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Experiences with transportation models: An international survey of planning practices

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ABSTRACT

Transport planning practice is experiencing rapid transitions. This shifting professional environment is prompting lively and sometimes bitter debates about how transportation models should be used. While these models and their outputs play an increasingly more important function in transport-related decision-making processes, growing concerns emerge about their limitations, assumptions, biases, and usability. This paper addresses the question of how different professionals involved in transportation planning perceive and experience these tensions. For that purpose, we developed an online survey which was completed by 229 European transport planning practitioners, primarily working in the Netherlands, Denmark and Germany. Our findings support the following key conclusions. *First*, and contrary to popular notions on the matter, practitioners are relatively satisfied with the models they use. *Second*, most respondents are confident that they understand the assumptions and uncertainties associated with transport models, but that other important stakeholders do not. However, *third*, the larger the distance that respondents have to hands-on working experience with transportation models, the lower is their trust on model outputs. Respondents who are not directly involved in the operation of the models a) report more negative experiences associated with model use in decision-making processes and b) identify more usability barriers. The overall picture revealed a lack of trust amongst transport planning professionals, which is a problem needing to be addressed. We propose bringing models closer to those who use their outputs as a constructive solution to this trust deficit.

1. Introduction

Transport planning practice is facing several challenges worldwide. Transport professionals are being asked to move away from the classical 'predict and provide' and later 'predict and prevent' rationale (Marvin and Guy, 1999; Owens, 1995) to adopt a more balanced view on mobility and accessibility (Banister, 2005, 2008). These professionals are no longer being invited to undertake their practice in a compartmentalised and disciplinary fashion. Instead, they are being requested to embrace a holistic view on mobility (Bertolini et al., 2008; Ferreira et al., 2013). Their work is no longer about developing and implementing linear solutions for clearly defined goals (e.g. building roads to reduce congestion) in simple institutional contexts with ample budgets. Now they are participants in highly complex decision-making processes taking place in heavily politicized environments with multiple stakeholders concerned with conflicting goals attached to divergent values and with scarce resources (Hull, 2008; Stead, 2008; Willson, 2001). All these transitions set new requirements for transport knowledge to support planning practice: not only different types of knowledge are needed, but also new ways of generating, combining and employing these knowledge types (Handy, 2002, 2008; Healey, 2007, pp. 235–263; Te Brömmelstroet and Bertolini, 2011).

The abovementioned developments put pressure not only on transport planners but also on their toolkit. Their technical instruments need to be constantly upgraded so that they can cope with the emerging challenges and criticisms. This holds especially true for one of their central knowledge instruments: the macroscopic transportation model (Gudmundsson, 2011). The technical limitations of the widely used, and often even obligatory, four-step model (Timmermans and Arentze, 2011), the heavy assumptions models are built on (Timms, 2008; van Exel, 2011), the lack of consensus about how model outputs should be used in transport decision making (Næss and Strand, 2012), the potential biases that models introduce (Ferreira et al., 2012; Naess et al., 2015; Næss et al., 2012; Nicolaisen and Næss, 2015) and their

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limited usability for strategy making phases (Te Brömmelstroet, 2010) are some of the key problems addressed in recent debates.

A special issue of Transport Reviews published in 2011 has focused on the contested roles of transportation models in this changing context (Te Brömmelstroet and Bertolini, 2011). The contributors agreed that planning practitioners fully acknowledge the very high potential that transport models have to support their decision-making challenges. However, they also agreed that the full potential of these models is not yet realised. A general thread emphasized that models need to actively and explicitly facilitate individual and collective learning processes in parallel with supporting decision-making process (Gudmundsson, 2011; Te Brömmelstroet and Bertolini, 2011). The high technical complexity of contemporary models can too easily create a black-box effect where the model itself becomes an additional source of incomprehensibility about the (already highly complex) real-world issues at stake. Not surprisingly, such excessive complexity and disregard for the individual learning processes of each decision-maker has resulted in severe reproaches against transport modelling. For example, Flyvbjerg (2007) and Bain (2009) have both criticised project proponents for using the so-called 'black-box effect' in order to manipulate demand forecasts in their favour. The fact that in many countries model-based demand forecasts are mandatory inputs for cost-benefit analyses and environmental impact assessments aggravates tensions and concerns about models. This means that trust in travel demand forecasts as a decision-support tool is at serious risk, at least among some professional classes. Indeed, Næss et al. (2014) found that the perceived objectivity of model-based forecasts is significantly higher among the private consultants who operate the models than it is among planning practitioners, civil servants, and elected officials. In addition to this, the perceived impact of model forecasts on decision-making was also significantly higher among model operators than other professionals.

