Factors Influencing the Composition of the Urban Transport System in the Year 2030

A Panel Analysis of Experts' Opinions

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Abstract

The future sustainability of the urban transport system is largely determined by the technological composition of and measures introduced in the system. This composition is dependent on many background factors. This paper investigates this relationship by means of a panel analysis of experts' opinions on developments of background factors and scores attached to the importance of transport modes in the year 2030; in addition, the model also includes personal features of the respondents. The main findings are that: a reversal of the individualization has a negative impact on several types of modes, which may be explained by a lower mobility level; the main decision level influences the importance of new and collective transport modes and the urban spatial organization has also a clear impact on the importance of collective modes. It is concluded that when governments wish to reduce the external costs of urban transport, developments in society, the spatial organization and the institutional environment - as well as general policies, other than transport oriented but influencing these developments - have to be taken into account by composing urban transport policy packages.

1 Introduction

Transport has become a main economic sector in our 'mobile' society; the external costs of current mobility behaviour are at the same time rising rapidly, and may be as high as 5% of GDP (Verhoef, 1994). Many measures have been implemented in Western countries to reduce these external costs, and these have often been rather successful. The introduction of catalytic converters, better composed fuels and strict emission targets, for example, have largely reduced the emissions of gases at the local and regional level; in this way the living conditions in many Western cities have been largely improved (Gwilliam and Geerlings, 1994). At the same time, many problems remain unsolved. CO_2 emissions caused by transport are still rising rapidly; the same holds for the increasing level of congestion caused by the rising mobility rates.

A blend of options and measures is necessary to reduce the external costs of transport in a substantial way. It should be acknowledged at the same time however, that some options are more acceptable and preferable than others. In general it appears that technological solutions are more acceptable than behavioural solutions.

Also urban transport causes high external costs (Hart, 1994). Metropolitan areas continue to be more productive and innovative growth poles than rural regions; at the same time, the spatial area covered by large metropolises has largely increased resulting in a more diffuse spatial structure. Also a trend of suburbanization took place, while car ownership and car use rose dramatically (Biéber et al., 1994). The future of cities is largely dependent on transport accessibility, while at the same time transport externalities may erode the quality of life in cities.

It is clear that the future sustainability of the (urban) transport system is largely determined by the technical composition of and measures introduced in the transport system. This composition is dependent on several background factors which are found in many scientific and disciplinary fields. This paper will analyze the extent to which a set of background factors influence the composition (including measures and modes) of the urban transport system in Western Europe in the year 2030 by means of statistical analysis of opinions of Dutch transportation experts. In particular, we will estimate a panel ordered probit model that allows for unobserved individual-specific effects. Hence, in our estimation we control for interdependencies in the error structure over "components"[1]. Recently, the issue of autocorrelation in panel models has also been addressed by Ouwersloot and Rietveld (1996) in the context of discrete choice models[2]. They recommend investigation of the seriousness of the autocorrelation problem in the context of stated choice modelling by applying methods that take account of the correlation structure. This will be done in this paper by

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[1] In the panel data literature, the relevant term is "period" since one usually deals with modelling repeated observations over time.

[2] They apply an estimation proposed by Chamberlain which avoids maximum likelihood techniques to stated choice data with repeated observations. In their empirical application, the dependency of the error terms across "states" appears to play no significant role.

employing Ordered Probit Maximum Likelihood methods to estimate a panel model for values attached to several components of the future transport system.

The structure of the paper is as follows. In Section 2 an analysis is made of technological options and policy measures for making the urban transport system more environmental friendly, as well as of background factors influencing the composition of the system. Then expectations and desires of Dutch transportation experts on background factors and the urban transport system will be analyzed in Section 3. Section 4 contains a statistical analysis of the impact of the background factors on the transport system by means of the above mentioned panel model. In Section 5 some conclusions are drawn.

2 Possibilities for Reducing Externalities in the Urban Transport System

There are several technological options and policy measures which can be introduced to reduce the external costs of urban transport. Most policies focus on reducing car use and stimulating the use of public transport. In several cities also cycling is promoted as an alternative for car use. However, there are many problems for making these policies successful. First, travel distances are small in urban areas. About 50% of the car trips for example are smaller than 5 kilometres; it is very hard for public transport to compete on such short distances, because of the long waiting times and the distances from and to the nodes (Rienstra et al. (1996). Furthermore, the profitability on such short distances is low because of the high fixed costs, the low average speed, etc.

The composition of the urban transport system can be split in policy measures, current modes and new transport modes. These groups will be discussed in some more detail in the remainder of this section, followed by an analysis of background factors influencing the composition of the system.

Improvements of current modes

Improvements of the current private car system may improve the sustainability of the transport system, since the private car is causing most external costs. It is expected that the energy consumption of conventional fuel cars may decrease by 15-22% per kilometre in the period 1990-2000, after this period an autonomous efficiency improvement up to 25% may be expected until the year 2030 (Rienstra et al., 1996). The expected mobility growth, however, is at least that high, so that there will be no (net) reduction of energy use by the car system.

Also other improvements of current modes may be introduced. Collective modes can be made more energy-efficient and there are several experiments with the introduction of new fuels in the bus system. Increasing the level of recycling has also become a main objective in both car industry and the public transport sector. It is generally acknowledged, however, that improvements of current modes will not be sufficient to achieve a sustainable transport system.

Policy measures

Many policy measures are or might be introduced to reduce car use in urban areas (see e.g., OECD/ECMT, 1995; Pharoah and Apel, 1995). A main policy introduced in many - mostly North-Western European - cities is the introduction of parking measures by increasing parking tariffs and reducing the number of parking places. These policies aim to reduce car use and to stimulate people to park the car at the border of cities.

A rather new policy is the introduction of road- or cordon pricing (Verhoef, 1996). In several Scandinavian cities such a system is already introduced. When a car passes a certain point by entering the city centre, an amount of money is automatically paid by the owner of the car. In this way, the variable costs of car use increase and the use may diminish.

Other policies introduced in several cities (such as, for example Amsterdam) are a reduction of the capacity of the road infrastructure in cities, stimulating car sharing projects, park and ride systems and fiscal measures to stimulate public transport use or to reduce car use. Although these measures may have an impact on mobility levels and modal split, the mobility level and car use are still rising. It is clear, however, that these measures may contribute to the achievement of policy targets, although it should be acknowledged that such measures also have adverse effects on the functioning of the local economy (e.g., the accessibility of city centres may decrease).

