the suppression of isolated shopping trips. Leisure activities are next most likely to be removed from the activity agenda or substituted by in-home activities. Least likely are more consequential changes in work hours or changes of job. The car-use reduction goal may still not be attained unless other modes are chosen. For instance, since work cannot easily be suppressed, public transport may be chosen for such trips. Additional planning, increased time pressure, and inconveniences are possible costs associated with switching mode. In addition, in order to alleviate a potentially harmful increase in time pressure (T.



Gärling, Gillholm, & Montgomery, 1999; Koslowsky, 1997), suppression of activities would also be necessary.

An additional assumption is that adding the change options to each other increases costs and effectiveness. Furthermore, each individual change option may be performed in varying degrees (frequency over time; e.g., increasing the frequency with which alternative modes to the car are used), thereby also increasing both its costs and effectiveness. In summary, the less costly change alternatives are chosen before the more costly. Assuming a direct relationship between cost and effectiveness for these change options, more costly alternatives are thus expected to be chosen for larger reduction goals. Choosing more alternatives and increasing the frequency of each, thereby increasing effectiveness and costs, is also expected for larger reduction goals.

*Table 1.* Adaptations to TDM measures

<b>Choice options</b>	<b>Possible costs</b>
More efficient car use:	
• Trip chaining	Additional planning
• Car pooling	
• Choosing closer destinations	
More efficient car use	Additional planning
Trip suppression	Activity suppression
More efficient car use	Additional planning
Trip chaining	Activity suppression
Mode switching	Increased time pressure Inconveniences

It should also be mentioned that if the TDM measure is non-coercive or the cost of adaptation is too high, people may cease searching for other adaptation alternatives to implement and instead give up their car-use reduction goal. This abandonment of a goal requiring great effort to implement is hypothesised to be more likely when the magnitude of the required reduction is large, a finding that has been demonstrated in research on goal setting (Yearta et al., 1995; Locke & Latham, 1990). Of course, there is also the potential for a car-use reduction goal to be coercive and the cost of adaptation great. In such cases, the goal cannot be abandoned. If the goal cannot be obtained then far-reaching consequences may be felt in areas such as family functioning (T. Gärling, A. Gärling et al., 2002), psychological and physiological stress (Novaco, Kliwer, & Broquet, 1991; Novaco, Stokols, & Milanese, 1990), and life satisfaction (T. Gärling, A. Gärling et al., 2002; T. Gärling, Lindberg, & Montgomery, 1989).

The temporal frame of reference for the adaptation process itself may be short-, medium-, or long-term (T. Gärling, A. Gärling et al., 2002). Short-term adaptations may include compressing activities in time, increasing the amount of trip chaining or switching to modes other than the automobile. Medium- or long-term adaptations include changing one's activity schedule (e.g., the nature of one's leisure activities), teleworking or changing one's place of residence or work. The focus of the present thesis is on the short-term adaptation process arising from the implementation of TDM measures. Nevertheless, as discussed in the following two sections below, long-term, land-use

planning TDM measures may assist in the options available to humans when adapting to other TDM measures.

### *TDM measures and the adaptation process*

*“Man is the animal that intends to shoot himself out into interplanetary space, after having given up on the problem of an efficient way to get himself five miles to work and back each day.”*

Bill Vaughn, author/journalist

As outlined in Figure 2, TDM measures aim to bring about a reduction in the negative consequences of car use, often through a reduction in travel, by changing the attributes of trips or trip chains. It is to be noted that often a package of TDM measures is proposed, not only push and pull measures, but also measures varying in time scale or spatial scale. This raises the interesting possibility for synergistic effects whereby a given TDM measure, implemented as part of a package, assists a car user to reduce his or her use of the car. For example, road pricing has almost always been implemented in conjunction with improvements to public transport as in Singapore or London. In such a situation, not only do public transport improvements function as a TDM measure aiming to reduce car use but they also assist the adaptation process to the more coercive road pricing measure. In short a TDM measure can influence the adaptation process outlined in Table 1 by making certain options less costly or more effective.

As an example, consider TDM measures that can be broadly classified as belonging to Intelligent Transportation Systems (ITS). The goals of any ITS (e.g., Advanced Traveller Information Systems, Automated Highway Systems, Advanced Public Transportation Systems, Advanced Traffic Management Systems) are to reduce congestion, increase safety and decrease stress for travellers, provide maximal access to system information so that informed decisions may be made by the traveller, and, in short, to promote free flowing traffic (Golledge, 2002). For these reasons, as discussed in greater detail by T. Gärling, Jakobsson, Loukopoulos, & Fujii (2004), it is expected that ITS can potentially increase the effectiveness of a TDM measure by reducing adaptation costs. In such cases, people can attain their car-use reduction goal more easily and, therefore, the likelihood of this car-use reduction goal being achieved or implemented is increased. As seen in Table 2, one may distinguish impacts of information technology that make substitution of travel feasible from those that may make car use more efficient. Examples belonging to the former category are flexible work arrangements, teleconferencing, and electronic commerce. Flexible working arrangements (e.g., telecommuting, a compressed work week) have long been studied with the general consensus being that there is an overall reduction in travel time and distance due to reductions in commuting trips (Golob, 2001). However, it is also known that any savings often generate new, longer trips for non-commuting purposes such as leisure activities or maintenance activities (e.g., grocery shopping), many of which were previously linked via chaining to the commuting trip (Black, 2001). Teleconferencing has the potential to decrease travel to the extent that the technology required is sufficiently developed. Yet, it is often the case that long trips are most likely to be substituted through teleconferencing as opposed to shorter trips, particularly given that in many cases employers pay for such work trips and face-to-face contacts are considered indispensable. Finally, electronic commerce also has the potential to suppress trips, notably service and maintenance trips such as paying bills and other non-grocery activities (e.g., book and music purchases),

*Table 2.* Decision support and substitutes offered by intelligent transportation systems. (Source: T. Gärling et al., 2004, p. 192)

Adaptation	Intelligent transportation system
More efficient car use	Invehicle navigation systems Pretrip/enroute congestion or accident information Car pooling or car sharing information Information about road-use charges
Suppressing trips	Teleworking Teleconferences Electronic commerce
Switching mode	On-line public transport time tables and routing Information about road-use charges Park and ride information Information about traffic regulations

although inroads have also been made with respect to grocery shopping. Golob (2001) provides the example of many large UK supermarket chains agreeing to deliver to offices, which could potentially allow for the suppression of the car-based commute to work when the need to drive to the grocery store after work no longer exists. Cairns (2004) concluded that, while van deliveries for Internet purchases of food and other household items can reduce traffic greatly, any reductions are likely to be offset by the use of the car for other trips and by people using such a service who typically never drive to the store. In sum, ITS has the potential to aid the adaptation of households to TDM measures if the adaptation required is that of trip suppression. However, further research is needed to empirically determine whether or not suppression occurs and, if it does, whether or not other trip types (e.g., home-store-home) replace the suppressed trip (e.g., home-school-work-school-store-home) or if other ITS developments can also limit the need to make extra trips (e.g., electronic commerce). Information technology that may make car use more efficient includes electronic devices providing pre-trip or en-route information about travel time, shortest routes, congestion and accidents, available parking spaces as well as in-vehicle navigation systems. In these cases information technology supports choices of departure times, routes, and destinations (Chatterjee & McDonald, 2004; Stern, 1998). Furthermore, while only a small portion of drivers may be affected by such information, this may be all that is required as the transport system as a whole may be considerably affected such that demand is prevented from exceeding capacity (Chatterjee, McDonald, Paulley, & N. Taylor, 1999). Information technology may also make information about alternative travel modes (e.g., public transport) better and more easily accessible, thus supporting travel mode choice. Furthermore, more efficient car use can be facilitated through the growth of car-sharing schemes, whose efficiency and attractiveness (e.g., on-line bookings and payments) can be much enhanced as a result of information technology (Golob, 2001). Such advancements may not only encourage more efficient car use insofar as people will only reserve a car if the perceived need is

substantial, they may also yield a decrease in car ownership followed by a consequent decrease in car use.