In this paper we seek to further investigate the relationship between different types of planning participants and the perceived usefulness of transport models as decision-support tools. To achieve this goal, and inspired by the tensions and concerns discussed above, we tested the following hypotheses:

- Practitioners perceive that transportation models are ill-suited to address and respond to the challenges and questions they are confronted with in their professional practice;
- The distance of planning participants to model output (operationalized as by whom the model is operated, see Table 1) correlates negatively with their level of trust in model outputs;
- The distance to model output correlates positively with seeing the communication of uncertainty as problematic;
- The distance to model output correlates negatively with considering model outputs useful for decision-making; and finally

- The more operational is the task that the model is used for, the higher is the trust in the model outputs.

The paper is structured as follows. First, it briefly discusses the research design choices and setup of the data-gathering and analysis instruments. Then, in Section 3, the relevant characteristics of the sample (survey respondents) are presented. Section 4 describes the experiences of the respondents regarding their use of transportation models and their outputs. A discussion of significant differences between countries and between different professional roles is included. Section 5 follows the same structure in discussing the perceived usability of the transportation models. The paper ends presenting the conclusions and a discussion on improvements for the usability of transportation models in planning practice. Future research steps are also proposed.

Table 1
Characteristics of respondents.

Contexts Total		NL 123	DE 48	DK 26	Other 32	Total 229
Professional role* see Table 2 below	Model specialist	36	10	5	20	71
	Planner	11	27	12	9	59
	Strategist	28	0	6	1	35
	Evaluator	6	9	1	1	17
	Designer	3	0	1	0	4
	Policy operator	17	0	0	0	17
	Advisor	15	0	0	0	15
	other	7	2	1	1	11
Expertise	Transport and mobility	110	46	25	31	212
	Land use	4	2	0	0	6
	Environment	7	0	1	0	8
	Integrated	2	0	0	1	3
Employer	Local authority < 50 K	24	1	0	0	25
	Local authority 50 K to 100 K	12	3	1	0	16
	Local authority 100 K to 300 K	17	5	3	4	29
	Local authority > 300 K	10	3	0	2	15
	A province	13	1	0	0	14
	A national government	4	0	6	1	11
	A regional government	9	0	2	1	12
	A consultancy firm	29	30	9	21	89
	A knowledge institute	2	2	4	2	10
	Other	3	3	1	1	8
Transportation model	Omnitrans	79	0	0	0	79
	Visum	2	40	11	9	62
	Don't know/prefer not to say	10	1	8	0	19
	Cube	11	0	0	7	18
	Questor	9	0	0	0	9
	Emme/2	0	0	2	6	8
	OTM	0	0	4	0	4
	PSV	0	4	0	0	4
	Other	12	3	1	10	26
Model is operated by...	...me.	38	33	6	9	86
	...people employed within my organisation.	47	9	5	20	81
	...people working outside my organisation.	31	5	8	3	47
	...people within and outside my organisation.	6	1	7	0	14
Experience	short (< 2 years)	8	3	1	2	14
	Middle (2–5 years)	19	5	7	4	35
	long (> 5 years)	96	40	18	26	180
Types of questions	1 - Very operational	6	9	1	1	17
	2	36	19	3	5	63
	3	25	10	2	2	39
	4	24	8	9	7	48
	5	14	1	7	9	31
	6	15	1	3	6	25
	7 – Very strategic	3	0	1	2	6

2. Research design

2.1. Data gathering

The research is based on survey responses from stakeholders in the

Netherlands, Germany, Denmark and the United Kingdom. The data was gathered with a Google Forms survey and adopted a similar set up to the one used in an earlier study on practitioner views on transportation models (Te Brömmelstroet, 2010). The survey was available in English and in the respective mother tongue of each country. We distributed the survey and several reminders via mailing lists from national planning organisations and local universities, and via a number of LinkedIn groups on transportation modelling and transport and urban planning. The survey's structure was the same in all languages and could be completed within ten to fifteen minutes. The structure of the survey was as follows:

- The first part consisted of ten questions about the respondent, the organisation he/she worked for, which transportation models they have used, and their relation with this model.
- In the second part, the respondent was asked to react to seventeen statements about experiences with transportation models, ranging from their own understanding about model outputs to the understanding that other key participants using the transportation model have about the same outputs.
- The third part included more general questions on the characteristics of the transportation models and their ease of use.