New technological options

Besides improvements of current modes and the introduction of measures, also new modes may be introduced in the urban transport system (Rienstra et al., 1996). An option which may be introduced for short distance traffic is the **electric car**, which can replace some of the existing car traffic. The main technical problem of electric cars is the battery, which limits the driving range to 70-100 km, allows only a moderate maximum speed (70-100 km/h), has a long charging time (on average, 8 hours) and a high price ($2.500 - $10.000); the battery has to be replaced 1 to 3 times during the life time of an average car. While it can be expected that these problems will be relaxed, it is not likely that they will be solved completely. Also other fuels, like liquid hydrogen or bio-fuels may be introduced in the car system. The potential of these options is not yet clear, however.

A second option, which may be introduced in urban areas is the **people mover**. In principle, people movers use very small vehicles, which may be driven automatically, so a large part of the labour costs of the operation of a public transport system may be saved. A high frequency is possible, which reduces the waiting times in comparison with current urban collective modes. People movers are until now only found in airports and large amusement parks. Problems with the introduction are primarily related to the high construction costs, which makes them not attractive for private companies.

In recent years more attention is paid to the advantages and disadvantages of constructing **subterranean infrastructure** for conventional modes. The emissions of gases will not be diminished by this technology, but several other externalities, like segmentation of landscapes, stench, noise and visual annoyance may be reduced to a large extent (compared to building more surface infrastructure). It is clear however, that constructing subterranean infrastructure is very expensive, which makes it only attractive in areas with a high value.

The future composition of the transport system will be dependent on many background factors, which will be discussed next.

Background factors influencing the urban transport system

Several background factors, which are important for the future composition of the urban transport sector can be distinguished. These factors emerge from different perspectives and scientific disciplines and may influence the composition of transport systems largely.

Until now new transport modes have failed to compete with the existing car and air technologies, which makes investments in these modes **unprofitable**. The low costs of conventional fuels, along with the present level of service make new options often not attractive for investors and users. Collective modes of travel are often dependent on a high occupancy rate and therefore need a high density of demand. The fixed investment costs (mainly infrastructure costs) are relatively high, while the capacity is very large (Wunsch, 1996). Therefore, it is necessary to divide these costs among many users. Another problem is the temporal distribution of demand and the high level of demand in peak hours, resulting in an unprofitable excess capacity outside these hours (Nijkamp and Rienstra, 1995).

The future **spatial organization** is of major importance for the efficiency of a future transport system. The importance of a balanced organization of residential and working areas for reducing transport demand is widely recognized (see for an extensive literature review: Anderson et al., 1996). At the urban scale compact cities may be viewed as supporting the success of collective modes, because in such a spatial structure there are voluminous and concentrated traffic flows, which may make such modes more competitive and profitable. Moreover, there is less space available, which may have a negative impact on private car use (Nijkamp and Rienstra, 1996). The well-known study of Newman and Kenworthy (1989) has also shown the negative relation between gasoline consumption and population density in urban areas.

Institutional factors are also important for the composition of the system. Supportive governmental policies (at the European as well as at lower scale levels) affect the possibilities and competitiveness of transport modes. Governments determine most of the user costs by subsidizing and taxing modes and fuels. It is also the government which plans, implements and finances most infrastructure. Another type of influence is found in steering private R & D, which the government can stimulate by subsidies, public acquisition and funding research programs. Also the management of transport systems (especially collective modes) may be regarded as an important factor (Costa, 1996).

Other factors which influence the composition of the urban transport system are **social-psychological** in nature. The social acceptance and adoption of new options is of major importance, especially when entirely new infrastructure has to be con structed. Often in a choice process to use a transport mode, the advantages of known modes are overestimated (mostly the private car), while the advantages of not-known modes (e.g., public transport) are underestimated. Psychological barriers may also play a role. When trains are driven unmanned or in long tunnels - e.g. the Channel tunnel - people may feel unsafe, the same may hold for unmanned people movers. Other psychological factors may be associated with a preference for privacy, comfort and security; in general these factors are favourable for car use and have a negative impact on the use of collective modes (Rienstra et al., 1996).

From this analysis it becomes clear, that the future composition of the urban transport system may be influenced by many background factors. This makes it interesting to analyze the extent to which this is the case by investigating the judgements of expert - which may be regarded as a group which may have most insight in the importance of these factors. This will be done by means of a statistical analysis of opinions of Dutch transportation experts on the future of urban transport in relation to several of these background factors. First, the data set and some general results will be discussed; in Section 3 a more sophisticated statistical analysis will be carried out.

3 The Data Set

In the previous sections the relation between background factors and the composition of the urban transport system has been discussed from a general point of view. In the present section, we will present opinions of Dutch experts on expected and desired developments of some of these factors; these will be used as explanatory variables in the statistical analysis of Section 4.

To investigate the future of transport a postal questionnaire survey has been sent to Dutch transportation experts; the reference year is 2030. For a detailed description and accounting of the questionnaire used we refer to Nijkamp et al. (1997); here we only note that the response rate was 36% (n = 271), and that the response gave a representative picture of the sample. In the questionnaire three types of questions were included:

- **personal features** of the respondent; e.g., age, affiliation, type of education);
- opinions on several **background factors**; these may - as discussed above - influence the mobility level, the modal split and the introduction of new transport modes and measures. In these questions it was possible to indicate both expected and desired future developments;
- values to several **policy measures, existing transporting modes and new transport modes**. An expected and desired score (ranging from 1-10; a way of ranking which is common in the educational system of the Netherlands) could be given to the measure or mode which indicates the importance in the year 2030 compared to the current importance. A score of '6' may in this respect be regarded as the score which indicated that the importance is about the same as today.

Next, some descriptive results of this survey on the background factors and the urban transport system will be discussed in the next subsections.

3.1 General results

The frequency distribution of the main background factors which may influence the future composition of the urban transport system - which are also used in the analysis of Section 4 - is presented in Figure 1.