As a further example, land-use measures can be considered long-term TDM measures not only affecting choices to use the car, as discussed in the section on TDM measures' impacts on latent demand, but also making certain adaptations less costly and/or more effective. This view is clearly espoused by proponents of what is referred to as New Urbanism or Neotraditionalism, who argue for a return to the city grid design that was so common up until just after World War I (see Ryan & McNally, 1995, for a review of the literature on neighbourhood design). The claim is that urban decentralisation and suburbanisation occurred because of dissatisfaction with the quality of life at the time — overcrowding, unsafe conditions arising from increased automobile usage, unsanitary conditions — and that urban decentralisation was the only humane pattern for the future (Ryan & McNally, 1995); a decentralisation made easily achievable with the growth in automobile ownership and usage. The human condition has always been a driving force in urban design: Planning in the nineteenth and early twentieth centuries was driven by poor sanitary conditions, which lead to decentralisation, suburbanisation and low urban densities, whereas modern planning needs to take emissions, human inactivity, and social and cultural isolation into account (Jackson, 2003). As succinctly stated by Ryan and McNally (1995), both Garden City (i.e., decentralisation) and neotraditional design concepts aimed to minimise the negative consequences of the automobile but:

... Garden City designers wanted to separate the automobile from the human environment by providing distinct right-of-ways for vehicular and nonvehicular travel and by reorienting houses away from streets. Neotraditionalists advocate the exact opposite approach. They would like to return the automobile to the common area but change the street design so that it functions for the lowest common denominator (namely, the pedestrian). The neotraditionalists seek to include the automobile but to de-emphasise and discourage its use (p. 93).

Consistent with this, work in the public health literature has revealed that aesthetics, proximity to shopping facilities, mixed-use zoning, safety, footpath maintenance and a host of other factors are positive correlates of walking (Brownson et al., 2001; Craig et al., 2002). Similarly, as noted by Handy (1996a, 2002), urban design aspects can influence the choice set of an individual (e.g., the presence of local shopping or leisure facilities or a nearby bus stop) or such aspects can influence the utility of individual elements in the individual's choice set (e.g., well-maintained footpaths, sheltered bus-stops, pleasant scenery). This is particularly important when considering quality of life and the changing demographic structure of an ageing, industrialised world; the elderly cannot drive to the same extent as people of younger age and risk being excluded without appropriate access to facilities and activities. It has been shown that good physical mobility is the best predictor of an elderly person's satisfaction with their mobility on the whole (Donaghy, Rudinger, & Poppelreuter, 2004). Furthermore, Bertolini and le Clercq (2003) contend that people ask not for generic mobility per se, but for opportunities to participate in spatially disjointed activities. Clearly, land-use planning and urban development can enhance residents' accessibility by increasing the amount and diversity of opportunities that can be reached by modes alternative to the car within a certain amount of time.

Nevertheless, there is a dearth of appropriate empirical research on the issue of whether or not land use, specifically neotraditionalism, influences travel. Crane and Crepeau (1998) examined data for San Diego neighbourhoods and claimed that there was insufficient evidence for the street network pattern influencing non-work travel decisions

but were willing to accept that results could vary in other areas. In contrast, van Wee (2002) reviewed the literature and concluded that there was sufficient evidence that land use affected travel behaviour insofar as, for example, shorter distances result in a higher share of slow modes, and shorter distances can be achieved via increased densities, mixed zoning, neighbourhood design (e.g., bicycle lanes and parking facilities, public transport priorities at intersections), and decreasing distances to public transport connections (e.g., more dwellings and job or service opportunities located near railway stations so as to minimise access and egress times). Similarly, Bertolini and le Clercq (2003) examined various neighbourhood regions within Amsterdam finding evidence that variations in urban form and land use influenced modal split. Finally, Ewing and Cervero (2001) concluded that the built environment has a greater impact on trip length than trip frequency and that mode choice is equally dependent on socio-economic characteristics and the built environment.

Irrespective of whether or not land-use planning TDM measures can bring about a reduction in travel, as outlined above, it is clear that in combination with other TDM measures — road pricing, prohibition, and even individualised marketing where information about local facilities are brought to the attention of households voluntarily wanting to reduce their car travel — land use may assist the adaptation process by providing a wider range of adaptations from which to choose (i.e., increasing the choice set) or by improving the effectiveness of options already included in the set (i.e., increasing the utility of options already in the choice set). That is, the reasons or mechanism by which land use would exert its influence are the same as those detailed above and the belief is that individuals and households are assisted in their choices of how to travel to work and other activities or destinations. The difference is, however, that the car-use reduction goal has been instigated by another TDM measure and that the adaptation process to that other TDM measure is assisted by appropriate land-use and neighbourhood-design principles.

#### *Land-use planning and public participation*

*“It is hard to feel individually responsible with respect to the invisible processes of a huge and distant government.”*

John W. Gardner, former US Secretary of Health, Education and Welfare (1965-1968)

An implicit goal underlying the topics discussed in this thesis is that of developing a sustainable society. The concept of sustainability, as with any complex, multifaceted term, has no single accepted definition although most definitions tend to imply the need to conserve natural resources and include a reference to the welfare of both the present society and the society of the distant future; see Friedl and Steininger (2002) and Perman, Ma, McGilvray, and Common (2003) for discussions of the main classes of definitions of sustainability developed in the literature. In this respect, the efficiency of the transportation system is but one important component. Other important components include social systems and institutions, as well as the economic and the environmental components. However, transport policies, of which TDM measures are an example, are notorious for their unpopularity amongst citizens and successful implementations, such as Singapore’s Electronic Road Pricing Scheme (Foo, 2000; Goh, 2002), are the exception. Indeed, many cities, such as Stockholm, have had difficulty implementing schemes including congestion pricing (Ahlstrand, 1998). Those cities, such as London, that have

succeeded in implementing schemes have often taken decades to do so, requiring the problem to reach an unbearable and critical state (Banister, 2003). In any case, land-use planning and many other existing measures pursued by authorities can contribute to travel reduction even if travel reduction itself has not always been the explicit objective of such measures (Marshall & Banister, 2000).

It is often the case that local authorities are generally responsible for community and land-use planning, or at least are the first step in an authority chain stretching to regional and national levels. As such, land-use planning presents an opportunity to engage citizens in the policy process and in the democratic process in general. Nevertheless, the long-range time scale of certain TDM measures' impacts (e.g., Goodwin, 1998) and the unpopularity of many such measures given the often strong preferences found for cul-de-sac developments and single-unit dwellings (e.g., Handy, 2003), imply that it is important that appropriate methods are developed and utilised for assessing citizens' preferences for various land-use and urban planning strategies.

While the case for public participation, defined as involvement in decision making with the purpose of influencing the choices being made, has a long history (for reviews, see Mernitz, 1980; Bacow & Wheeler, 1984), research focussing on participatory methods is a relatively recent phenomenon (van Asselt, 2000). This research reflects social scientific theories and issues concerning transdisciplinarity, social-constructivism and post-modernism, where the common thread is that science ought not to have a monopoly on knowledge and that there exist different perspectives along with local, contextualised knowledge. The reasons given for the inclusion of non-scientific knowledge, practical experience, opinions, values, beliefs and preferences is that the quality of both the research and the planning processes will be improved (Booth & T. Richardson, 2001; Funtowicz & Ravetz, 1994; Renn, Webler, & Wiedemann, 1995; Scholz & Marks, 2001; van Asselt & Rijkens-Klomp, 2002). Yet the means by which citizens are to be engaged is critical. Participation cannot and should not occur in an unsystematic, non-transparent, ad-hoc fashion. Research by Leach and Wingfield (1999) found that the overwhelming type of participation required of citizens by local authorities was passive (e.g., survey- or questionnaire-based). There was little evidence showing the application of methods encouraging citizen deliberation, which they argued implied in-depth debate and knowledge sharing. Furthermore, one cannot automatically assume that greater public participation is a good thing; one also needs to consider the representativeness, inclusiveness and relevance of those who participate (Bickerstaff & Walker, 2001; Booth & T. Richardson, 2001). Additionally, appropriate data collection tools need to be used so that the relevant information is elicited from participants, which then needs to be analysed appropriately (Glicksen, 2000).