The main setup presented a series of statements that respondents had to grade based on a 7-point Likert scale, ranging from 'Completely disagree' to 'Very much agree'. This format is easy to interpret and quick to fill in. The 7-point scale also avoids the strong border effects of the often used 5- or 10-point scale (Matell and Jacoby, 1971). Although still under academic debate (see e.g. Allen and Seaman, 2007), we argue that the Likert scales allow us to run a number of standard parametric tests on the data (following Norman, 2010).

2.2. Data analysis

The first part of the analysis was aimed at identifying general patterns. We used a one-sample T-test to identify scores that deviate significantly from the average Likert score (4.00). If the score was significantly higher than 4.00, we interpreted it as a positive attitude to the statement. Similarly, if the score was significantly lower than 4.00, we viewed this as a negative attitude to the statement. After that, we explored the differences between countries and professional roles. To achieve this we selected statements with significant differences according to a standard one-way ANOVA test.

3. The respondents

A total of 229 respondents completed the survey. Their characteristics are presented in Table 1. More than half of the respondents work in the Netherlands and therefore the aggregate data is heavily skewed towards Dutch viewpoints and experiences. Model specialists, planners and strategists are the dominant specializations – see Table 2 for an explanation of the meaning of these categories. The predominant expertise in the sample of all countries is transport and mobility. The respondents work mainly for consultancy firms and local authorities.

Regarding transport models adopted and how they are used, it became clear that *Omnitrans* has a monopoly position in the Netherlands; *VISUM* is especially present in the German sample, but also in other contexts. Indeed, even though Denmark has a specialised model for the capital region (OTM), *VISUM* is often used in other regions. Most of the respondents have hands-on interaction with transportation models or have direct colleagues that run them. The respondents in general have more than five years of professional experience with transport models. Although there is a considerable range of use, most use the models to answer planning questions that are more operational than strategic.

4. Experiences with transportation models

The first group of questions on the survey aimed at understanding the experience that the respondents have with transportation models and their outputs (see Table 3 and Fig. 1). The first identified pattern was that the respondents typically have positive views about the suitability of transportation models to help addressing the planning questions they encounter in professional practice. Contrary to the popular notion that transportation models are not meeting the expectations of professionals, the respondents did not express discontent. In fact, they were satisfied with the level of usefulness of modelling outputs to analyse bottlenecks and evaluate projects. They were also satisfied with the ease of translating model outputs into solutions and communicating them with other disciplinary fields. In general, they were also positive about the speed of the model and the level of output detail. Finally, respondents stated that they have enough influence on the assumptions embedded on the transportation model they use. Note that all these evaluations do not express the highest levels of satisfaction possible (they are not close to 7, which would be the maximum level of satisfaction), but do not express at all a tangible sense of dissatisfaction (values are all above 4, which is the middle of the Likert Scale used).

This basically positive impression practitioners have is noteworthy as it is associated with another, somewhat dissonant, impression. Respondents typically claim that, for themselves, transportation models are understandable and that they are aware of the weak points and assumptions of the models they use. The respondents felt they knew how much they could trust the model outputs (score significantly higher than 4.00). However, they also typically felt that other key people involved in the planning process are much less aware than they are of the weak points and assumptions embedded in the models. Additionally to this, respondents seemed to believe that most people besides themselves do not properly understand how much trust should be placed in the models (scores significantly lower than 4.00).

4.1. Country-specific experiences

Twelve of the seventeen statements show significant national differences (Table 4 and Fig. 2). As a general pattern, the Dutch respondents present more negative answers than the others about their experiences with transportation models and their outputs. On the contrary, the German respondents seem the most positive. Overall, the

Table 2
Explanation of professional roles of respondents.