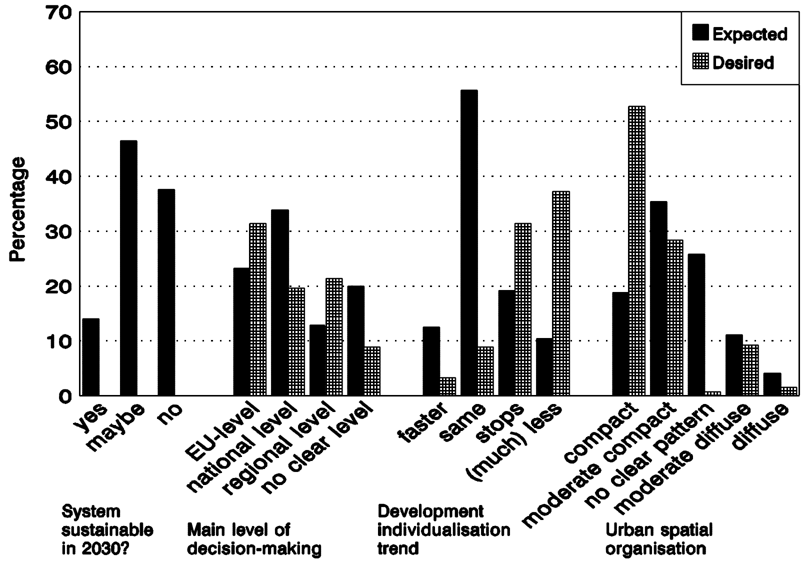

Figure 1 Expected and desired future developments of background factors
Note: n = 271

More than 80% answers 'no' or 'maybe' on the question whether the transport system will be sustainable in the year 2030, which can be regarded as a rather pessimistic view.

The institutional level at which the main decisions are taken may be important for the introduction of measures and the development of new technologies. In a centralized decision-making process, developments may be coordinated which avoids free rider behaviour of countries and regions, while also economies of scale may be achieved. On the other hand, a centralized system may be less efficient, because it may be more bureaucratic, while local and regional characteristics are not taken into account in the decision-making process. The respondents expect the main decisions to be taken at the national level, while a large minority expects that the European Union (EU) will gain more influence. Apparently, the majority expect that current trends of the EU gaining more influence will largely stop in the future. Striking is that in the desired situation the influence of national authorities should be much smaller, while the EU and the regional level should become more important.

The majority expect the individualization trend to be continued at about the same speed as is the case nowadays. This trend may lead to smaller households (and in this way also to a more diffuse spatial organization), an increase in mobility levels (more recreative trips), to less focus on social issues (like the environment) and as a result to more car use (Nijkamp et al., 1997).

As discussed above, a compact urban spatial organization may be an important success factor for collective modes. This concept appears to be very popular among Dutch transportation experts. 44% of the respondents expect that there will be a moderate compact urban development, so that the policy to achieve more compact cities will largely succeed. As a result, the trend towards 'green suburbs' will largely stop. Striking is that only 14 per cent expects a more diffuse spatial organization, a share which is smaller than what might be expected beforehand because of past spatial diffusion trends. When the desired developments are analyzed, a majority of the experts is in favour of a compact urban structure, while a large minority wishes a moderately compact organization. Only a small group thinks that a (moderate) diffuse spatial organization is to be desired.

3.2 The urban transport system in the year 2030

As discussed above in the questionnaire a distinction is made between policy measures, improvements of current modes and the introduction of new transport modes by giving a score (ranging from 1 to 10) on the importance of a measure or mode in comparison with the current importance. The results are presented in Figure 2.

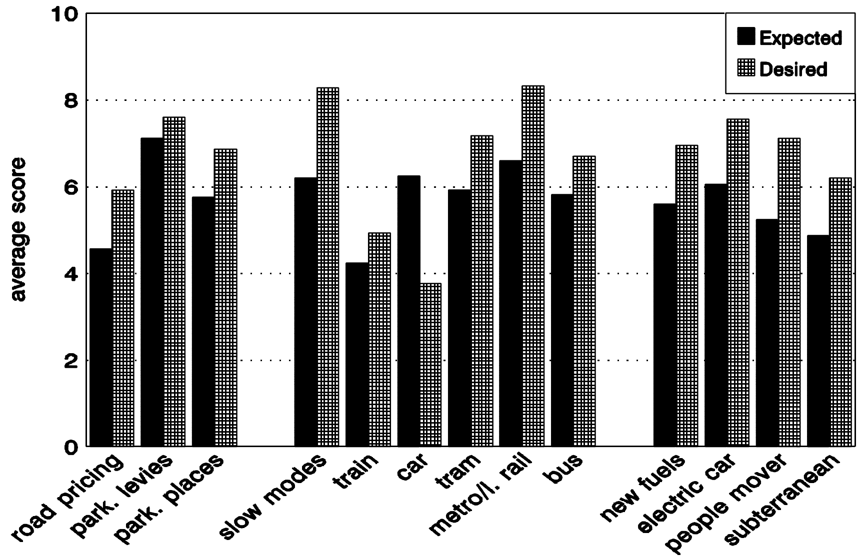

Figure 2 The average scores on measures and modes in the urban transport system

Notes: 1) Score 1 - 10; 1 is lowest, 10 is highest
2) n = 254-266

Expected and desired policy measures

The highest score on expected policy measures is found for an increase in parking levies which may make the use of private cars less attractive. The second highest score is given to reducing the number of parking places, which is expected to be introduced to a smaller extent than an increase in parking levies. Road pricing (or in cities maybe cordon pricing) is not expected to be introduced at a large scale, given the score far below 5.

The scores for the desired measures are all higher than for the expected ones, although for the parking levies this score is just a little higher. It is still the highest score however, with a reduction of the number of parking places on the second place. The new technology of road pricing gets also a much higher score, viz. above 6, so it may be concluded that also this option is desired to be introduced at a reasonable scale. As expected, the standard deviation of the scores on this measure is the highest, so that the experts disagree most on this measure.

Expected and desired use of conventional modes

The scores by the experts on the expected use of conventional modes fluctuate all (except for the train) around 6. The highest score is assigned to metro and light rail systems, which are expected to be introduced at a larger scale than is the case now. This is a quite likely situation, since for example in several Dutch cities (Amsterdam, Rotterdam) new links are under construction. For the remainder, the car and slow modes (cycling, walking) are given the next highest scores, while the bus and tram get somewhat lower scores. It seems plausible that the score for the train is somewhat lower, since this mode is not in the first place meant for urban transport, although the train is sometimes also used as a mass transit system.

When the desired scores are analyzed, it appears that all modes are getting higher scores, except the private car, which is plausible because of the high external effects of this mode. Especially the slow modes and the metro/light rail system get now very high scores of above 8, implying that the modal split in urban traffic should change in favour of these modes. Also the tram and bus get relatively high scores, while the score of the private car is here even below 4, so that a much lower modal share is regarded as desirable for the conventional car.

Expected and desired use of new modes and technologies

Respondents were also asked to assign scores for several new technologies and modes which might be introduced until the year 2030. The highest expected score is found for electric cars, although this score is only about 6, so that only an intermediate large scale introduction is expected. The second highest score is found for new fuels (e.g., liquid hydrogen), which means again an improvement of the position of the private car. The people mover is getting a rather low score, while subterranean transport is expected to be introduced at only a small scale. So especially improvements of the private car are likely to be introduced, while the other developments are having far less chances in the opinion of experts.