Clearly then, how any participatory input is incorporated into the decision-making process and the extent of the influence of these inputs are crucial factors. Arnstein (1969) proposed a ladder of citizen participation in which real participation occurred only when there was at least full partnership (but preferably full control) by the participants; all other forms of participation were equated with tokenism or mere consultation. Bickerstaff and Walker (2001) distinguish between *participation*, which gives some level of power to external interests, stakeholders or the general public, and *consultation*, where decision makers, experts or some other 'elite' group have defined a problem, selected preferred solutions, and then seek public comment on these proposals but with no commitment to

acting upon such comment and feedback. Glicken (2000) reports three types of public participation: (i) *paternalistic*, where the decision maker selects and invites people to participate in a process that is controlled and determined by the decision maker's needs; (ii) *consensus-building*, in which all affected groups participate, and (iii) *confrontational*, in which public participation results in some form of litigation or adversarial process. True participation is argued to be bottom-up and inclusive, directly involving local people in research so as to shift the balance of control from professionals and service deliverers to local communities, with associated benefits being the spread of knowledge and the use of local resources (Dobbs & Moore, 2002). In a recent review of the participation literature, van Asselt and Rijkens-Klomp (2002) classified participatory methods along two dimensions: (i) whether the process is a goal (e.g., empowering citizens) or a means (e.g., enriching assessments through the introduction of non-scientific knowledge) and (ii) whether the output of the process is to reach consensus and select one alternative or to map out a spectrum of diverse views and alternatives. While this classification scheme is useful, it is possible (as argued in Study IV) for a participatory method to consider participation both as a process and as a goal, where the aim is to reach consensus amongst stakeholders after having first mapped out and understood the diversity of opinions, values, belief and knowledge bases possessed by stakeholders.

There are also other benefits of public participation as seen by gleaning the extant literature on direct democracy, which can be characterised by the fact that, in principle, everyone may participate in the decision-making process (see Zimmerman & Just, 2000, for a review of the literature on democratic processes). Frey, Kucher, and Stutzer (2001) claim that direct democracy results in outcomes that are more favourable to citizens compared to situations where there is no option for direct participation. They further demonstrate that direct participation provides utility in and of itself and is associated with greater life satisfaction in the population. This research parallels psychological research that has examined goal and process utility (e.g., T. Gärling, Axhausen, & Brydsten, 1996) or distributive and procedural justice (e.g., van den Bos, Lind, & Wilke, 2001). In the former domain, research has demonstrated that the way in which a goal is achieved is an important source of utility independent of achievement of the goal. In the latter, judgements of fairness and justice involved issues concerning how decisions were made and which procedures were utilised as well as what the decisions or outcomes were.

In sum, long-term land-use and mobility planning represents an ideal opportunity for increasing citizen engagement in societal affairs while at the same time, through the use of appropriate methods, enriching the policy and planning processes with reference to both scientific and non-scientific knowledge bases. Long-term policies can then build upon this information and guide society towards desired and effective sustainable futures, of which the transportation system is a vital component. These TDM measures require a great deal of effort, time and money to implement and it is highly undesirable to embark on a certain policy route that is either ineffective or unpopular amongst citizens. The reason being that if this were the case, then a proposed long-term TDM measure will ultimately not achieve its goals or will potentially have other unintended side-effects or both.

## Summary of Empirical Studies

*“Would you tell me which way I ought to go from here?” asked Alice.*

*“That depends a good deal on where you want to get” said the Cat.*

*“I really don’t care where” replied Alice.*

*“Then it doesn’t much matter which way you go” said the Cat.*

Lewis Carroll, author, “Alice’s Adventures in Wonderland”.

But, of course, it does matter. It may be argued that the specific aim of any TDM measure is to contribute to the achievement of sustainable societal mobility and travel patterns (economically, environmentally, and socially, not to mention from the perspective of public health), with the ultimate, general aim being a sustainable society. Furthermore, there is no point in implementing a TDM measure, for example, if most of the current activities or trips of people remain largely unaffected. Therefore, an appropriate way by which to achieve sustainable urban mobility is to examine how the existing travel and activity patterns of various segments of the population would be affected by various types of TDM measure, the goals set in response to various TDM measures, and the adjustments people make to their travel behaviour in order to achieve these goals. Furthermore, ways in which to achieve a sustainable society, of which the transportation sector is an important component, should also include longer-term TDM measures which not only assist in potentially reducing the need to use the automobile and in enhancing the adaptation process, but also in improving the democratic policy process.

### *Aims and hypotheses*

*“I respect the man who knows distinctly what he wishes. The greater part of all mischief in the world arises from the fact that men do not sufficiently understand their own aims. They have undertaken to build a tower, and spend no more labour on the foundation than would be necessary to erect a hut.”*

Johann Wolfgang von Goethe, dramatist/novelist/poet/scientist

Despite the ever-increasing popularity of various forms of policy measures aimed at reducing the use of the automobile by altering people’s behaviour, very little is known of the way in which such measures exert their influence on individuals and households and the way in which they react and adapt to such measures. The implications are that a first step in any study of the influences of TDM measures on individuals and households is the determination of the impact of a (proposed) TDM measure on existing travel patterns. Stated bluntly, if one’s current travel behaviour is unaffected by a particular TDM measure, then there is no need to adapt. Research examining the sociospatial consequences of TDM measures is scarce despite the importance of this first step. Highlighting this fact, recent work by Santos and Rojey (2004) has demonstrated that a road pricing scheme may be regressive, progressive or neutral in nature depending upon where it is implemented, where people live, where they work and existing modal splits.

Only upon the establishment of whose trips are affected is it relevant to begin consideration of how these individuals and households react and adapt to various TDM measures. Scant attention has also been devoted to the adaptation process and the principles assumed to guide it. While a cost-minimisation process is assumed, it is unclear how this process may vary according to activity type (e.g., work, shopping, leisure), sociodemographic factors (e.g., age, sex, households with children) or spatial and urban factors (e.g., proximity of public transport, urban form). Furthermore, the nature of the cost-minimisation process is also a critical element. Additionally, means by



which to assist the adaptation process by improving the availability and effectiveness of adaptation alternatives or by reducing the costliness of adopting certain adaptation strategies is important. Land-use planning, with its implications for the policy process, plays a vital role in this regard.

The present thesis focuses specifically on TDM measures altering the objective characteristics of trip chains and on the short-term adaptation process resulting from the implementation of such TDM measures. Study I is exploratory in nature and investigates the sociospatial consequences of various hypothetical TDM measures — not only road pricing as in Santos and Rojey (2004) — so as to examine how their implementation would change the travel options faced by households in different segments and for different trip purposes and activities. Study II is an attempt at understanding the goals households set in response to various TDM measures and the determinants of these goals, as well as the adaptation process behind attempts to achieve adopted car-use reduction goals. It is hypothesised that the more coercive the TDM measure, the greater the car-use reduction goal. Furthermore, it is hypothesised that the adaptation process follows the cost-minimisation principle as outlined in Table 1. Study III further examines the hypothesised cost-minimisation process assumed to underlie the adaptation process. Finally, Study IV is an exploratory study, examining the nature of preferences for a series of future urban land-use and mobility scenarios within the context of public participation in the policy and planning processes, and a real-world demonstration of a particular participatory method, Area Development Negotiations, developed within case study research (Scholz & Tietje, 2002). Taken together, these studies should enable a better understanding of the changes effected by TDM measures, the people and trips affected by such measures, the ensuing adaptation process, and of ways in which to assist the adaptation process through participatory land-use planning.

### *Study I*

*“Study the situation thoroughly, go over the various courses of action possible ... and the consequences which can and may follow from each course. Pick out the course which gives the most promise and go ahead.”*

Maxwell Maltz, surgeon/author

Study I was undertaken to determine the potential of certain TDM measures, specifically prohibition and congestion pricing, to affect people’s automobile travel for various activities within a city centre. This was achieved with the use of data available from surveys of daily travel making it possible to associate flows of traffic with the decision making concerning trips made by individuals as well as their activity patterns within a city. This study relied on the use of data from the Swedish National Travel Survey (Statens Institut för Kommunikationsanalys [SIKA], 2002) for the city of Gothenburg, Sweden (pop. 474,900 in 2002).

