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# Land Use and Mobility: a Synthesis of Findings and Policy Implications

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*In this article we assess the contributions of the authors in this special issue. A conceptual model is used to identify the relevant components for the impact of land use on travel behavior and the relationships that should be addressed in empirical research on the effects of land use on travel behavior. The following conclusions are drawn. Firstly, very limited attention has been paid to the policy reasons behind why land-use policies could be used to influence travel behavior. These reasons include effects on the environment, such as noise nuisance and emissions, and safety and accessibility. Secondly, the indicators used for travel behavior are trip frequencies and travel distances by mode. Hardly any attention has been paid to other travel behavior indicators, such as route choice and time of day, which might also have an impact on effects such as noise nuisance, concentrations of pollutants and safety. Thirdly, with respect to land use little attention has been paid to the decomposition of the total effects of land use on travel behavior into direct and indirect effects. Indirect effects of land use include effects via self-selection processes of individuals and households. Fourthly, the behavioral mechanisms and related theories for travel behavior have received almost no attention in the literature reviewed by the authors of the contributions. Fifthly, the use of more advanced techniques such as Structural Equations Models and Multi-level Regression may contribute to a better understanding of the impacts of land use on travel behavior. Sixthly, all the authors of the contributions conclude that land use has an impact on travel behavior, though only a modest one. Finally, several policy recommendations have been made, related to land-use policies that might have an impact on travel behavior. These recommendations mainly focus on mixed use and high-density designs, transit-oriented*

*developments and transit, bike and pedestrian-oriented designs. A broader evaluation of all relevant effects of land-use alternatives is required for policy conclusions, however, including effects on costs, accessibility impacts, and consumer preferences with regard to residential, job and other locations.*

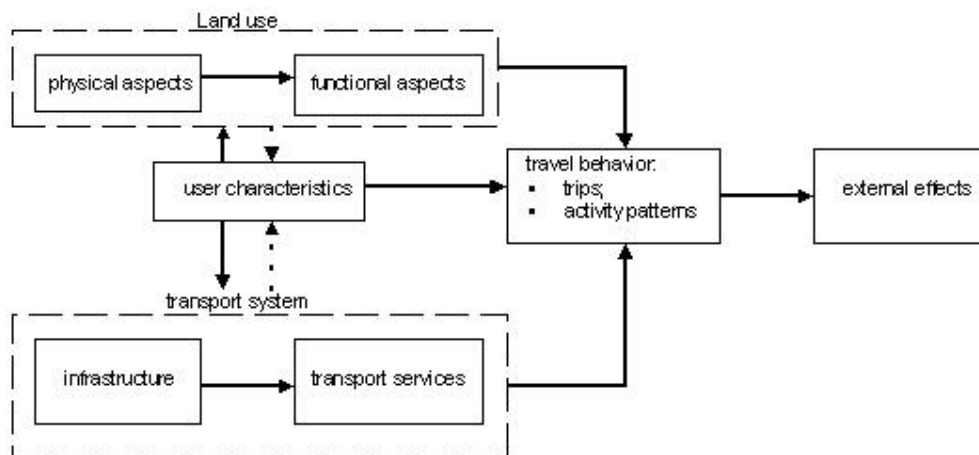
## 1. Introduction

The last few years have shown an increasing interest in the potential of land-use policies to address transport-related problems. Planners on both sides of the Atlantic are looking for strategies to halt and revert the negative effects of increasing demand for mobility, by adopting land-use policies that yield less mobility and reduce car use. The contributions in this issue summarize the results of research and policy experiences in several countries, as an addition to overviews presented elsewhere (Wegener and Forst, 1999; Badoe and Miller, 2000).

In this article we present a synthesis of the results of the contributions in this special issue. A conceptual model is used as basis for this synthesis. This model allows us to assess the contributions systematically and to provide directions for future work. We start with a description of the conceptual model. Next, we critically assess the contributions in this issue and provide directions for further work. Finally, we conclude with the major findings.

## 2. A conceptual framework

In this section a conceptual framework is presented which outlines the influences of land use and the transport system on travel behavior and the external effects of travel behavior. The conceptual model is shown in figure 1.



*Figure 1. Relationships between land use, transport, travel behavior and external effects.*

Figure 1 shows that travel behavior results from land-use related aspects, transport-system related aspects and user characteristics. This is generally recognized in almost every theory

regarding travel behavior as well as in models regarding travel behavior, including the traditional four-stage model and activity-based models.