The desired scores are all higher than the expected scores. Thus, it is desired that more of the new modes and technologies should be introduced than is at present expected. The electric car is again getting the highest score, followed by the people mover. Also somewhat higher, but still low scores are given to the introduction of new fuels and subterranean transport by car and train.

Conclusions

From the results discussed above, it may be concluded that the private car and its improved versions are expected to dominate the urban transport system (also) in the future, although various policy measures will be introduced to make the car less attractive. It appears that these developments are expected to occur despite the fact that the urban spatial organization is expected to become moderate compact.

In the desired situation however, there is more emphasis on collective modes, while also more and far-reaching measures should be introduced to make the car less attractive as the dominant mode. Several trends in the background factors influencing the urban transport system should be reversed in order to reinforce this modal shift.

In the next section, the impact of the above discussed background factors on the composition of the urban transport system will be investigated in a statistical way.

4 A Statistical Analysis of Experts' Opinions

In this section, a model will be developed in order to examine the relationship between the *importance attached by experts* to components (policy measures, current and new modes) of the urban transport system in the year 2030 and the experts' opinions on the development of the above discussed set of *background factors* influencing the future transport system. In addition, the model will control for the impact of several personal features of the experts (employer, age, education type, gender), which may show differences in opinions between several subgroups. First, the statistical model will be described; next, the results of the estimations will be presented.

4.1 Description of the model

The data to be used to estimate this model consist of expected and desired levels for the variables of interest, namely, the components of the system (y_1, y_2, …, y_{13}) and a selected number of background factors (Z). The components of the system can be grouped systematically into the following - non-overlapping - classes (see also Section 2) S_l, $l = 1,2,3$:

(1) policy measures
(2) current modes
(3) new modes

As regards the sub-grouping of modes into current and new modes, one could also apply an alternative decomposition, namely (2") individual modes and (3") collective modes[3]. This allows us to investigate both the impact of the background factors (Z) on the introduction of technical innovations in the transport system (composition (1), (2) and (3)) and the impact on the achievement of a modal shift towards collective modes (composition (2'') and (3'')). As discussed in Section 2, these are main aims of transport policies. Hence, we postulate the following relationships:

$$\begin{aligned} E(y_k) &= f(E(Z)\,|X) \\ D(y_k) &= g(D(Z)\,|X) \\ \forall k \in S_l, l &= 1,2,3\ (\vee\ l = 2'', 3'') \end{aligned} \qquad \textbf{(1)}$$

with E = expected value, D = desired value, l = number of sub-groups, and X a set of features of the experts.

In principle, the functions f and g should be the same since they both reflect the underlying relationship between background factors on the one hand and the importance attached to components of the system on the other hand (while controlling for personal features). A comparison of the estimated impact of Z on the importance attached to subgroups of components either in expectations or desires may reveal whether this is actually true (we will come back to this issue later on). At this stage, we also like to emphasize that the model specified in (1) has a reduced form nature and will therefore not be able to reveal underlying structural (causal) relationships such as the impact of policy instruments on the use of modes or substitution-effects between modes. However, the model enables us to identify the main determinants of the components (*including* policy measures) of the future urban transport system.

As a result of the discrete, ordered nature of the dependent variable of our model ($E(y_k)/D(y_k$ are measured in scores ranging from 1 to 10), we will use an ordered response model (see Maddala, 1983) to estimate the parameters of interest for *each* subgroup (l). Consequently, this type of model has to be adjusted to take into consideration that the data related to a subgroup has a panel structure. For example, the same group of experts have answered questions on the importance attached to a set of new modes. In other words, we have repeated observations of individuals on scores related a subgroup of components. To control for this phenomenon, we modify the (cross-sectional) ordered-response model as a panel-model that allows for (i) component-specific effects *and* (ii) individual-specific effects. The component-specific (or fixed) effects are included to control for general shifts in the evaluation of experts across components. The inclusion of a (random[4]) individual-specific effect may prove

[3] Note that the new mode "subterranean" is not classified when using the distinction between individual and collective modes.

[4] Notice that the inclusion of fixed-effects for the individuals as well clearly leads to a overparametrization of our model.

to be essential for our data on scores since these values are attributed to components of the (future) transport system in comparison to its current importance (unknown to the researcher). Hence, it is possible that individuals differ in their reference value when repeatedly providing values to (a set of) components. In that case, we may observe low values (on average across components) for some people while for others we may obtain - on average - rather high values.

Hence, we have the following panel ordered-response model for scores given to the set of components in subgroup l[5]:

$$E(y^*_{ik}) = \delta_k.D_k+\beta.E(Z_i)+\gamma.X_i+\epsilon_{ik} \ , \ k\in S_l$$
$$\epsilon_{ik} = v_i+\mu_{ik} \qquad (2)$$

with

y_{ik} = score (value: 1,...,10) given by expert i on component k,

y_{ik}^* = the underlying response (or latent) variable, related to y_{ik} in the usual way: it belongs to the jth category if $\alpha_{j-1} < y_{ik} < \alpha_j$ (j=1,2,...,10), $\alpha_0 = -\infty$ and $\alpha_{10} = \infty$, so we have $\Pr(y_{ik}=j) = \Pr(\alpha_{j-1} < y^*_{ik} < \alpha_j) = \Phi(\alpha_j - y^*_{ik}) - \Phi(\alpha_{j-1} - y^*_{ik})$; were Φ is the cumulative standard normal;

and

Z_i = a vector of variables measuring the expected developments of background factors as provided by individual i,

X_i = a vector of features related to individual i;

δ_k = a parameter related to component k (D_k=1 if a value is given to component k, and 0 elsewhere)

v_i = a random (individual-specific) error term

μ_{ik} = an error term, distributed normal (0,1)[6]

Estimating this Panel Ordered-Probit (POP) model[7] generates our parameters of interest (ß, γ and δ_k[8]) and also yields the α-parameters (the set of constants) and the parameters related to the distribution of the random term v, h(v). When we assume an arbitrary, discrete (two-points) distribution for v (with mass-points v_1,v_2 and corresponding probabilities p_1,p_2) we can estimate this comprehensive model by

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[5] For expositional purposes we will show the panel model for data on expectations only since the data on desires can, of course, be dealt with in the same way.

[6] In ordered-response models one needs to fix the variance of the error term to ensure identification of the model.