The data from the Swedish National Travel Survey (SIKA, 2002) span the years 1994 through 2001 and target the population of all Swedes between the ages of 6 and 84 years. The sample was contacted via telephone and regular post, with a cover letter explaining the aims of the survey being sent to the sample one week prior to the individual’s assigned day of the week. The individual was to record and answer questions regarding all movements on this particular day, which was varied across the sample so as to cover all days of the week and the year. An interview obtaining, amongst other things,

sociodemographic information, residential location, work location, household information, and information on actual travel on the assigned day, was conducted the following day by telephone. Finally, the data analysed were the subsample of all trips ending in the greater Gothenburg metropolitan area yielding a total of 7339 trips conducted by a sample of 2810 respondents.

The spatial and temporal definitions of possible TDM-zones were as follows. An inner zone (referred to as the *Small Zone*) and an outer zone, which together with the inner zone formed the *Large Zone*, comprised the spatial components of the TDM measure specifications. Entry into these two zones was proposed to be either totally prohibited (*prohibition*) or restricted such that, on weekdays, between the hours of i) 0730 – 0830 (*morning peak restriction*) or ii) 1000 – 1600 (*daytime restriction*) entry was either no longer cost free or possible. In sum, a total of 2 (spatial restrictions) by 3 (temporal restrictions) yielded each of prohibition, a morning peak restriction and a daytime restriction in either a small or large zone. The number of trips that would be affected by these spatial and temporal definitions of zones was analysed in a series of logistic regression analyses.

Key findings from Study I included the fact that the proposed, hypothetical TDM measures differentially affected car travel in terms of number and purpose of trips. More specifically, were total prohibition to be implemented in Gothenburg, then 25.7% (for a small zone) and 46.7% (for a large zone) of all car trips ending in the greater Gothenburg metropolitan area would be affected. The corresponding figures for a small and a large zone for a morning peak restriction were 1.9% and 9.0%, respectively, and for a daytime restriction were 3.7% and 17.7%, respectively. If the goal is an overall reduction in traffic, then total prohibition is clearly the most effective, while a daytime restriction is less than twice as effective as a morning peak restriction despite being six times longer in duration. However, a total reduction in traffic is not always the primary goal of a TDM measure; often the creation of a liveable, vibrant city centre (daytime restriction) or the shifting of some commuter traffic to the pre- and post-rush hour shoulder periods (morning peak restriction) are held as primary aims. Consistent with this, it was also shown that the TDM measures differentially affected trip purpose, with a morning peak restriction overwhelmingly affecting work trips and potentially changing demand for the car-based work commute during the morning rush hour. Were a daytime restriction to be introduced, then all car trips for all activity types would be affected, thereby potentially altering the demand for car travel to the city during the day, consistent with the aim of creating a more liveable city centre.

Affected travel options were also independently related to individuals and key sociodemographic and economic factors. In the case of prohibition, it was shown that car trips conducted by men would be more affected than those conducted by women, as would car trips conducted by those of working age and car trips conducted by lower income groups. In addition, weekday car travel would be more affected than weekend travel. With respect to a morning peak restriction, car trips conducted by those of working age were more likely to be affected, as would be car trips conducted by males and, once again, those car trips conducted by lower income groups. Finally, were a daytime restriction to be introduced, then not only would the car trips conducted by males, by those of working age and by lower income groups be more likely to be affected — as was the case for the other two TDM scenarios — but the car trips conducted by

those persons not in full-time employment would also be more likely to be affected. This is not unexpected given that those in part-time employment have more flexible time schedules such that they begin working later in the day or such that they are free to enter the central areas during the middle of the day (when those in full-time employment are already at work).

In summary, Study I provided valuable insights into the ways in which the demand for travel can be affected by various policy measures. Changes in travel options were related to both trip purpose and a host of background and sociodemographic factors. Such findings are vital in the travel policy context because knowing which trips and whose trips are affected may enable better prediction and understanding of the responses and adaptation strategies adopted in response to the introduction of TDM measures. This very goal-setting and adaptation process was the focus of the next study.

### *Study II*

*“The weather-cock on the church spire, though made of iron, would soon be broken by the storm-wind if it ... did not understand the noble art of turning to every wind.”*

Heinrich Heine, poet

Study II sought to examine the nature of the goals households form in response to a range of TDM measures, their commitment to these goals, and the implementation intentions adopted in order to achieve these goals. Three TDM measures presently in operation in the world were compared. These TDM measures vary in coerciveness: prohibiting car traffic from entering the city centre (a coercive push measure), individualised marketing (a non-coercive pull measure) and road pricing (moderately coercive). Scenario descriptions are provided in the Appendix to Study II.

A dual data-collection procedure was utilised. A focus group study was first conducted so as to investigate regular users of the automobile. Participants' goals, and their motivation to reach these goals, were ascertained as were the adaptations they would consider in response to each TDM measure in order to achieve their goals. An Internet questionnaire study was then conducted, building upon the responses provided by focus group participants with respect to choice of adaptation alternatives. Here, the aim was to examine the size of the car-use reduction goals set by households in response to the TDM measures and the changes they would implement in order to achieve these goals. It was hypothesised that the cost-minimisation principle would guide the adaptation process such that the more costly adaptation alternatives would be selected for larger car-use reduction goals, which are more likely to arise as a result of the implementation of a coercive TDM measure. Emphasising the complementary nature of the dual data-collection process, whereas the focus group study obtained a range and breadth of goals (not necessarily confined to car-use reduction) and adaptation alternatives, the Internet survey provided quantitative estimates of the car-use reduction that households would implement in response to the TDM measures, as well as of the adoption frequency of adaptation alternatives they would implement in order to achieve these goals.

Twenty participants, who were staff employed at Göteborg University, were recruited for the focus group study. Participants believed that work trips would be more affected than other trip types for all three TDM measures and, in most cases, the main response of participants was to switch mode and to a lesser extent (in the case of road pricing) change the time of travel. When participants stated that they would not be affected by the TDM

measures, it was mainly due to their workplace being outside the affected area or to a willingness to accept the additional costs. The difficulty in influencing shopping and leisure trips lay more in the fact that these activities tended not to be conducted in the TDM-affected area or, if they were, then the hours during which participants would normally conduct these activities allowed them to continue using the car without additional costs being incurred. Additionally, people were willing to regard the increased costs as belonging to an “entertainment account” or equivalent and not as being associated with driving per se. An adaptation unique to shopping and leisure trips was changing destination so as to be able to continue using the car. The focus group discussions also revealed that participants were divided when it came to opinions of demand-based traffic and transport policies. Even so, the general consensus was that combinations of the TDM measures discussed in the focus groups would be more effective in reducing car use and in assisting with the choice of adaptation alternatives, particularly given the opinion that individualised marketing functioned as more of a complement to the remaining TDM measures.

The sample in the Internet survey also consisted of randomly selected employees from all levels and areas of duty (e.g., professors, technicians, research assistants, project managers, administrative staff) at Göteborg University, excluding those who had been contacted for the focus group study. A regression analysis examining size of the stated car-use reduction goal accounted for almost 39% of variance. Despite much of this variance being attributable to individual differences, only a small portion (5.6%) of variance in individual differences was due to income, environmental concern, and residential location. Furthermore, the results demonstrated that, with one exception, the coerciveness of the various TDM measures, the type of trip undertaken or the interaction between these two factors did not play a large role in determining the size of respondents’ reduction goals. The exception was the comparison between individualised marketing and the remaining two TDM measures; as expected, individualised marketing (a pull measure) resulted in smaller car-use reduction goals than the more coercive measures.

An additional regression analysis examining which adaptations would be implemented in order to achieve a stated car-use reduction goal accounted for slightly more than 40% of the variance. Inconveniences arising from a TDM measure tended to be resolved wherever possible by changing travel pattern (e.g., driving to other destinations or changing time of travel) rather than by reducing car use, a finding consistent with the focus group study. This resulted in the most common reduction in frequency of car use being none at all. Even so, as expected, the more coercive the TDM measure the greater the car-use reduction goal.