User characteristics influence travel behavior directly, and they have a direct effect on land use and the transportation system. These effects reflect variation in demand for space and the transport system among different user segments. Households' preferences for housing vary with their characteristics, including wealth, income, education, race, employment location and family composition. Changes in these characteristics and preferences will, in the long run, affect land use through the real estate market. Similarly, these changes will also affect the transport system through the transport market. These direct effects of user characteristics on land use and the transport system imply that it is not only direct effects of user characteristics on travel behavior that are important, the indirect effects through land use and the transportation system are also important. Indirect effects can be both 'positive', i.e. increase the impact of user characteristics on travel behavior, and 'negative'. The total effects of the user characteristics are the sum of the direct and indirect effects. In establishing the effects of land use on travel behavior direct effects should be taken into account, by controlling for user characteristics, as well as indirect effects through the land-use system. Not distinguishing between direct and indirect effects may result in an overestimation or underestimation of effects of land use on travel behavior.

Reciprocal effects can also be identified, these are represented by the dashed arrows in figure 1. These arrows show the effect of land-use characteristics and the transport system on the spatial choices made by individuals. In the literature this is referred to as self-selection. This represents for example, the tendency of people with a disposition towards using transit to reside in areas well-served by such services or that of people with a preference for car use to settle in areas easily accessible by car (Pickup and Town, 1983; Voith, 1991; Boarnet and Crane, 2001; Cervero and Duncan, 2002). The question is whether people's travel decisions are influenced by land use or whether travel preferences have influenced residential choice. For example, a household may live in a transit-oriented development (TOD) and drive their vehicles less than a household living in a more suburban neighborhood without transit access. If, after controlling for factors such as income and household structure, the difference in vehicle use still holds, can we then attribute this reduction in driving to the TOD? Hence, the direction of the cause-effect relationship is unclear. Did the household choose to live in the TOD neighborhood because they wanted to drive less or did they choose to live there for other reasons, and later found out that they could drive less?

The issue of selection is not just important from a statistical point of view, it is also important from the point of view of policy making and providing the right mixture of land use and transportation system policies is important. Levine (1999), for example, argues that there is a segment of the population that wants to live in walkable neighborhoods with mixed uses, but the market does not provide these neighborhoods. Policy interventions are warranted to provide these households with their preferred type of neighborhoods. Further analysis may shed light on this issue.

Next, the separate components identified in the figure are considered. We present the relevant components, the relationships with other components and the implications for research into the effects of land use on travel behavior and external effects.

*Land use*

The term land use is frequently used without first giving a proper definition of its meaning, this also holds for the contributions in this issue Bourne (1982) recounted that he encountered an immense diversity of terms and definitions when looking at the ways researchers use different terms, partly because a large number of disciplines study cities. Land use refers to the activities of humans on the land and is related to physical and functional characteristics of space (Madanipour, 1996). The physical characteristics refer to the built space. In this context the term urban design is often used. This refers to the physical aspects of land use, including the lay-out of streets and provision of parking spaces (Greed and Roberts, 1998). The functional characteristics refer to the human activities in the built environment. Although there is often a relationship between form and function, the form of something may not be presumed by its function (Madanipour, 1996). It is only necessary to recall the many occasions when old houses are re-used as office buildings or restaurants to see how the house *form* is not tied down to the idea of *residence*.

Between locations there are potential functional relations describing the demand for the interaction of people. This demand results from the physical aspect of land use. If residential lots are large, then longer distances have to be traveled to reach desired destinations, but it also depends upon the functional characteristics of land use and the spatial interactions between different users. The ideas of Le Corbusier and the International Modern Architecture Congress (CIAM) promoted cities with zoned, single-use high-rise developments, codified in the 1931 Athens Charter of CIAM (Greed and Roberts, 1998). This led to the spatial separation of activities and hence to longer travel distances. Yet mixed land use is often seen as contributing to less mobility and to more travel using slow modes of travel. Meurs and Haaijer (2001) show that this is the case for shopping and leisure trips. However, they could not find effects of land use on travel to work.