Professional role	Explanation
Model Specialist	A professional who has personally worked with and developed own transport models and has provided modelling expertise on various occasions
Planner	A planner who has personally worked with transport models, but not necessarily developed their own models
Strategist	Professionals responsible for drafting the overarching transport strategies of the region
Evaluator	Professional responsible for evaluating transport policies
Designer	Professionals responsible for design of urban structures
Policy operator	Person directly/ indirectly responsible for developing transport policies
Advisor	A professional who is responsible for advising the stakeholders and provide his/her expertise on the matters of transportation issues

Table 3
Experiences with transportation models.

Statement	Mean
The output of the transportation model we use is understandable to me	5.86[a]
The output of the transportation model we use is understandable for all key people involved in planning	3.90
I know how well I can trust the model output	5.42[a]
All key people that are involved in planning and/or decision making know how well they can trust the model output	3.34[a]
I am well acquainted with the assumptions of the transportation model we use	5.35[a]
All key people involved in planning are well acquainted with the assumptions of the transportation model we use	3.34[a]
The weak points of the transportation model we use are clear to me	5.49[a]
The weak points of the transportation model we use are clear to all key people involved in planning and decision making	3.24[a]
The output of the transportation model we use can be easily used to analyse bottlenecks	5.26[a]
The output of the transportation model we use can be easily translated into solutions for identified problems	4.93[a]
The output of our transportation model can be easily used to evaluate projects	4.85[a]
The output of the transportation model we use are easily communicated to colleagues from other policy domains	4.55[a]
I trust the output of the transportation model we use	4.59[a]
Uncertainties of model output are well communicated	4.00
The calculation speed of the transportation model we use fits well with the planning issues I face	4.68[a]
The level of detail of the output of the transportation model we use fits well with the planning issues I face	4.79[a]
I have enough influence on determining which assumptions are made in the transportation model	4.79[a]

[a] These differences are significant on a 0.05 level (difference with 4.00).

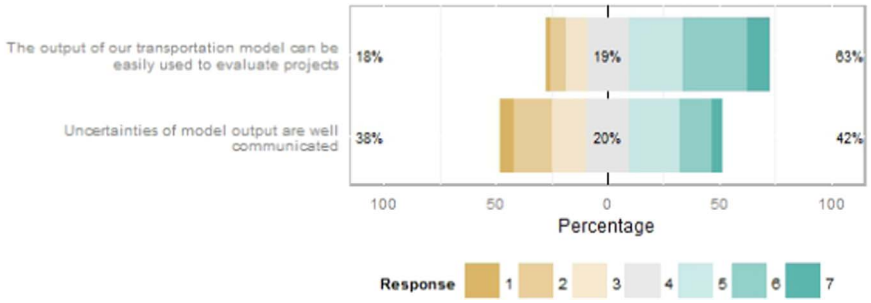

Fig. 1. General patterns for responses on ease of use for evaluation of projects and communication of uncertainties.

findings show that respondents think that key people have a limited understanding of model outputs, except the respondent him- or herself. In other words, most of them believe that they are individually, but not collectively, very capable of understanding the limitations and weaknesses of the models they use.

4.2. Role-specific experiences

There are some significant differences in the respondents´ perceptions according to their professional roles (see Table 5 and Fig. 3). It is clear that model specialists have the most positive experiences. This is only exceeded by the evaluators' score in the categories of trust in output, trust in the model, and fitness of detail level. Policy operators scored the lowest on most statements, suggesting that they may have the most negative experience with transport models. This might be explained by the fact that these professionals are those primarily responsible for the development of transport policies. Transport models impose specific constraints to this creative process, and therefore it is possible that their presence is not seen very kindly (see also Beukers et al., 2011).

Additional analysis has shown that the further apart respondents are from hands-on model operation (as shown in Table 1), the more negative are their perceptions about the fifteen statements presented. The scores become the highest when respondents operate the model themselves and the lowest when someone outside of their organisation operates it. There are similar differences regarding how different types of planning practitioners view the communication of model uncertainty. Experts who deal with the models very closely state that this communication is good while other roles who interact less closely with the models are more critical.

Table 4
Significant country-specific differences in experiences with transportation models (highest score for each statement in **bold**, lowest in *italic*).