The three adaptation alternatives (more efficient car use, trip suppression, and mode change; see Table 1) all exhibited significant correlations with the car-use reduction goal. Furthermore, the size of the correlation increased as one progressed from less costly to more costly adaptation alternatives. If the cost-minimisation principle were to receive support, then all adaptations should have significant zero-order correlations with a car-use reduction goal but only the costliest and most effective adaptation alternative should have a significant regression coefficient. In line with this, only mode change was significantly related to stated car-use reduction goal. Nevertheless, it was also the case that the adaptation alternatives interacted with the TDM measures and with trip purpose, thereby also suggesting qualifications to the assumed invariance of the cost-minimisation

principle. Together, both studies illuminate some potential qualifications, with the focus group study permitting richer interpretations of many of the findings from the Internet survey. For example, significant interactions suggested that participants were not likely to suppress their shopping trips (i.e., they would continue to use their car as before, presumably because of the convenience when conducting weekly grocery shopping, as revealed in the focus group discussions) but they would consider a mode change (presumably for purchasing a few items at the local store, which is within walking or cycling distance, although this was not mentioned in the focus group discussions). The same interactions imply that people would conduct more leisure activities at home but would not switch mode (if and when they participate in activities outside the home, as also revealed in the focus group discussions). In sum, therefore, while Study II supports the concept of cost-minimisation principle, it also suggests that future research examine how this principle may vary according to trip purpose or other factors.

### *Study III*

*“In life, the first thing you must do is decide what you really want. Weigh the costs and the results. Are the results worthy of the costs? Then make up your mind completely and go after your goal with all your might.”*

Alfred A. Montapert, author

A shortcoming of Study II, despite its qualified support for the hypothesised adaptation process, was that the car-use reduction goals set by people in response to the utilised TDM measures were small (a mean reduction of 1.3 trips per month). Study III bypassed this problem by utilising experimenter-provided reduction goals: a 5%, 25%, and 50% reduction in car use. This should not be problematic given that (i) the source of a goal has been shown not to be a critical factor (Locke et al., 1988) and (ii) arguably, the spatial and temporal parameters of coercive TDM measures can always be sufficiently calibrated so as to lead to individuals setting larger car-use reduction goals, paralleling the larger, experimenter-provided reduction goals. Not only did Study III permit a more rigorous examination of the adaptation process in response to car-use reduction goals of varying size, it also built upon Study II by expanding the concept of costliness of adaptation to include the frequency with which an adaptation is performed. That is, not only are some adaptations inherently more costly than others, as outlined in Table 1, but performing an adaptation more frequently is argued to be more costly than performing the same adaptation less frequently (e.g., using public transport 5 times a week as opposed to once or twice a week). The hypothesis tested in Study III, therefore, was that a greater number of adaptations, and more costly adaptations (see Table 1), would be chosen at a higher frequency when the size of the reduction goal increases.

Another Internet survey was conducted with a randomly selected sample of Göteborg University employees from all levels and areas of duty. Participants were provided with three reductions goals (5% vs. 25% vs. 50%) which they could achieve by reducing trips on any or all of three trip purposes (work vs. shopping vs. leisure) using any combination of 10 adaptation alternatives (choosing other destinations so as to not need the car vs. conducting the activity from home vs. walking vs. using ITS vs. driving to nearer destinations vs. using public transport vs. car pooling vs. trip chaining vs. conducting the activity less frequently vs. cycling).

As expected, and functioning as a manipulation check, the results revealed that the stated expected frequency of car use decreased as the size of the car-use reduction goal increased. With respect to the adaptations selected by participants for achieving their car-use reduction goals, reductions were observed to be greater for the more discretionary trips than for work trips and for shopping trips than for leisure trips. Additionally, an overall linear increase in frequency of adoption of adaptation alternatives was associated with increasing car-use reduction goals.

The average frequency of adoption and the linear increases in adoption frequency associated with increasing car-use reduction goals were then examined for each adaptation alternative within each trip purpose (see the Appendix to Study III). Using the resulting pattern of statistically significant differences, adaptation alternatives within each purpose were grouped on the basis of the average frequency (low vs. high) and degree of linear slope (gradual vs. steep). For work trips, choosing other destinations so as to not need the car, driving to nearer destinations, conducting the activity less frequently, car pooling, and walking are classified as low frequency/gradual slope adaptations; they are least preferred and it is not until a large reduction is required that an increase in frequency of adoption is observed and even then these adaptations are still least frequent. The adaptations that can be classified as high frequency/steep slope are using public transport, trip chaining, conducting work activities from home, and using ITS. Finally, cycling to work is very common for a small reduction but the rate of its uptake wanes as the size of reduction goal increases (i.e., high frequency/gradual slope). With respect to shopping trips, trip chaining, conducting the activity less frequently, choosing other destinations so as to not need the car, driving to nearer destinations, walking, and using public transport can, despite small internal variations, be classified as high frequency/steep slope strategies. These tend to be the most preferred alternatives and the alternatives whose frequency of adoption increases at the greatest rate with increasing reduction goal. Least popular, but nevertheless increasing in frequency with size of reduction goal are using ITS and car pooling (low frequency/gradual slope). Cycling lies between these two groups of adaptations (high frequency/gradual slope). Finally, for leisure trips, the pattern of significant pairwise comparisons illustrated that walking, using public transport, cycling, car pooling and trip chaining could be grouped together as high frequency/steep slope adaptation strategies; they are most popular for all reduction goals and they increase rather uniformly with size of reduction goal. Choosing other destinations so as to not need the car, driving to nearer destinations and conducting leisure activities less frequently are low frequency/steep slope strategies. Least popular is using ITS (low frequency/gradual slope).

Given that all slopes are positive, the results support the hypothesis that the frequency of adoption of each individual adaptation alternative increases with the size of the induced car-use reduction goal. It is also apparent that different trip purposes have different patterns with respect to the proposed change hierarchy. Additional tests also confirmed the fact that a greater number of adaptation alternatives were chosen, in addition to the total frequency of adoption, as the size of the reduction goal increased. Finally, it was also observed that the extent to which more adaptations were adopted with increasing reduction goals was larger for discretionary trips than for work trips, suggesting that the former have a greater number of adaptation alternatives available from which to choose than the latter — consider choosing other destinations so as to not

need to use the car, an alternative typically not available for work trips — and as a result the increase in number of adopted adaptations is greater for discretionary trips as the reduction goal increases.

In sum, Study III suggests that the adaptation process instigated in response to an increasing car-use reduction goal is complex. In line with the hypotheses, attempts to achieve a specified car-use reduction goal led to the consideration of both the frequency with which a specific adaptation alternative needs to be performed as well as the number of adaptation alternatives required. Both these factors significantly increased with size of reduction goal. Additionally, both these factors varied as a function of trip purpose, presumably because of variations in costliness and effectiveness of adaptations across trip purpose. An implication of the assumed differences in costs for different adaptation alternatives (see Table 1), is that one should expect the less costly adaptation alternatives in the high frequency/gradual slope category (because they are easy to adopt but not very effective for larger goals) and the most costly adaptation alternatives in the low frequency/steep slope category (because most people are loathe to adopt such adaptations unless the situation calls for it, as in the case of a large reduction goal). However, such a pattern was not at all evident, thereby suggesting that other possible operationalisations of the principle of sequential cost minimising of choices of adaptation alternatives may exist in addition to the hypothesised hierarchy outlined in Table 1. Furthermore, it is also clear that any proposed hierarchy will differ as a function of trip purpose.

#### *Study IV*

*“Planning is bringing the future into the present so that you can do something about it now.”*

Alan Lakein, writer

Study IV is a real-world demonstration of the redevelopment of a neighbourhood area in Gothenburg, Sweden, conducted as part of a larger case study (Scholz, Kåberger, Koucky, Engwall, & Månsson, 2004). It builds on the aforementioned studies by creating a series of plausible and internally consistent future urban mobility and land-use scenarios varying in terms of a range of sustainability criteria. These scenarios were created from the combination of four local shopping structure variants (subsequently labelled: the status quo; shopping centre developments; local town square developments; Internet-shopping developments) with various mobility arrangements (e.g., extension of the road network; public transport investments). The resulting number of scenarios from the combination of these two facets was whittled down to seven, in essence developed through consultation of council, regional and national development plans and with the use of the Formative Scenario Analysis Method (FSA) (Scholz & Tietje, 2002). This method reduces the number of scenarios by excluding those which are internally inconsistent and implausible. The scenarios, along with the shopping and mobility arrangements comprising them, are presented in the Appendix (Study IV, Table 4). These scenarios can be construed as long-term TDM measures that, in varying degrees, both affect the need to travel and assist in the adaptation process were any other TDM measure to be concurrently implemented. Also examined in Study IV is the nature of the preferences various stakeholder groups have for the various scenarios. There were three stakeholder groups: business representatives (e.g., local entrepreneurs, national business

interests), society representatives (e.g., political decision makers, local associations), and local residents<sup>7</sup>.