In assessing the effects of land use, different spatial scales should be distinguished, i.e. from the individual buildings via neighborhoods, cities and regions, to the national and international scale. Issues to be addressed and indicators for land use vary with these scales. For example, building one small high-density neighborhood will have little impact, because almost all destinations will be outside that neighborhood. However, compact building at the level of a city or region will reduce travel distances for many trips. A large number of empirical studies are available at the level of regions, cities and neighborhoods (see the contributions in this issue). Less attention has been paid to national and international scales.

A large number of indicators can be developed that may represent land-use characteristics at different spatial scales for both the physical and functional land-use dimensions. For example, Van Beusekom (2003) provides an extensive list of indicators representing physical characteristics of land use. MuConsult (2000) provides an extensive list of physical and functional characteristics of land use at the scale of the neighborhood. This includes characteristics of the buildings (size, type), streets (patterns, parking facilities) and so on.

*Transport system*

As with the land-use system a distinction is made between the physical aspect, the infrastructure, and the non-physical aspects: Level-of-Service (LOS) characteristics and transport services. LOS-characteristics depend on the physical infrastructure and on the legal aspects such as maximum speeds on roads and the actual use of infrastructure. For example, a higher level of use may result in lower speeds on the roads due to congestion. Transport

services include public transport services such as quality and quantity of bus and train connections.

The transport system has a direct effect on travel behavior through the availability of different modes and through the effects of LOS. In addition, it is important to realize that characteristics of the transport system are also related to the land-use characteristics. For example, travel speeds depend on the spatial structure of cities. Hence, to assess the effects of land use on transport, it is important to distinguish between the direct effects of land-use characteristics and the indirect effects caused by the transport system.

A large number of indicators may be used to describe the LOS-characteristics of the transport system. These include speeds, costs, comfort, reliability and so on. In addition, indicators are available to describe the structure of the networks. With respect to the physical characteristics of the network one may use traffic-engineering characteristics at the level of network segments, but also network characteristics, such as the type of network (radial, ring, grid and so on). Of course, it is not just the unimodal networks that are important, the connectivity between networks of different modes is also important.

### *Individuals*

It is people who have a demand for travel. Relevant user characteristics include, among others, age, sex, household structure, education level and job type (see, for example, De Dios Ortuzar and Willumsen, 2001). Within so-called homogeneous groups of people, attitudes, life styles and preferences for transport modes exist and these are relevant for travel behavior and choices of locations such as residential choice (Kitamura *et al.*, 1997, Van Wee *et al.*, 2002; Bagley and Mokhtarian, 2002).

It is important to recognize the decision making of individuals in space when trying to understand travel behavior. The literature on human cognition suggests that the configurational aspects of built environment have significant cognitive consequences. Lynch (1960) notes that to be imaginable, an area needs to be apprehended as a pattern of high continuity, with a number of distinctive but interconnected parts. Golledge and Stimson (1997) have also emphasized that the path or network structure used in everyday spatial behavior becomes a critical feature of the image of a spatial environment. Others suggest that spatial lay-out of the built environment influences the accuracy of cognitive representations of real world spatial information (e.g., Appleyard, 1969; OiNeill, 1991).

Transport dynamics may also be important for assessing the effects of land-use changes on residential choice and destination choices of people and related travel behavior. Behavior of households regarding spatial characteristics such as residential and work location often takes a long period of adjusting to new circumstances. This is because transaction costs are high. Hence the short-term effects of these policies may be smaller than the long-term effects. When considering a behavioral basis for the effects of land-use policies on travel behavior, it could be hypothesized that short-term effects are smaller than long-term effects.

### *Travel behavior*

Travel behavior is usually characterized by trips in terms of modes, distances, time of day and routes used. The limitation of traditional trip-based travel demand models has led to the emergence of an activity-based approach to studying travel behavior (Ettema and Timmermans, 1997). The activity-based approach views travel as a derived demand, i.e. derived from the need to pursue activities distributed over space and time. The conceptual

appeal of this approach originates from the realization that the need to participate in activities is the basic reason for travel. By placing primary emphasis on activities and focusing on sequences or patterns of activity behavior (activity schedule), a more realistic model of people's adaptation to a changing travel environment including land use can be achieved than by using a trip-based approach. In particular, in the case of complex trip chains people relatively often use cars because of the locations of the related activities. Land-use concepts that reduce car dependency in the case of complex trip chains might influence travel behavior.