	Netherlands	Germany	Denmark	Other
N	123	48	26	32
The output of the transportation model we use are understandable for all key people involved in planning.	*3.51*	**4.63**	3.77	4.44
The output of the transportation model we use can be easily used to analyse bottlenecks.	5.41	**5.46**	*4.46*	5.03
The output of our transportation model can be easily used to evaluate projects.	*4.37*	5.31	5.35	**5.63**
I trust the output of the transportation model we use.	*4.24*	5.02	**5.12**	4.81
All key people that are involved in planning and/or decision-making know how well they can trust the model output.	*3.03*	3.67	3.65	**3.75**
The weak points of the transportation model we use are clear to me.	5.36	**5.96**	*4.81*	5.88
The weak points of the transportation model we use are clear to all key people involved in planning and decision-making.	*2.91*	**3.71**	3.38	3.69
The calculation speed of the transportation model we use fits well with the planning issues I face.	*4.36*	**5.33**	4.73	4.91
The level of detail of the output of the transportation model we use fits well with the planning issues I face.	*4.29*	**5.46**	5.23	5.34
I am well acquainted with the assumptions of the transportation model we use.	*5.13*	5.52	5.19	**6.06**
All key people involved in planning are well acquainted with the assumptions of the transportation model we use.	*3.08*	3.35	3.77	**3.94**
I have enough influence on determining which assumptions are made in the transportation model.	*4.48*	5.17	4.88	**5.34**

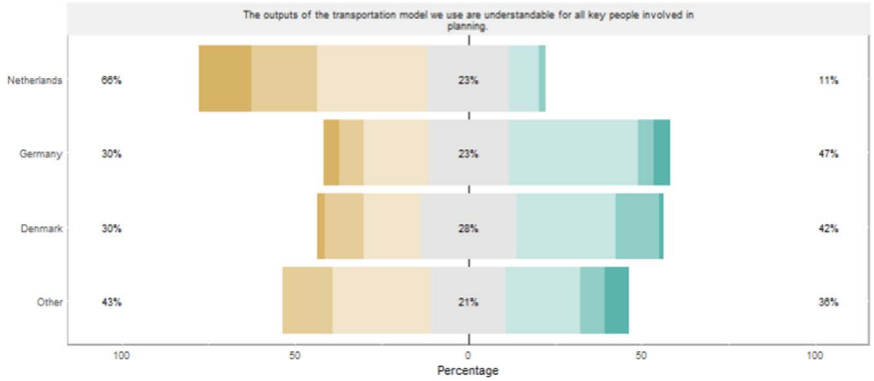

Fig. 2. Country-specific responses to understandability of model output for all key people involved.

4.3. Relation with planning tasks

We hypothesised that the more operational a planning task is, the higher the trust in model output would be. To test this, we analysed correlations between statements about the 'usefulness of model output' and the level of tasks that the models are used for (from 1= purely operational to 7= purely strategic). Operational models focus on detailed, short-term effects in a smaller network while strategic models focus on broader, long-term effects in a wider geographical area. Table 5 shows that when models are used for more strategic purposes, respondents indicate that outputs are less understandable and that the working of the model and assuptions made in it are less clear (black-box effect). The model weaknesses appear to be less understood by respondents that use them for more strategic tasks (Table 6).

5. Usability of transportation models

The next set of statements relates to the characteristics of the transportation models that are used by the respondents (Table 7). Three of these were rated significantly positive: the excessively strong legal role of model output, the opaqueness of the models, and the lack of userfriendliness. The respondents disagree with eight other statements. The strongest disagreement is on the lack of credibility of model output, on the excessively global nature of outputs and on insufficient support for evaluating projects.

5.1. Country-specific usability

We found significant differences in the responses from the different countries on nine statements (see Table 8). In particular the Dutch respondents believe that model outputs play an excessively strong role in planning processes. They also have the highest agreement about low communicative value, low userfriendliness, poor adjustability, and insufficient support for evaluating projects. From this survey, it seems that the German respondents are those most satisfied with the usability of their transportation models. This could be because a higher proportion of German respondents, compared to their Dutch and Danish counterparts, are capable of operating the models themselves. It could also be due to the differences in the transport modelling tools (eg. VISUM, Omnitrans, etc.) used by the respondents from different countries. Future research should be dedicated to clarify these differences.