The study presents a unique opportunity to demonstrate the application of an appropriate participatory planning procedure for the democratic policy process. More specifically, the method is Area Development Negotiations (ADN) and can be considered an analytic variant of mediation. The procedure requires a will for cooperation on the part of stakeholders, an acceptance of the mediation mandate of the researcher(s), the recording of stakeholder interests and evaluations (i.e., of future urban mobility scenarios developed using FSA), the discussion of relevant results and the initiation of dedicated bargaining and negotiation, and the submission of final results to the relevant authorities. As can be seen, the aim was to present a series of internally consistent, potential future urban mobility scenarios that varied across participants and stakeholder groups in terms of their sustainability and their attractiveness, so as to record these interests and evaluations, thereby defining the problem space and allowing the relevant stakeholders to discuss the most desired goal or outcome within this space. That is, the case study assisted the development of sustainability orientations (e.g., by aiding the development of cognitive or action schemes when dealing with variants and scenarios) but left the decision of how to realise these orientations up to the decision makers (not the stakeholders nor the researcher(s), who attempts to successfully mediate amongst the various stakeholders in order to deliver a mediated proposal to assist the decision makers in their decision making process).

In order to record participants' interests and evaluations of the various scenarios, a multiattribute utility analysis was conducted (for reviews, see Edwards & Barron, 1994; Yoon & Hwang, 1995). Briefly, a multiattribute evaluation involves several steps including the identification and structuring of relevant aspects or criteria on which the objects (i.e., future urban mobility scenarios) are evaluated, assessing the relative importance of these various criteria, rating scenarios' performance with respect to the criteria, aggregating evaluations and importance weights so as to obtain a utility score (van Poll, 2003). In essence, participating stakeholders were asked to evaluate future scenarios on a series of different criteria to which they then assigned weights. The criteria by which to evaluate the scenarios were developed in consultation with the scientific literature, and with the local community and its representatives in a series of meetings. These covered the economic, social and environmental aspects of sustainability.

The results revealed that, of the potential future urban scenarios examined, there was an awareness on the part of participants of the importance of environmental factors. These were, with the exception of the business representative group, generally given more weight than economic factors. With respect to the various scenarios, participants preferred local town squares and Internet shopping to shopping centres. This is interpreted as a desire to see the possibility of Internet shopping and a lively town square, as opposed to the steady disappearance of present suburban squares. Bearing in mind the present thesis' discussion of the attributes of TDM measures, both scenarios can be argued to bring the activity to the individual. Additionally, both scenarios are also able to aid any adaptation process instigated as a response to the implementation of another

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<sup>7</sup> The case study also examined other scenarios, not reported in Study IV, having to do with local residential conditions and local and regional mobility issues. The composition and inclusion of stakeholder groups also varied dependent on the scenarios being evaluated (see Scholz et al., 2004).



TDM measure. One can interpret such results as being consistent with Bertolini and le Clercq's (2003) claims that people seek opportunities to participate in spatially disjointed activities: Local town squares and Internet shopping assist residents' accessibility by increasing the amount and diversity of opportunities, albeit in different ways, that can be reached within a certain amount of time. Nor are either of these possibilities unrealistic; at present, as revealed in a questionnaire study carried out as part of the larger case study (Scholz et al., 2004), approximately 50% of the total number of daily grocery purchases by residents currently take place at local squares, whereas 75% of purchases of other goods take place at larger shopping centres. Should the variety and breadth of goods and services available at local squares improve, then there is a strong chance that a larger number of customers would choose to purchase there, thereby presumably reducing car use as documented for certain regions of Amsterdam (Bertolini & le Clercq, 2003).

On a substantive level, local authorities can use the provided information to design policies and planning measures that assist in either of these developments (i.e., Internet shopping or local town squares). On a more methodological level, they could do so with the knowledge that these scenarios are the ones unanimously preferred, as revealed in terms of utility scores, by various stakeholder groups representing subsections of the community. Theoretically, as already described in this thesis, such developments are argued to either reduce the need for travel by car and/or assist residents' adaptation to other TDM measures. With respect to public participation it can be said that the ADN procedure embodies an appropriate instantiation of direct participation. It is not only means to an end; it also yields benefits associated with procedural utility. For example, all participants had a highly positive opinion of the procedure. While not the equivalent of procedural utility, and while further research specifically examining these issues is needed, these findings are consistent with previous research showing that direct participation results in positive utility being experienced. The procedure also overcomes many of the criticisms of tokenism often targeted at other attempts to increase participation, as reviewed previously with reference to Leach and Wingfield (1999). It is claimed that ADN encourages deliberation by placing people in a moderately challenging environment and asking them to make a series of judgements and criteria evaluations. Stakeholder ratings of the difficulty of the task confirmed that it was by no means simple and that it required serious deliberation.

In sum, Study IV demonstrated that the implementation of long-term TDM measures focusing on land use and on mobility arrangements are well suited to participatory planning methods involving the evaluation of future scenarios that are the result of careful analysis of present trends and plausible future developments. The methods examined are a means by which to better project potential and expected futures, and a means by which to systematically understand and communicate preferences for these futures, with reference to both scientific and non-scientific knowledge bases. Long-term policies can then build upon this information and guide society towards desired and effective sustainable futures, of which the transportation system is a vital component.

## Conclusions and Discussion

*“Things alter for the worse spontaneously, if they be not altered for the better designedly.”*

Francis Bacon, philosopher/scientist

*“Not everything that counts can be counted and not everything that can be counted counts”*

Sign hanging outside Albert Einstein’s office at Princeton University

This thesis’ point of departure was the need to reduce the steadily increasing trends in automobile availability, ownership, and usage, along with the need to minimise the consequences such trends bring. This very practical emphasis was complemented by the couching of relevant issues in psychological theories of human behaviour, something that is for the most part lacking in the transportation literature. The four reported empirical studies follow each other in a logical sequence with respect to the practical emphasis, while at the same time taking up relevant psychological theories where appropriate. Study I examined the potential impacts of coercive TDM measures both on different population segments and for different trip purposes. Studies II and III examined the goals automobile users set in response to such policies, referred to as TDM measures, as well as the nature of the adaptation process initiated in order to achieve such goals. Finally, Study IV examined public preferences for a variety of land-use options from within the framework of participatory processes, where land-use planning is conceptualised as a long-term TDM measure impacting both the mobility options and adaptation alternatives available to people.

The results of Study I revealed that the spatial and temporal specifications of TDM measures were critical in terms of the number and type of automobile trips affected. For example, while a morning peak restriction was, at best, 20% as effective as total prohibition in terms of number of trips, it successfully targeted the morning car commute. Irrespective of the specific policy goals of authorities, the practical implications of such findings are considerable when one considers that a conservative estimate of the number of commuter car trips ending in the greater Gothenburg area, made as either passenger or driver, is 135 million per year. In other words, each of the examined traffic regulations could represent substantial decreases in the number of undertaken car trips should the goal be a reduction of car traffic. Additionally, the car trips that would be affected could also be related to sociodemographic factors, an important finding in itself because knowing whose trips are affected, along with the type of trips affected, may aid in understanding the nature of the adaptation process. The general findings of Study I tie in nicely with work by Dijst, de Jong, and Ritsema van Eck (2002) who noted that the ability for people to use alternative travel modes to the car differed as a function of action spaces and household type. More specifically, they define potential (and actual) action spaces as the areas incorporating all the potential (or actual) places of activity given certain temporal and spatial constraints. Furthermore, they identify three idealised action spaces: (i) elliptical, in which there are two foci such as the home and work location; (ii) circular, in which activities cluster around a single location (e.g., the home for retirees or the workplace for employees during their lunch break); and (iii) linear, in which two activity locations or foci mark the ends of the action within which no other activities are visited (e.g., people travelling solely between home and work). Their simulations revealed that activities carried out within circular and elliptical action spaces would be particularly amenable to using an alternative mode to the car, provided that time pressure was not too great and/or that the order of activities was flexible. The implications are that