[7] In the literature, this type of model has also been referred as a random effects probit model (see for an overview, Maddala, 1987)

[8] Obviously, to ensure identification of the δ's, one has to be fixed at zero.

means of maximum likelihood methods[9].

The individual contribution of the scores (related to subgroup l) to the likelihood function L then becomes equal to[10]:

$$L_i = \int_v \prod_{k \in S_l} Pr[E(y^*_{ik} \mid v)]\, h(v)\, dv =$$

$$p_1 . \prod_{k \in S_l} Pr[E(y^*_{ik} \mid v_1)] + p_2 . \prod_{k \in S_l} Pr[E(y^*_{ik} \mid v_2)]$$

Note that the difference between v_1 and v_2 will be estimated, because the model already includes a set of constants (α), and that we specify the probability p related to the level (v2-v1), as $1/(1+\exp(\tau))$ to let p be between the range [0,1]. In this way, the model can be estimated for the components in the distinct groupings. We delete the observations with missing values on one or more components and as a result obtain samples of 198 and 193 observations for the expected and desired data, respectively. For several models however, it appears to be impossible to obtain the results of the full model because the Maximum Likelihood computer program (written in Gauss) does converge, but fails to produce the covariance matrix (that is, the inversion of the Hessian fails). Therefore, we start the following *backward* model selection procedure when this estimation problem occurs:

(1) select those variables that have the smallest values in absolute size;
(2) re-estimate the model without these variables;
(3) when necessary, continue with deleting (the subsequent smallest) variables until the Hessian can be inverted;
(4) verify whether the restrictions ultimately imposed hold by applying Log-Ratio tests. The LR test statistics T_1 will be distributed X^2_k (with k equal to the number restrictions). Moreover, we also test our final specification (for each subgroup) against a baseline model (i.e., without explanatory variables) by means of the LR test statistic T_2. Both test statistics (T_1, T_2) are presented in the bottom line of each Table.

The variables which have been deleted in this way will be presented in the tables by '--'. The LR-tests on the restrictions imposed (T_1) appear to hold at the usual level of 5% in all models, with the exception of the model for desired values on individual modes; their values will be presented in the tables, but will not be discussed any further. We also observe that our final models usually (statistically) outperform the

[9] Alternatively, one could assume a normal distribution for the error term v (see Heckman and Willis, 1976) and use an efficient computer algorithm (developed by Butler and Moffit, 1982) to estimated this random effects probit model by means of Maximum Likelihood methods. We also apply a Maximum Likelihood estimation procedure, but prefer to use the discrete (mass-points) distribution since it is flexible and does not require any strong assumption on the distribution of the error term (such as normality).

[10] This model is similar to the one used by Gorter and Kalb (1996) in which they use data on applications for jobs across individuals (unemployed job seekers) over time.

baseline models (as shown by T_2).

Moreover, we further investigate the estimation problem mentioned above by estimating ordered probit models as well (so thereby excluding the individual-specific effects). The results of these more simplified models show that the same problem (singularity of the Hessian) is encountered again. This strongly suggests that it is caused by a lack of 'explanatory power' of the variables in some of the models.

A final issue that deserves attention is whether our results are robust against the specification chosen for v (two-discrete mass points). To examine this, we re-estimate our models with additional mass models (as much as needed from a statistical point of view). The results show that the fit of the models do usually not improve. In case the extension towards more mass-points does lead to a statistical improvement of the model, the estimation results with respect to the explanatory variables appear to be quite robust. So it can be concluded that the individual specific effect is taken into account in a (statistically) proper way by using an arbitrary two mass-points distribution.

In the next subsections we will present the results of the two types of classification.

4.2 Results of the estimations for policy measures, new and existing modes

In this subsection, we will present the results of the POP model (both for expected and desired answers) for the classification into policy measures, new and existing transport modes.

The influence of background factors on the importance of policy measures

First, we discuss the influence of background factors on policy measures; the results for both the expected and desired case are presented in Table 1.

As also appeared in Section 3.2, when considering the sample means of the scores, road pricing is both expected and desired to be introduced the least, while 'increasing parking levies' receives significant higher scores (ceteris paribus).

The background factors included in the analysis do not have a lot of impact according to the experts. In the model using expected data (the 'expected case'), the individualization trend at current pace is associated with lower scores when confronted with an accelerated individualization trend, which is not conform the expectations beforehand; the same holds for an individualization trend which stops in the desired case. In the latter case, a situation without a clear main decision level receives significant higher scores than in a centralized decision making process, which can be explained by the fact that measures are taken at the most appropriate level (subsidiarity principle).

In the expected case, personal features of the respondents do mostly not have a significant impact on the scores attached to the policy measures. The only exception is found for university employees, who give significant lower scores to the introduction of policy measures compared to ministry employees. In the desired case, however, more significant personal features are found. Employees

Table 1 Estimation results of the impact of background factors on the importance of policy measures

	Expected values		Desired values	
Variable	**Coeff.**	**T-value**	**Coeff.**	**T-value**
Components (D)				
road pricing	-0.56	-5.33[4]	-0.42	-3.92[4]
parking levies	0.71	6.64[4]	0.35	3.27[4]
Background factors (Z)				
individ.: present pace	-0.18	-2.17[4]	-0.05	-0.26
individ.: stops	-0.10	-1.64	-0.40	-2.01[4]
individ.: reduces (largely)	0.01	0.17	-0.04	-0.20
decision level: national	--	--	-0.15	-0.98
decision level: regional	--	--	-0.07	-0.35
decision level: not clear	--	--	0.36	1.92[5]
system sustainable: maybe[6]	--	--	..	..
system sustainable: no[6]	--	--	..	..
Personal features (X)				
education: economist	0.03	0.16	-0.04	-0.21
education: planner	-0.23	-1.20	0.17	0.88
education: technician	0.15	0.93	-0.17	-1.11
employer: regional/local	-0.18	-0.08	-0.44	-2.25[4]
employer: consultancy	-0.17	-1.03	-0.47	-2.62[4]
employer: university	-0.45	-1.82[5]	-0.41	-2.01[4]
employer: transport firm	-0.24	-1.36	0.02	0.16
gender: male	--	--	-0.88	-3.55[4]
age: 30-40 years	--	--	0.33	1.79[5]
age: 41-50 years	--	--	0.37	1.78[5]
age: > 50 years	--	--	0.12	0.49
Random effect				
v2-v1	1.28	6.53[4]	1.21	8.64[4]
τ	-0.94	-1.44	-0.40	-0.86
Mean log-likelihood (LL)	-6.213		-6.029	
Mean LL full/ baseline model	-6.202	-6.252	-6.029	-6.162
Test-statistics T_1, T_2	4.4[4]	15.7	..	50.2[4]

Notes: 1) The reference values are: policy measures: reduction of parking places; education: traffic engineer; employer: ministry; gender: female; age: < 30 years; individualization trend: accelerates; main decision taking level: EU; system sustainable (expected)?: yes.
2) The coefficients and t-values of the constants (α-vector) are not presented in the Table.
3) The number of observations is equal to 198 (expected data) and 193 (desired data).
4) Significant at the 5% level.
5) Significant at the 10% level.
6) 'Sustainability of the system' is only included in the 'expected' model.

of universities, local and regional authorities as well as consultants desire less measures than the ministry employees, the same holds for men compared to women. The youngest age category is significantly less in favour of policy measures compared to the medium categories; the oldest category does not give significant different scores, however.