The difference in the extent of legal role the model outputs play in different countries could be due to a couple of reasons (see Table 8). This difference could be due to the differences in the way planning processes are structured in different countries. For example, a country with a strong bureaucratic hierarchical structure will see a lower legal role of model outputs. The other factor that could affect this is the personal ability of the operators to effectively convey the useful model outputs, along with their limitations and assumptions, to the stakeholders. When this is done in an effective way, the model outputs are well accepted and considered in the decision-making and policy-making processes. In case professionals fail to do so, it could lead to a general distrust towards the model outputs and could undermine the role of transport model outputs in decision making processes. This relation can be said to be generally true for all the countries present in the survey.

5.2. Role specific viewpoints

Table 9 shows the results of two statements only. These were the only ones where significant differences were found between the different professional roles considered. As both sentences are framed in negative terms, a high score indicates that respondents assess things as problematic. A low score indicates that respondents are tranquil about how things present themselves at the moment. Regarding the first statement, designers, strategists, advisors and model specialists agree with the excessively strong legal role transport models have acquired, while evaluators do not agree. The second statement shows lower scores for most roles. Here, the data suggests that advisors, policy operators and strategists consider that transportation models do not support the evaluation of projects sufficiently well, while planners and model specialists find the support provided by models adequate.

To better understand these findings, Table 10 summarizes statements for which there are significant differences according to the distance of the respondents to operating the transportation model. These all confirm a similar pattern: the higher the operational distance to the transportation model is, the stronger they feel about usability problems. For instance, when respondents operate the model themselves they feel that models can be adjusted well to user demands; conversely, respondents that work with models that operate outside their own organisation perceive the existence of usability problems (Fig. 4).

6. Summary of findings

The theory behind the present paper is based on two bodies of literature. The first is concerned with the use of computer instruments in planning practice. The second, more specific, is concerned with the usability of models in transport planning. This theoretical background allowed discussing with rigour the perceived utility of model outputs among different types of users, such as planners, strategy makers and advisors. We also looked at what factors impact the level of reliance of the users on the transportation model outcomes.

This research builds upon the promise that transportation models can potentially offer significant opportunities to support a rapidly changing urban transport planning context. However, there are a number of difficulties associated with model use. In order to help solving this mismatch, we discuss here how the findings relate to the five working hypotheses that guided the research.

Table 5
Significant differences in role specific experiences with transportation models (highest score for each statement **bold**, lowest in *italic*).

N	Model specialist 71	Plan ner 59	Strate gist 35	Evaluator 17	Designer 4	Policy operator 17	Adviser 15	other 11
The output of the transportation model we use are understandable to me	**6.31**	5.63	5.91	5.94	5.50	5.65	5.40	*5.09*
The output of the transportation model we use are understandable for all key people involved in planning	**4.31**	3.95	3.46	4.18	*2.50*	3.24	4.00	3.45
The output of the transportation model we use can be easily translated into solutions for identified problems	**5.34**	4.68	4.97	5.29	*4.25*	4.41	4.53	4.45
The output of our transportation model can be easily used to evaluate projects	**5.41**	5.02	4.60	4.94	4.75	*3.76*	3.87	4.09
The output of the transportation model we use are easily communicated to colleagues from other policy domains	**5.06**	4.15	4.49	5.00	*3.50*	3.88	4.27	4.64
I trust the output of the transportation model we use	4.99	4.46	4.74	**5.24**	4.00	*3.24*	4.07	4.18
Uncertainty of model output are well communicated	**4.55**	3.66	3.89	4.18	*3.25*	3.82	3.47	3.55
I know how well I can trust the model output	5.80	5.20	5.63	**5.94**	5.00	4.71	*4.60*	5.09
The weak points of the transportation model we use are clear to me	**6.04**	5.31	5.66	5.12	*4.75*	5.00	4.93	4.82
The level of detail of the output of the transportation model we use fits well the planning issues I face	5.01	5.08	4.66	**5.12**	4.00	3.76	*3.87*	4.82
I am well acquainted with the assumptions of the transportation model we use	**6.14**	5.07	5.29	5.47	5.50	*4.12*	4.60	4.64
I have enough influence on determining which assumptions are made in the transportation model	5.32	4.53	4.74	**5.47**	*4.00*	4.06	4.27	*4.00*

Practitioners perceive that transportation models are ill-suited to address and respond to the challenges and questions they are confronted with in their professional practice; contrary to what popular understandings would suggest, this hypothesis was not validated by this research. In fact, practitioners seem to have relatively positive perceptions about the models they work with, as described in Section 4.