### *Effects*

Transport causes several effects, most of which are not included in the decision making of the traveler. It is well-known that consumers of goods or services do not generally foot the full bill for the costs their travel decisions impose on society and the environment. Such costs are defined as 'external'. The main effects of transport, most of which are external, are:

- accidents: accidents generate a whole range of costs which are only partly covered by mutual risk insurance schemes. Land use can be related to the design of road infrastructure. This design has an impact on travel speeds and safe driving. In addition, urban design has an impact on the amount of interceptions between the different categories of road users and hence on traffic safety.
- air pollution: emission of particulate matter, carbon monoxide (CO), lead, volatile organic compounds (VOC), nitrogen oxides (NO<sub>x</sub>) and sulphur dioxide (SO<sub>2</sub>), damaging health, the environment and buildings. Emission levels are mode-dependent.
- climate change: greenhouse gases have an enduring impact on the earth's climate, resulting in increased desertification, raised sea levels, serious harm to agriculture and other destructive environmental and health-related side effects.
- noise: transport generates noise, which adversely affects humans in a variety of ways, causing noise nuisance, sleep disturbances, stress and more serious health problems. The amount of traffic is important in noise nuisance and the characteristics of the infrastructure and the built-up area surrounding the streets.
- congestion: if vehicles are added to already dense traffic flows, substantial loss of time for other road users is the result.
- health: It is hypothesized that land use influences the amount of physical activity (walking, cycling) and hence public health (Frank et al., 2002).
- ecosystem: Different physical and functional land-use characteristics may have direct and indirect effects on the dynamics of the ecosystem, for example in terms of natural patches (Alberti, 2000).

External effects firstly depend on travel behavior characteristics, the numbers of kilometers per mode being the most relevant. Secondly, the distribution of these kilometers over space and time are relevant. The distribution over space is relevant because impacts of traffic on noise levels and concentrations of pollutants vary between road sections, depending on distances between the roads and buildings and other locations of recipients. The distribution over time is relevant because night traffic causes much more noise nuisance than day traffic. Thirdly, other factors are relevant, i.e. the technologies used, and the way people use vehicles (speeds, acceleration, deceleration). The latter is related to the physical characteristics of land use, as is shown in a recent experimental study by MuConsult (2003). For example, if

buildings are located close to roads, the speeds on these roads are relatively low if properly controlled for other factors.

As the effects of travel behavior are related to the vehicle miles traveled and to the spatial and temporal distribution of traffic, evaluation of land-use policies on more of these final criteria may improve the quality of such policies.

### 3. Synthesis of the contributions

Using the conceptual model, the contributions in this issue can be characterized using the following aspects:

- the individual components in empirical research
- the relationships among the components
- the methods used to establish impacts of land use on travel behavior
- results
- implications for policies

It should be noted that our assessment of the literature is based on the papers in this issue. Although we believe they provide us with a well-documented overview of main stream research in the countries represented, there may be contributions which are not reviewed by the authors of the papers in this special issue that do pay attention to our assessment of the state of the art.

#### 3.1 The individual components

In this section, the focus is on the individual components in the conceptual model presented in the previous section. We start with (external) effects, the reduction of which is often the main reason for interest in the impact of land use on travel behavior. We then pay attention to travel behavior characteristics that may have an impact on these external effects. Finally, we concentrate on the land-use variables that might have an impact on travel behavior.

##### *Effects of transport*

Although the main subject of the conference, at which the papers of this special issue were presented, was the impact of land use on mode choice, this impact is not a goal in itself, but an intermediate goal to reduce effects of travel behavior. In general, only limited attention has been paid to the external effects that may be of more direct importance to society as a whole: accidents, air pollution, climate change, noise, congestion, health and the ecosystem. Naess and Simma point to the importance of planning for accessibility of jobs and services. They emphasize the importance of developing urban centers and suburban locations of concentration with the purpose of providing residents with good access to work and services. In addition, some work is related to transport-related energy use as a function of urban densities. For example, Naess analyses the relationship between transport-related energy consumption and urban density for Nordic countries. He concludes that increasing urban densities will imply that less energy is used for transport.

However, the research described in the papers does not address external effects such as accidents, livability and risks, and the impact of land use on related travel behavior. The influence of land use on these effects may be important in the light of environmental and



sustainability objectives adopted by many governments. An implicit assumption of the contributions is that all the effects of land use on the external effects are established through travel distance and mode choice. This may be approximately true for CO<sub>2</sub>-emissions, but certainly not for other characteristics such as noise nuisance.