the impacts of a TDM measure would also vary as a function of the distribution of action spaces within a given population or city. More specifically, while Study I demonstrated the need to ascertain the potential effectiveness of the more coercive TDM measures prior to implementation, the work by Dijst et al. (2002) provides a means by which to gauge the relative effectiveness of the more voluntary TDM measures — presumably those voluntary change programmes focussing on mode change and correcting false beliefs about public transport would be less effective in populations or cities dominated by linear action spaces. Relating these findings back to the conceptual framework presented in Figure 2, the spatial and temporal specifications of TDM measures and the nature of action spaces are critical in terms of the potential to alter the travel options (e.g., an inability to drive to one's preferred shopping centre, an increase in the costs of driving to work, or the perceived ability to voluntarily reduce car travel) available to car users. Study I also alluded to the importance of sociodemographic factors (individual factors in Figure 2) for understanding the setting of the adjustment goal and the resultant adaptation process (e.g., driving to another shopping centre or paying a toll to continue to drive to work). This is also consistent with Dijst et al. (2002) who note that distribution of action spaces varies across different types of households: compare two-earner households with children and households comprised of retirees. These analyses are vital because, as implied in the conceptual framework, should a TDM measure not significantly affect existing travel options or should a person's action spaces or activity schedules be too rigid, then the chances of a car-use reduction goal being adopted are minimal, as is the need for adaptation to occur.

Taken together, Studies II and III revealed that people tend to minimise any reductions to their car use wherever possible (i.e., goal setting) and when reductions are believed to be necessary then these are achieved in a manner that minimises the psychological costs incurred by the car user (i.e., choice of adaptations in order to achieve a set goal). In other words, the choice of goal and the steps taken to achieve the goal are vital in the proposed conceptual framework, which, in contrast to the bulk of transportation research on behavioural responses to TDM measures, has drawn heavily on a wide variety of psychological theories. Indeed, the proposed conceptual framework can be argued to integrate the various theories proposed by Locke and colleagues (Lee et al. 1989; Locke & Latham, 1984, 1990), Ajzen (1985, 1991) and Gollwitzer (1990, 1993, 1996). Briefly, Locke and Latham propose that a goal can be divided into the primary attributes of *content* (difficulty, specificity, complexity, conflict) and *intensity* (commitment, goal importance, goal attainment processes). Ajzen proposes that the motivation to perform a behaviour is related towards an attitude towards the behaviour, normative beliefs, and perceived behavioural control. Finally, Gollwitzer (1996) questions whether simply having a goal, wish or desire, generally referred to as the goal intention, is sufficient; a plan or commitment to act so as to achieve the goal is also important as otherwise, passively waiting for a good opportunity may not necessarily arise despite a preference for a certain goal, wish or desire.

This raises the theoretical issue concerning the nature of a goal. How is it related to attitude? In Ajzen's *Theory of Planned Behaviour* (TPB) the motivation to perform a behaviour (i.e., the goal, which in the context of the present thesis is a car-use reduction goal) is a function of an attitude towards the goal, subject to additional influences of subjective norm and perceived behavioural control. As such, other things being equal, a

more positive attitude leads to a greater motivation to perform a behaviour or goal<sup>8</sup>. Yet, Gollwitzer (1990, 1993, 1996; see also Gollwitzer & Schaal, 1998) argues that motivation or goal intention — placed at the strategic, conscious, and effortful level of action control — is insufficient. Rather, an implementation intention for how to achieve a goal — placed at action control levels dealing with operative and tactical planning in which control of one's actions is consciously delegated to anticipated internal or external events — is required if a behaviour is to be performed. In this sense, a goal can be argued to be the representation of a commitment plan for realising certain preferences or desires (i.e., the 'when', 'where', and 'how' of getting started). Gollwitzer (1996) refers to this as the volitional or preactional phase that occurs between a decision or goal intention and action initiation. This, of course, raises another interesting question of whether the implementation intentions for a given behaviour can vary (say, according to a cost-minimisation principle) across trip purpose or sociodemographic factors — a point to be returned to later. Note, however, that even though forming an implementation intention means that control over behaviour is shifted from the self to specified situational cues (Gollwitzer, 1993) such that as soon as the relevant cues are encountered the behaviour is elicited automatically and efficiently, this does not imply actions occur mechanistically. The underlying goal intention needs to be strong and activated for an implementation intention to assist in goal attainment; what is referred to as goal-dependent automaticity (Sheeran, Webb, & Gollwitzer, 2005)<sup>9</sup>. Finally, Lee et al.'s (1989) conceptualisation of goal has substantial overlap with the aforementioned conceptualisations. Most notably, difficulty may be argued to be related to the notion of perceived behavioural control in the TPB, although there may be room for some differences in terms of whether the difficulty has to do with the characteristics of the required or desired goal, task, or skills (i.e., an objective component) or with the individual's perception of his or her abilities (i.e., a subjective component). Furthermore, the attribute of intensity is compatible with the notion of implementation intention and with attitude (insofar as the perception of goal importance is associated with a positive attitude towards the goal).

Relating the preceding discussion to the conceptual framework presented in Figure 2, a TDM measure is argued to yield a change in the objective or subjective situation of car users. This, in turn, leads to the setting of an adaptation goal, which is also subject to influence from individual factors such as income or other attitudes such as environmental concern (see also Loukopoulos et al., 2005). This adaptation goal can be cast in terms of attitude or motivation to perform a behaviour, as in the TPB, or it can be cast in terms of implementation intentions or goal content and intensity, which can be argued to supplement the attitude to the goal. Implementation intentions and goal intensity are arguably represented in the conceptual framework in terms of the travel choices or adaptations for achieving the goal (see Figure 2). The present thesis and conceptual framework, while building on this previous work, deliberately distinguish between goal content or intention (e.g., size of the car-use reduction goal) and the steps taken to achieve that goal. In this sense, the individual's attitude (positive or negative) and the

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<sup>8</sup> Habitual behaviour is excluded from this formulation. However, initial reactions to a TDM measure are argued not to be habitual as a measure changes either the objective situation (in the case of, for example, prohibition or road pricing) or the perceived situation (in the case of, for example, voluntary behaviour change programmes).

<sup>9</sup> As an aside, this suggests that the class of TDM measures referred to as voluntary behaviour change strategies do well in focussing only on those individuals and households wishing to participate in such programmes (and who, presumably, have the requisite strong goal intentions).

source of the goal (internal or external) are irrelevant because a car-use reduction can be coercively induced if need be. The implementation intention or goal intensity are argued to be more related to the adaptation process in the present thesis, rather than the goal per se. As mentioned earlier, different plans may arise for different goals, trip purposes or sociodemographic groups. Studies II and III suggest that such plans are defined in such a way that the psychological costs for achieving the adaptation goal are minimised.

The very notion of an adaptation goal implies a change from a previously desired or preferred situation. As such, notions of comparison to an initial or reference situation are relevant. The present thesis complements the aforementioned theories of goal setting and achievement with Carver and Scheier's (1990, 1998) work on feedback mechanisms. More specifically, the outlined adaptation process extends previous work on travel behaviour by introducing dynamic elements. The assumption is that after for whatever reason having set a goal, people adopt certain responses (e.g., telecommuting) that aid in the achievement of the goal. If this goal is not achieved (or if, as in Study III the reference situation changes such that a larger adaptation goal is required), which implies a comparison with an updated reference situation in which the reduction goal is represented, then other adaptation alternatives are added or adopted or the performance of already-adopted alternatives is increased in frequency. Again, a cost-minimisation principle is assumed. In this sense, notions of implementation intentions and of goal intensity can be considered to be initial (pre-feedback) attempts with an accepted or adopted adjustment goal, with Carver and Scheier's work suggesting that the adaptations adopted (i.e., the implementation intentions or the goal intensity) are modified if comparison with the reference situation reveals that the adaptation goal has not been achieved. That is, a dynamic element has been introduced to the process of adaptation to TDM measures.