The distance to hands-on model operation correlates negatively with the level of trust in model outputs; the findings offer strong support for this hypothesis. This may be because the model specialists are familiar with the software and know how to tweak the models to obtain useful information for a given planning task. Conversely, non-experts are often balancing many different types of inputs (e.g. working with the public, working to push certain boundaries, etc), and often have to take model outputs at face value.

Similarly we found quite strong indications that *the distance to hands-on model operation correlates positively with seeing the communication of uncertainty as problematic.* This may be because the inherent uncertainties in model-based forecasting are well understood by the experts that interact with the models directly, but not necessarily by non-experts who do not know in detail how the models work. This situation might create a sense of mistrust towards model outputs, which naturally reinforces the black-box effect in model-based decision-making processes. Another possibility is that non-experts confidence on model outputs is undermined by experts presenting uncertainty issues in a way that is not constructive. In other words, when non-experts are told by experts that there are uncertainties, their confidence on the process might be undermined as their expectation is that the models are there precisely to reduce uncertainty. Indeed, research has shown that when experts include detailed analysis of uncertainties, there is greater probability that the model outputs are ignored in decision-making processes (e.g. Nicolaisen (2012) reports on an example of this from the Danish rail sector). How to account for and communicate uncertainties in transportation planning thus seems a key focal point for both research and practice.

The distance to hands-on model operation correlates negatively with considering model outputs useful for decision-making was also confirmed by our sample. This may be because experts are better aware of what the model can, and cannot, do. Model experts are able to manipulate the software in order to obtain a more useful set of data, or to tailor the data to make it more applicable to the analysis being undertaken. Non-experts typically depend on model outputs produced by other people to support decision-making processes for a specific planning objective regardless of how well a given output is suited for that process or objective. Without the necessary insight to gauge which types of analysis the model is suited or not suited for, non-experts on transport modelling may end up adopting a general scepticism towards model outputs.

Overall, we found evidence that *trust in model outputs is higher for respondents that use models for more operational planning tasks and lower for more strategic tasks.* This is not particularly surprising as it is known that strategic tasks are those where higher uncertainties exist regarding model inputs, network structure, among other aspects (e.g. Næss and Strand, 2012). However, this is problematic as confidence in the model outputs is important to facilitate model-based individual learning during decision-making. Since strategic planning is a particularly important and complex process where learning and making decisions are intertwined in a deep and meaningful way, having models there reducing trust in the process is counterproductive.

In regards to usefulness, trust and value of the transportation models, the results of the present study show that most professionals consider transport models to be useful and valuable tools in transport planning, but also indicate that they are concerned about how model outputs are understood and used *by others*.

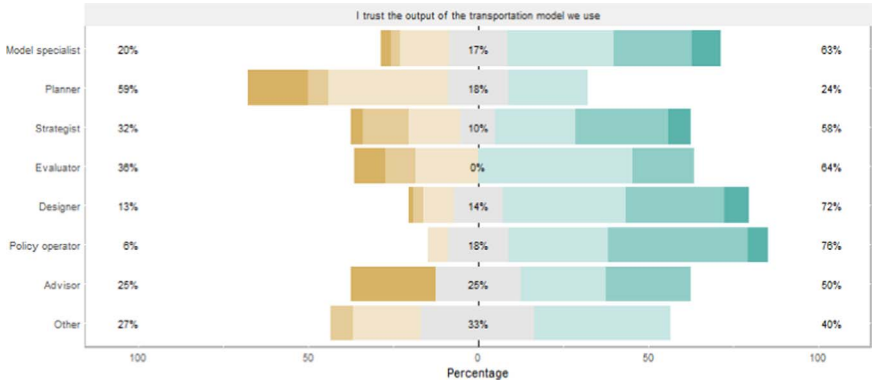

Fig. 3. Role specific response on trust in transportation models.

Table 6
Correlation between statements about the usefulness of model output and the planning level that they apply to (1=operational, 7=strategic).