Further research into the effects of physical and functional land-use characteristics is needed to provide policy makers with improved suggestions.

#### *Indicators for travel behavior*

Most research in the area of land-use effects on travel behavior uses mobility indicators such as travel distance and mode use. The underlying policy issues are related to the reduction of travel distances and to the reduction of car use while stimulating the use of public transport and slow modes.

With respect to travel variables, effects on route choice and time of day do not appear to be variables in the research described in the papers, despite the impact of route choice and time on negative external effects such as noise nuisance and safety. This may require more work in future research.

In addition, no attention has been given to trips, rather than activities, including chaining and activity scheduling. When adopting specific land-use mixes near nodes of public transport, mode choice and trip distances may be affected. In addition, it may allow individuals to combine activities into activity chains that do not only rely on car use. Of course, these effects are implicitly taken into account in discussions on car dependencies. Analyzing the interactions between complex activity scheduling and mobility may shed light on policy options to influence mode choice with land-use policies.

#### *Land-use variables*

With respect to the land-use variables that have an impact on travel behavior, the contributions focus on three different spatial scales, i.e. local, regional and national. Most contributions focus on the direct effects of the physical characteristics of land use. With respect to the local scale considerable attention has been paid by the contributors to urban design features, such as density and street lay-outs. The contribution of Cervero presents the results of North American studies, including a meta-analysis of the findings. He shows that the urban design elasticities with respect to non-car travel were fairly modest. He states that underpricing of the automobile is, due to the availability of free parking, so prevalent that the influences of neighborhood design were swamped. In addition, some authors pay attention to the functional aspects of land use such as mixed neighborhoods and location of facilities with respect to city centers. At the regional level attention is paid to home-work balances. In addition, effects of compact urban extensions versus scattered developments are discussed. At the regional level attention is also paid to urbanization in relation to transport networks, especially public transport. At the national level the contributions focus on the distribution of urbanization over regions, having an impact on job-housing balances and on the use of transport networks

Some authors state that density may have an effect on travel behavior. However, density involves many other land-use characteristics, such as mixed land uses, good transit service, parking constraints, etc. These effects should be distinguished to properly assess the effects.

*User characteristics*

Traditional analyses show that travel behavior differs between different areas, without taking user characteristics into account. In most contributions presented in this issue, the authors describe research that actually takes variation in user characteristics into account. Most of the well-known demographic and socio-economic characteristics that influence travel behavior are dealt with in the papers. Much less attention has been paid to attitudinal characteristics of individuals and households making travel choices (see section 2). For example, subjective safety may have an effect on the decision to use slow modes. In addition, more research with respect to the psychological aspects of the land-use effects may be important. For example, it is unknown how different mental maps associated with urban design have an impact on travel behavior.

*Transportation system supply characteristics*

Finally, hardly any attention has been paid to transportation system supply variables. The close relationships between land-use characteristics and the transport system should be taken into account when assessing the effects of land use with the land-use effects being separated from the effects of the transport system. If these effects are not separated, the outcomes of the research will confound the effects of land use and the transport system. If, for example, urban density and LOS of transit are correlated positively, omitting LOS will imply that the effects of density are overestimated.

**3.2 Relationships among components**

Most of the authors establish direct links between land use and mobility variables, and because multivariate statistical analyses are used quite often, the results for specific components are obtained by controlling for effects of others.

In the contributions little attention has been paid to the simultaneous effects of land use, the transport system and user characteristics on travel behavior. Especially if self-selection is present, models will yield inconsistent parameter estimates. The direction of the bias depends on the correlation between the land use and the transportation system. If, for example, households with preferences for high-density environments are also prone to use transit, the correlation between these two indicators is positive. This will result in an overestimation of the effects of density on transit usage. The consequences of these effects are not only of interest for statistical purposes. The presence of these correlations also implies that travel behavior can be influenced by the supply of high-density residential areas near transit stops for user segments prone to use transit.

Two points for further research can be identified related to a better understanding of the simultaneous effects of land use, the transport system and user characteristics on travel behavior. The first one is that almost no attention has been paid to the underlying behavioral mechanisms. These mechanisms explain *how* land-use affects travel behavior. Only gross effects of land use are considered. Hence, most research establishes statistical associations, without testing psychological, economic and sociological theories of behavior in the context of the physical environment.