In both estimations, there is a substantial impact of the individual specific effect as reflected by the highly significant value of (v2-v1). The value of τ is much less precisely estimated, but reveals that - in the expected case - roughly 75% of the experts prefer to give higher scores (on average across components) than the other 25%. It can be concluded from the distances between the α-values (not presented in the table) that the predicted difference between the expected value of both groups is at least 3 (full) points (ceteris paribus). Clearly, the inclusion of a random individual-specific effect is of crucial importance in our model.

The influence of background factors on the importance of current modes

The next model to be estimated is that of the impact on current modes; the results are presented in Table 2. A lower score for current modes can be interpreted in two ways: first, it may mean that the current modes are replaced by new ones; second, the general mobility level may be lower.

The scores for the distinct modes (ceteris paribus) are conform the analysis in Section 3.2; especially the difference in scores for the car in the expected and desired case is remarkably.

In the expected estimation only the main decision level of local/regional authorities has a significant negative impact on the importance of existing modes. In the desired case it appears that a main decision level of the national government has a positive impact on the importance of current modes. Taking these findings together, it becomes clear that, when the main decision level is the EU or the national government, this has a negative impact on the reduction in the mobility level and/or the introduction of new modes; the opposite holds for regionalization of decision making. The other background factors do not have a significant impact in the expected case. In the desired case, however, more significant variables are found. Less individualization will result in less importance of current modes, which may be explained by a resulting lower mobility rate.

No significant differences are found in the 'expected' scores of several subgroups of respondents according to their personal features (that is, their opinions do not differ). In the desired case some significant differences are found: economists and men give significant lower scores to current modes, while employees of transport firms (especially public transport firms) give significant higher scores to the importance of current modes.

As was the case in the previous estimation results, there is again a significant impact of the individual specific component, in particular in the expected case.

Table 2 Estimation results of the impact of background factors on the importance of current transport modes

	Expected value		**Desired value**	
Variable	**Coeff.**	**T-value**	**Coeff.**	**T-value**
Components (D)				
cycling/walking	0.28	2.83[4]	1.14	10.42[4]
conventional trains	-0.84	-8.22[4]	-0.81	-7.58[4]
conventional cars	0.33	3.35[4]	-1.55	-13.42[4]
trams	0.13	1.38	0.34	3.24[4]
metro/light rail	0.63	6.33[4]	1.15	10.50[4]
Background factors (Z)				
individ.: present pace	--	--	-0.16	-1.16
individ.: stops	--	--	-0.27	-1.74[5]
individ.: reduces (largely)	--	--	-0.33	-1.89[5]
decision level: national	-0.05	-0.48	0.18	1.78[5]
decision level: regional	-0.31	-2.35[4]	-0.02	-0.19
decision level: not clear	-0.10	-0.81	-0.08	0.53
system sustainable: maybe[6]	-0.11	-0.95	..	..
system sustainable: no[6]	-0.18	-1.46	..	..
Personal features (X)				
education: economist	--	--	-0.20	-1.79[5]
education: planner	--	--	0.11	0.90
education: technician	--	--	-0.11	-1.18
employer: regional/local	--	--	0.13	0.85
employer: consultancy	--	--	0.01	0.08
employer: university	--	--	-0.05	-0.36
employer: transport firm	--	--	0.18	1.73[5]
gender: male	--	--	-0.28	-1.78[5]
age: 30-40 years	--	--	-0.02	-0.22
age: 41-50 years	--	--	-0.02	-0.19
age: > 50 years	--	--	-0.12	-0.88
Random effect				
v2-v1	0.99	12.53[4]	0.98	2.04[4]
τ	-0.62	-2.28[4]	1.86	1.18
Mean log-likelihood (LL)	-11.458		-11.160	
Mean LL full/ baseline model	-11.446	-11.483	-11.160	-11.221
Test-statistic T_1, T_2	4.8	10.1[5]	..	23.5

Note: The reference value for the modes is the bus; for other notes see Table 1.

The influence of background factors on the importance of new modes

The next estimation results relate to the importance of new transport modes (se Table 3).

Table 3 Estimation results of the impact of background factors on the importance of new transport modes

	Expected estimation		**Desired estimation**	
Variable	**Coeff.**	**T-value**	**Coeff.**	**T-value**
Components (D)				
new fuels	0.39	3.85[4]	0.39	3.76[4]
electric car	0.68	6.55[4]	0.80	7.52[4]
people mover	0.21	2.02[4]	0.54	5.16[4]
Background factors (Z)				
individ.: present pace	--	--	-0.22	-1.56
individ.: stops	--	--	-0.13	-0.84
individ.: reduces (largely)	--	--	-0.25	-1.15
decision level: national	-0.37	-2.68[4]	--	--
decision level: regional	-0.34	-2.01[4]	--	--
decision level: not clear	-0.33	-1.74[5]	--	--
system sustainable: maybe[6]	-0.25	-1.41	..	..
system sustainable: no[6]	-0.54	-2.95[4]	..	..
Personal features (X)				
education: economist	--	--	-0.19	-1.29
education: planner	--	--	-0.11	-0.77
education: technician	--	--	-0.07	-0.60
employer: regional/local	--	--	--	--
employer: consultancy	--	--	--	--
employer: university	--	--	--	--
employer: transport firm	--	--	--	--
gender: male	--	--	-0.35	-1.78[5]
age: 30-40 years	0.47	2.98[4]	0.10	0.60
age: 41-50 years	0.18	1.10	0.43	2.30[4]
age: > 50 years	0.26	1.24	0.35	1.72[5]
Random effect				
v2-v1	1.28	12.36[4]	1.08	7.64[4]
τ	-0.27	-1.06	0.95	2.30[4]
Mean log-likelihood (LL)	-8.156		-7.886	
Mean LL full/ baseline model	-8.141	-8.203	-7.864	-7.936
Test-statistics T_1, T_2	5.9	18.2[4]	8.5	18.9[4]

Note: The reference value for the modes is subterranean transport; for other notes see Table 1.