This suggests limitations of the present research and directions for future research. One such avenue would be research directly examining the costs of various adaptation alternatives. This should be able to confirm whether or not costliness varies across different population segments and trip purposes; the current research infers such costs from variations in frequency of adoption. Responses to questions of how difficult it would be to adopt a given adaptation strategy represent one potential method by which to gauge psychological costs. Measurement over time will be valuable to see how people react to failing to meet a stated adaptation goal (or, indeed, to exceeding the required amount of change). The use of simulations or experimenter-provided (false) feedback may be of some use here. Such research should be able to see how initial attempts at adaptation vary dynamically over time as assumed in the conceptual framework. Of course, real-life change data measured over several occasions would be most preferable in this regard. Loukopoulos, T. Gärling, Jakobsson, Meland, and Fujii (in press) utilise retrospective reports of actual behaviour changes in response to the introduction of the Trondheim toll ring and also find evidence consonant with the hypothesised cost-minimisation principle of Studies II and III. However, due to data limitations, this research was unable to examine the dynamic nature of the adaptation process. Finally, a further valuable direction for future research could be a test of whether the assumption that costs are evaluated prior to effectiveness holds. This was assumed in the present thesis because it is generally the case that costs are felt immediately while effectiveness is evaluated over time on the basis of negative feedback. While this may be expected in the

case of a coercive TDM measure, voluntary behaviour change programmes may initiate a different adaptation process. The basic argument is that an individual tends to prefer not to alter his or her travel behaviour and that he or she minimises the need to change if a coercive TDM measure is implemented. On the other hand, individuals involved in voluntary behaviour change programmes may seek to maximise the extent of their car-use reduction by means of an adaptation process based on effectiveness maximisation. It may, therefore, be expected that the reduction goal increases in importance so that costs are downplayed. Thus, the choice of adaptation options is primarily based on effectiveness with costs being secondary. At first glance, this may seem to contradict the assumptions made in Study III; namely, that car-use reduction goals forced upon individuals and goals that are voluntarily adopted are equivalent. However, while previous research has shown that the source of a goal — internal/voluntary or external/coercive — does not seem to be important (cf. Locke et al., 1988), this is not to say that the processes by which the goals are achieved are the same. Previous experimental research has demonstrated the existence of tradeoffs between mental costs and accuracy (e.g., Payne et al., 1993) and, by extension, costs and effectiveness; whether, and under which conditions, costs are primarily minimised or effectiveness primarily maximised is a question for future empirical research.

Study IV demonstrated that public participation in the planning process is a viable and appropriate means by which to assist the implementation of long-term TDM measures focusing on land use and mobility arrangements. Such measures are assumed to influence the travel and activity-participation patterns of citizens through the encouragement of the use of alternative modes to the car (e.g., walking in a mixed-zone, compact neighbourhood) or through the greater penetration of accessibility enhancing instruments (e.g., telecommuting and Internet shopping). Study IV indicated that citizens felt sufficiently challenged by the ADN procedure, such that participation was meaningful and deliberative, and that scenarios that can be thought of as accessibility enhancing (e.g., local town squares) were preferred to those that were mobility enhancing (e.g., increased development of road network and shopping centre developments). This is consistent with the findings of many other researchers (e.g., Bertolini & le Clerq, 2003). However, despite such preferences — and it should be noted this may vary from area to area; Handy (2003) provides examples of competing trends and preferences in the USA for neotraditional neighbourhoods, in which accessibility and amenity are enhanced, and for gated communities, in which exclusivity and severance are emphasised — the evidence surrounding the influence of land use and urban form on travel behaviour is equivocal and the causal mechanisms behind any association are for the time being still unclear. For example, in addition to work reviewed earlier, Saelens, Sallis, and Frank (2003) found that there were significant differences in the frequency of walking in neighbourhoods classified as being highly walkable when compared to those classified as being low in walkability — although this does not necessarily imply lower levels of driving (although it could if land-use planning is considered a complement aiding adaptation to other TDM measures, as has also been argued for in the present thesis). Furthermore, Berrigan and Troiano (2002) used home age as a proxy for urban form — neighbourhoods with older homes in urban areas tend to be more likely to have footpaths, a denser interconnected street grid and a mix of business and residential uses (Handy, 1996b, 1996c) — and found that the odds of walking are greater for people living in

residences built prior to 1974. This is where the distinction between the public health and transportation literatures is most distinct: while research tends to consistently provide support for environmental correlates of walking there is less evidence with respect to the environmental correlates associated with less driving.

This latter point has been examined in greater detail by research that has sought to explicate the exact nature of causality between land use and travel behaviour. In short, the issue boils down to one of whether individuals who prefer not to drive choose to live in neighbourhoods conducive to driving less or whether it is the neighbourhood character that leads to their lower frequency of driving. Initial research on this self-selection phenomenon, as it is called, has revealed less promising results concerning the impact of urban form on travel behaviour than had been hoped for. Schwanen and Mokhtarian (2005a, 2005b) have found that while the observed associations between urban form and travel behaviour can largely be accounted for by self-selection of residents with certain attitudes or neighbourhood preferences, urban form and neighbourhood type does have an additional independent impact on travel behaviour. Unfortunately, this impact is small and works against efforts to reduce car use: in suburban neighbourhoods the influence of the local environment dominates traveller preferences regarding their residential environment, whereas in the urban neighbourhood the contributions of residential preferences and urban form of the local environment are more balanced. That is, whereas suburban residents preferring high-density neighbourhoods drove to work as often as suburban residents preferring low-density neighbourhoods, urban residents preferring low-density neighbourhoods drove more often to work — although not as often as their suburban counterparts — than urban residents preferring high-density neighbourhoods. Nevertheless, even after taking into account self-selection, research has shown that neighbourhood characteristics influence the frequency of walking as a leisure trip/activity, while the characteristics of local business areas influence walking to shopping locations (Cao, Handy, & Mokhtarian, 2005). What is clear from the above review is that future research should go beyond the typical cross-sectional study if the causal mechanisms linking the environment or urban form and travel behaviour are to be understood. Such longitudinal research should be able to tease apart the influences of self-selection, travel and neighbourhood preferences, and urban form such that answers can be provided to questions concerning why people move into the areas they do, how their travel behaviour changes in their new environment compared to the previous environment, as well as how their travel behaviour develops over time in the new neighbourhood.

In conclusion, the present research has provided initial steps towards the greater understanding of responses to TDM measures by drawing on psychological theories so as to complement existing travel research. This theoretical extension and development has also been paralleled by a definite practical emphasis. Namely, that any potential impacts of a specified TDM measure need to be evaluated prior to implementation through reference to existing travel patterns, that the adaptations ensuing from the implementation of a TDM measure follow a cost-minimisation principle, and that other TDM measures, notably land-use planning and urban design may contribute not only to influencing travel behaviour but also to assisting the adaptation process to other TDM measures by altering the psychological costs of specific adaptation alternatives. While the recommendation that a variety of TDM measures be simultaneously implemented is not new (e.g.,

Marshall & Banister, 2000; Meyer, 1999), it is the case that the arguments put forward in the present thesis concerning the fact that a variety of TDM measures influence the adaptation costs and effectiveness of other TDM measures (although not necessarily equally for all population segments), and not merely public attitudes, is new. So, too, is the explicit link to public participation in the planning process; important given the purported influence of local land use and neighbourhood design on travel behaviour and adaptation costs. And while it may seem that a great deal more needs to be done, it should be borne in mind that this is to be expected given that the reasons for automobile usage, as outlined at the beginning of this thesis, are many, varied and extremely pervasive. Even so, to paraphrase Einstein, not everything that can be done should be done: the present thesis has suggested theoretically grounded methods concerning which things to do and why, as well as how these things might potentially be achieved and implemented.



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## Appendix

- I. Loukopoulos, P., Gärling, T., & Vilhelmson, B. (2005). Mapping the potential consequences of car-use reduction in urban areas. *Journal of Transport Geography*, 13, 135-150.
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- IV. Loukopoulos, P., & Scholz, R. W. (2004). Sustainable future urban mobility: using 'area development negotiations' for scenario assessment and participatory strategic planning. *Environment and Planning A*, 36, 2203-2226.