The second point is that more work is required with respect to the split into direct and indirect effects of land use on travel behavior. In particular we refer to indirect effects through the transport system and the relation between land use and different types of population segments

attracted to certain areas. This refers to the self-selection issue discussed in the previous paragraph.

### 3.3 Methodological issues

Most authors of the contributions in this special issue recognize that descriptive research methods adopted in assessing the effects of land use on travel behavior lead to conclusions which cannot be used for assessing the potential effects of land use on travel behavior. It is recognized that neighborhoods differ in many ways, such as the characteristics of the population. Hence, proper multivariate statistical methods are required to assess the effects of land use on travel behavior. Two main methodological strategies are used. The statistical method assesses the current travel behavior characteristics and relates them to several contributing factors, among which land-use characteristics. The estimated parameters reflect the effects of land use on travel, controlling for other effects. The second methodological strategy involves the use of land use transportation interaction models, where researchers systematically vary certain variables to assess effects on travel behavior.

Several authors conclude that many studies have weaknesses either in data used or in methodology, see for example the contributions of Cervero, and Headicar in special issue, Handy, 1996, for an overview, or Mindali *et al.*, 2004, for an example of the importance of the methodology for the outcomes. This may obscure conclusions with respect to the direction and magnitude of policy impacts. Several of these studies have worked with aggregate variables for spatial units that are not homogenous with respect to land-use and socio-economic characteristics. Other studies have not considered any variables of transit supply in their model specifications, and have thus ascribed differences in observed travel behavior to primarily urban form variables. In order to examine the effects properly, individual data analyzed with multivariate models including all components and relationships in the conceptual model used in the previous section, are required.

Many improvements can be made in modeling the relationships between land use and transport, including multi-level regression models and structural equation models. These models offer better opportunities to analyze complex relationships between variables, including intermediate variables, and related decision-making processes. For an overview of the state of the art in structural equation models in the area of transport, we refer to Golob (2003). For an example of multi-level regression models used for research into the impact of land use on travel behavior see Schwanen and Dijst (2002).

Another issue is the neglect of dynamics in almost all analyses reviewed in the articles. We suggest doing more short-term and long-term evaluations of effects of land-use policies and infrastructure development than currently being carried out. This will require the use of longitudinal data, such as panels. An first example of such an analysis is provided by Meurs and Haaijer (2001). They analyse the effects of changing land use on mobility using a 10-year time interval for a panel of the Dutch population.

The methodological improvements are of interest from a scientific perspective and for assessing the potential contribution of land-use planning for reducing the external effects of transport.

### 3.4 Results

The results presented in the contributions are summarized in the editorial and will not be repeated here. Most of the research presented in this issue shows modest links between land-use patterns and travel behavior. Travel indicators such as the number of kilometers per mode are affected by land-use factors, both physically and functionally. However, the effects of land use on these indicators are not substantial and the contributions in this issue show mixed findings. We have suggested that there may be many reasons for these findings, including lack of comprehensive analysis, methodological weaknesses, data limitations, etc.

Most of the results presented only draw attention to the effects of land use on travel behavior, controlling for socio-economic and transport system characteristics. It is frequently argued that the latter are more important variables. This calls for more work on the indirect effects of land-use policies.

### 3.5 Policy implications

Many contributions assess the implications of the results for policies. The question whether spatial planning should play an important role in mobility policy is answered affirmatively by all authors.

Important measures mentioned in the papers are:

- infill-development on skipped-over or under-utilized lands in urbanized districts.
- revitalization and redevelopment of existing developed areas.
- development in higher densities, physical as well as functional.
- compact development ñ including high densities; urbanization contiguous to existing urban areas; clustering mixed use development ñ combining land uses to provide access through propinquity, reducing trip lengths and facilitating walk and bike trips.
- transit-oriented development ñ providing for higher densities and higher intensity usages within walking distance of transit.
- transit, bike, and pedestrian-oriented design ñ providing for comfortable, safe, convenient access through site design and street lay-out.
- to realize the potential for better coordination, some authors mention the importance of fiscal measurements so that users pay the real costs of mobility. This includes costs of owning and driving cars and the costs of parking spaces. Some of the authors in this issue point to difficulties in achieving land use transportation coordination and relate this partly to the low proportion of the social costs paid by car users. At the current price levels households and firms hardly take transport costs into consideration when making spatial choices about where to locate.
- other measures. These include regulatory methods of planning, including influencing firm locational decisions such as being carried out in the Netherlands and referred to as the "ABC policy". According to this policy firms with many employees per square meter should be located near public transport nodal points, whereas firms that do not have many employees and generate much goods transport by road should be located near motorway exits /access points. Cervero mentions the development of "Location Efficient" mortgages in the USA as a financial incentive to "level-the-playing-field". The idea is that households trade-off location and travel costs against overall housing costs in a way which looks at the budget for both housing and transport. Hence, households located in areas with lower transport costs should be allowed to borrow more compared to their

incomes.