Again the order of the coefficients for the distinct modes is the same as was discussed in Section 3.2. Several background factors have a significant impact on the importance of new modes in the urban transport system. A centralized decision-making process is expected to have a positive impact on their introduction, which may be due to advantages of scale and by avoiding free rider behaviour. As expected, the respondents who think the transport system will not be sustainable in the year 2030 give significant lower scores to new modes. In the desired case no significant impact is found for the distinct background factors: the introduction of new modes is apparently not influenced by these factors.

The personal features have little impact in the desired case. The youngest category is compared to the other age categories somewhat more pessimistic about the introduction of new modes in both the expected and desired case. Men also desire less introduction of new transport modes. The education or employer's type do not have any significant impact on the scores given.

Again the individual specific effect in the scores appears to be strongly significant in both cases.

Cross comparative overview

In the opinions of the Dutch transport experts, the impact of several background factors on the composition of the urban transport system in the year 2030 is only present in some cases. A reversal of the individualization trend has a negative impact on the use of current modes in the desired composition, which may be a result of a lower mobility level. Maybe less measures are necessary then, which may explain the negative impact of a reversal in this trend on the introduction of policy measures. In the desired case, mostly no significant impact is found.

The main decision-level is especially important for the success of new transport modes. Centralization may stimulate R & D and a lowering of production costs because of advantages of scale, while at the same time free rider behaviour of urban areas and countries can be avoided. On the other hand, subsidiarity may increase the efficiency of the introduction of policy measures. In the expected case, less significant impacts are found. When there is no clear main decision-making level, measures are wished to be introduced less, while the national government as main authority may have a positive impact on the use of current modes.

The personal features of the experts have only in a few cases an impact on expectations and desires. The youngest age category is somewhat more pessimistic on the importance of policy measures and new transport modes. In all desired cases, men give lower scores than females, which is a striking and unexpected result. An explanation may be that men desire lower mobility levels, so that in this way the distinct modes and the policy measures become less important.

The educational type of the respondents does not have any significant impact on the scores. All scientific disciplines seem to agree in their expectations and desires for the future composition, which is again a striking result. The employer's type has only once a great impact on the opinions of respondents: ministry employees value the importance of the policy measures higher in the desired case than the other subgroups.

In the other estimations the role of employer's type is limited. The youngest age category is less in favour of policy measures and new modes; their expectations do not differ from the other age categories, however. The individual-specific effect, finally has a highly significant impact in all models.

Next, the impact of the background factors will be analyzed in another grouping of the transport modes: a distinction between individual and collective transport modes.

4.3 Results of the estimations on individual and collective modes

The alternative grouping in individual and collective modes allows us to test the impact of background variables on the policy objective of stimulating the use of collective modes. In addition to the factors included in the previous estimations, also the urban spatial organization is included in the analysis.

The influence of background factors on the importance of individual modes

The results of the estimations for individual modes are presented in Table 4.

In the expected case, a significant difference between the scores of the electric car, the conventional car and cycling/walking is not found; only new fuels are getting a significant lower score. The order in scores in the desired estimations are as presented in Section 3.2.

Of the background factors, the compact city appears to be favourable for the individual modes in the expected case (relative to the moderate compact spatial organization), which is not conform our expectations[11]. At the same time, a centralized decision making process at the EU level has a positive impact on the importance of individual modes. Apparently this level is not well suited for making the transport system more collective oriented; these policies should be introduced at lower authority levels. Another unexpected result is that the less sustainable the system is expected to be, the less individual modes are expected to be introduced. Individual modes are generally considered to be less environmental benign (space, waste, emissions, depletion renewable resources), so this result is counter intuitive. In the desired estimation no significant impact of the background factors is found; apparently the importance of these modes is in the desired situation determined autonomously.

The personal features do not have any impact on the importance attached to individual modes. Every subgroup appears to give about the same scores to the distinct modes in both the expected and the desired estimation.

Again, there is a strong individual specific effect in the model based on expectations. In the desired case, the random effect is somewhat smaller, but remains significant.

[11] In an alternative choice set of individual modes we excluded walking/cycling; the results based on expected data were, however, about the same as in the estimation results presented in Table 4.

Table 4 Estimation results of the impact of background factors on the importance of individual transport modes

	Expected values		Desired values	
Variable	**Coeff.**	**T-value**	**Coeff.**	**T-value**
Components (D)				
cycling/walking	0.02	0.27	0.47	4.44[4]
conventional car	0.06	0.73	-2.00	-16.25[4]
new fuels in car	-0.28	-2.99[4]	-0.38	-3.66[4]
Background factors (Z)				
spatial org.: mod. compact	-0.31	-2.36[4]	-0.19	-1.54
spatial org.: no clear pattern	-0.07	-0.52	-0.17	-1.34
spatial org.: mod. diffuse	-0.13	-0.78	-0.04	-0.26
spatial org.: diffuse	0.14	0.52	0.39	1.57
individ.: present pace	--	--	--	--
individ.: stops	--	--	--	--
individ.: reduces (largely)	--	--	--	--
decision level: national	-0.21	-1.85[5]	--	--
decision level: regional	-0.22	-1.44	--	--
decision level: not clear	-0.24	-1.79[5]	--	--
system sustainable: maybe[6]	-0.25	-1.84[5]	..	..
system sustainable: no[6]	-0.34	-2.45[4]	..	..
Personal features (X)				
education: economist	--	--	--	--
education: planner	--	--	--	--
education: technician	--	--	--	--
employer: regional/local	--	--	--	--
employer: consultancy	--	--	--	--
employer: university	--	--	--	--
employer: transport firm	--	--	--	--
gender: male	--	--	--	--
age: 30-40 years	--	--	--	--
age: 41-50 years	--	--	--	--
age: > 50 years	--	--	--	--
Random effect				
v2-v1	1.02	5.42[4]	0.67	2.02[4]
τ	-1.49	-2.43[4]	1.33	0.81
Mean log-likelihood (LL)	-7.960		-7.607	
Mean LL full/ baseline model	-7.930	-8.011	-7.533	-7.628
Test-statistic T_1, T_2	11.9[4]	19.8[4]	28.6[4]	8.0[5]

Note: Additional reference values: modes: electric car; urban spatial org.: compact; for other notes see Table 1.

Table 5 Estimation results of the influence of background factors on the importance of collective transport modes

	Expected values		**Desired values**	
Variable	**Coeff.**	**T-value**	**Coeff.**	**T-value**
Components (D)				
conventional trains	-0.63	-5.99[4]	-1.15	-9.58[4]
tram	0.41	3.88[4]	-0.03	-0.19
metro/light rail	0.94	8.82[4]	0.85	7.15[4]
bus	0.26	2.54[4]	-0.39	-3.31[4]
Background factors (Z)				
spatial org.: mod. compact	-0.33	-2.20[4]	-0.11	-0.84
spatial org.: no clear pattern	-0.20	-1.34	-0.09	-0.61
spatial org.: mod. diffuse	-0.26	-1.34	-0.18	-0.92
spatial org.: diffuse	-0.81	-3.31[4]	-0.83	-2.11[4]
individ.: present pace	--	--	-0.14	-1.02
individ.: stops	--	--	-0.48	-2.73[4]
individ.: reduces (largely)	--	--	-0.37	-1.80[5]
decision level: national	--	--	0.31	2.50[4]
decision level: regional	--	--	0.05	0.31
decision level: not clear	--	--	0.01	0.07
system sustainable: maybe[6]	--	--	..	..
system sustainable: no[6]	--	--	..	..
Personal features (X)				
education: economist	--	--	-0.15	-1.26
education: planner	--	--	0.19	1.38
education: technician	--	--	0.05	0.36
employer: regional/local	-0.37	-1.89[5]	0.06	0.37
employer: consultancy	-0.62	-3.47[4]	0.14	0.94
employer: university	-0.35	-1.70[5]	-0.10	-0.58
employer: transport firm	-0.30	-1.82[5]	0.34	2.72[4]
gender: male	0.34	1.81[5]	-0.22	-1.12
age: 30-40 years	--	--	-0.21	-1.60
age: 41-50 years	--	--	-0.06	-0.41
age: > 50 years	--	--	-0.16	-0.97
Random effect				
v2-v1	1.32	14.77[4]	1.53	10.26[4]
τ	-0.16	-0.76	1.71	6.56[4]
Mean log-likelihood	-9.491		-9.271	
Mean log-likelihood full model	-9.452	-9.539	-9.271	-9.377
Test-statistic T	15.4	19.2[4]	..	40.9[4]

Note: Ref. values: modes: people mover; urban spatial org.: compact; for other notes see Table 1.

The influence of background factors on the importance of collective modes

In Table 5 the results of the estimation for collective modes is presented. As was the case in the previous estimations, the dummy-parameters for the distinct modes are conform the analysis in Section 3.2. Both in the expected and the desired case a relation is found between the importance of collective modes and the spatial organization. In a compact urban spatial organization, collective modes receive the highest scores, while in the diffuse organization collective modes are less important (for the latter also the size of the coefficients is about equal). This can be explained by the lower transport densities in more diffuse cities, which make these modes less attractive and profitable (see Section 2). In the desired case some other background factors also have a significant impact, which do not show up in the expected case. When the individualization trend stops or will largely be reduced, this has a negative impact on the (desired) importance of collective modes, which can be explained by lower mobility rates. When the main decision level is the national government, this has a significant positive impact on the importance. This may be explained by the fact that the national government should finance expansions of the infrastructure of these modes. Apparently, the EU is not considered to be beneficial for collective mode use at the urban level, which seems plausible since this level is too high to coordinate an efficient policy aiming at stimulating collective modes use at the urban level.

Striking is, that ministry employees are significantly more positive on the expected role of collective modes than all other employees. Apparently employees, working in urban areas (regional/local authorities, transport firms) as are more pessimistic on the role of collective modes than national policy makers, which is an interesting contrast. An additional result is that (public) transport firm employees desire a more important role for collective modes than the other employee types, which may be explained by their own job and carrier perspectives. Furthermore, men have higher expectations of the importance of collective modes than women. The other personal features do not have a significant impact.

The individual specific-effects show up high and very strongly in both models, whereas in the desired case it is also observed that the value for p (equal to about 15%) is quite precisely estimated. As revealed by the α-vector (not presented here) roughly 15% of the experts attribute much higher scores to collective modes on average (3 full points) than the rest of the group.

Comparative overview

The importance of individual modes seems not be influenced by the background factors included in our analysis; apparently, these modes are both in the desired and expected situation rather autonomously determined; even some counter-intuitive results are found in the model based on expectations.

The importance of collective modes, however, is influenced by background factors to a much larger extent. This holds in the first place for the spatial organization, while in the desired case also the individualization trend and the decision level influences the use of these modes.

5 Conclusions

Transport is influenced by many factors, which may be of an economic, institutional, social or spatial nature. These factors can be subject to many policies and general trends. The mobility level, the modal split, the introduction of policy measures and of new transport technologies may be influenced by these factors. In this paper we examined the impact of some of these factors on the composition of the urban transport system, by carrying out a panel analysis on the opinions of Dutch transport experts on expected and desired developments in the year 2030.

Several interesting conclusions can be drawn from the analysis. A reversal of the individualization trend will mainly reduce the importance of policy measures, current and collective modes. This may largely be explained by lower mobility rates due to the smaller size of households. The main level of decision making usually has a significant impact. A centralized decision making system is expected to have positive impacts on the introduction of new transport modes. Free rider behaviour becomes more difficult in this case, while R & D can be coordinated which may result in scale advantages. The national level appears to be important for collective mode use, but regionalization or measures to be taken at the most appropriate level may increase the efficiency of policies. A compact urban spatial organization has a positive impact on the use of collective modes, because of the more concentrated transport flows.

Also several personal features do have in several cases an impact on the expectations and wishes of experts. It is especially striking that ministry employees expect and desire more introduction of policy measures. They also expect more collective mode use in the urban area, while the respondents working at this level are more sceptical about this.

In our statistical model for the values given to the distinct modes and measures, we also included an individual-specific (random) error term to control for the intrinsically present autocorrelation of the error terms. This effect appears to show up significantly in each model estimated and hence proves to be an essential element of our model.

An interesting observation is that both background factors and personal features have in most cases less impact in the models based on expectations than in the models based on desired data. Apparently, experts agree to a larger extent on future expectations of the system. This consensus among experts is so strong that different developments in background factors have little impact on the expected composition of the urban transport system. When the desired system has to be composed, however, experts do appear to reveal underlying background factors to a larger extent.

Finally, it can be concluded, that when governments wish to reduce the external costs of urban transport, developments in society, the spatial organization and the institutional environment - as well as general policies, non-transport oriented but influencing these developments - have to be taken into account by composing urban transport policy packages.

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