A number of reasons can be given for why it is so difficult to achieve a better coordination between transport and land-use policy making. Firstly, Van Wee (2002) states that not only travel behavior related indicators but also other indicators are relevant to evaluate possible policy options, including indicators related to accessibility, the option value, i.e. the value that people attach to the possibility of having access to a good or service, even if they do not use it, the consumers surplus of travel, safety, the valuation by people of residential, job and other locations, financial aspects and the robustness of the land-use transport system. Secondly, it is difficult to use an evaluation methodology to integrate impacts on these indicators. Cost-benefit analyses, or multi-criteria analyses, of land-use policies could lead to a different answer, but attempts to make up such an evaluation got stuck on operational problems. How can one determine the costs and benefits of variables which cannot easily be measured, for example? And what value does one ascribe to more subjective aspects, such as the quality of the environment in which people live and work? These are a number of questions to be addressed in future work regarding the desirability for better coordination between land use and transport. Thirdly, and partly related to the second reason, there is, to a certain degree, an institutional problem. Transport planning takes place at different levels of government, whereas land-use planning is predominantly a local activity. Land-use policies are influenced by many other interests than transport. Since transport-planning systems are organized differently from land-use planning, it is rather difficult to coordinate. This institutional problem is further complicated by the need for a more extensive evaluation framework for land-use policies, as mentioned above. For example, many politicians are committed to the provision of housing according to the expected needs of individual households. Transport is only one aspect of importance for decisions with respect to housing policies, including densities. This implies that more work needs to be done in the area of the organization of land use and transport coordination.

Fourthly, planners and transport professionals use different languages leading to communication problems. For example, many transport professionals frequently discuss specific projects, whereas planners are concerned with more general spatial strategies designed to achieve certain spatial qualities. New organizational structures need to be found to allow practitioners in the two domains to communicate. Finally, in many countries potential benefits of careful transport land-use integration will often not become evident until some time has passed, often a period of about ten years or so, because land-use developments for the next decade are often already in the pipeline, and for an even longer period it will be difficult to identify and measure the benefits unambiguously. This is inherently at odds with political systems that demand short-term payments.

#### **4. Conclusions**

The contributions in this issue reflect that considerable attention has been paid to the question whether land-use strategies could result in a reduction of car use and stimulate the use of transit and slow modes. Most contributions show that indeed positive effects are to be expected, although there is substantial variation in the outcomes. Results of a meta-study by Cervero (2003, this issue) show that the effects are small but significant.

A number of reasons for the variation of outcomes can be identified, including type of data used, research methods and indicators used to operationalize effects. In addition, the context in which land-use planning takes place is considered to be important by some authors. Cervero (this issue) states that the costs of using the car are set too low. He implies that land-use effects are swamped by the price effects. These results suggest that land-use planning may be considered a precondition for achieving desired effects of other transport policies that may affect travel behavior (Wegener and F, rst, 1999). For example, if the area around a possible new railway station is built up intensively, the impact of building the new railway station on travel behavior will be greater. Therefore, if land-use and transport policies are well coordinated, the scene is set for providing opportunities for transport policies that will affect travel behavior. In addition, individuals affected by such transport policies may be less opposed to such policies since they are able to choose alternatives. This conclusion is confirmed by several studies in which it is shown that price elasticities are higher in urban areas than in rural areas (MuConsult, 2000). This stems from more substitution alternatives being available to urban residents.

Challenging areas for further research have been identified here. In particular we find it important to improve the behavioral basis of the research. Too much work relates land-use characteristics without proper theories with respect to the behavior of individuals in space. In addition, most work relates to the effects of land-use planning on travel behavior, rather than to effects policy makers are also interested in, such as costs and consumer preferences. Finally, institutional barriers may require much more work to be done to break down the barricades and actually realize better coordination in practice.

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