Statement	Corr.
The output of the transportation model we use is understandable to me	−0.12[a]
The output of the transportation model we use is understandable for all key people involved in planning	−0.67
I know how well I can trust the model output	−0.12
All key people that are involved in planning and/or decision making know how well they can trust the model output	0.85
I am well acquainted with the assumptions of the transportation model we use	−0.91
All key people involved in planning are well acquainted with the assumptions of the transportation model we use	0.39
The weak points of the transportation model we use are clear to me	−1.29[a]
The weak points of the transportation model we use are clear to all key people involved in planning and decision making	−0.22
The output of the transportation model we use can be easily used to analyse bottlenecks	−0.24
The output of the transportation model we use can be easily translated into solutions for identified problems	−0.94
The output of our transportation model can be easily used to evaluate projects	−0.53
The output of the transportation model we use are easily communicated to colleagues from other policy domains	−0.97
I trust the output of the transportation model we use	−0.01
Uncertainties of model output are well communicated	0.09
The calculation speed of the transportation model we use fits well with the planning issues I face	−0.08
The level of detail of the output of the transportation model we use fits well with the planning issues I face	−0.03
I have enough influence on determining which assumptions are made in the transportation model	−0.17

[a] These correlations are significant on a 0.05 level.

Table 7
Perceived usability of transportation models and output.

Statement	Mean
Transportation models are not transparent	4.44[a]
The output of transportation models have an excessively strong legal role	4.41[a]
Transportation models are too expensive	4.15
Transportation models cannot be used interactively	4.05
Calculation times are too long	4.04
The communicative value of outcomes of transportation models is too low	3.99
Transportation models provide insufficient support for creating ideas	3.66[a]
Transportation models are too focused on a specific part of the land use/transport system	3.55[a]
Transportation models cannot be adjusted well to user demands	3.54[a]
Transportation models are too extensive/inclusive	3.50[a]
Transportation models provide excessively detailed output	3.43[a]
Transportation models are not userfriendly	4.39[a]
Transportation models provide insufficient support for evaluating projects	3.35[a]
Transportation models provide excessively global output	3.31[a]
The output of transportation models are not credible	3.02[a]

[a] These differences are significant on a 0..05 level (difference with 4.00).

7. Discussion and recommendations

Our research setup allowed the identification of some patterns that bridge country-specific borders. This indicates that these findings are unlikely to be the result of specific planning systems or model characteristics. Among these patterns, one can mention the consistent tendency for respondents to trust in model outputs, find models transparent and value models as decision support tools *when they work very closely with the models*. Respondents who operate the models themselves have the highest level of trust, especially when they use them for operational tasks. Respondents who rely on external consultancy firms for acquiring model outputs and those who work with more strategic tasks have less trust in, and understanding of, model outputs. This is well in line with a previous study on a larger Danish sample that concluded that clients are much more sceptical of model validity and model outputs than the consultants who produced them (Nicolaisen, 2012). It is clear that lack of model transparency, an inadequate understanding of the underlying assumptions of the model, and the uncertainties related to model outputs contribute to feelings of scepticism. Based on this evidence, we argue that bringing transport models closer to those who use their outputs would be a very constructive policy measure. Concrete ways of doing this should be identified and assessed in terms of their costs, merits and drawbacks. In any case, under this light the use of consultancies as external model operators and model output providers appears as problematic.

Reinforcing the need to develop a new approach beyond consultancies working as model operators and model output providers, this research has identified another pattern. Most respondents consider themselves skilled in working with transportation models, knowledgeable about how models operate and capable of interpreting their outcomes. However, most respondents also consider that other stakeholders are not as well qualified as they are in doing the same. One interpretation for such pattern is that a systematic mistrust among all groups of professionals might exist. This is especially problematic when considering the need to work with model outputs in increasingly more

Table 8
Country specific views on usability of transportation models (highest score for each statement in **bold**, lowest in *italic*).

	Netherlands 123	Germany 48	Denmark 26	Other 32
The output of transportation models have an excessively strong legal role	**5.00**	*3.54*	3.73	4.00
Calculation times are too long	4.31	*3.08*	4.00	**4.47**
Transportation models are not transparent	4.62	*3.77*	4.50	**4.69**
The communicative value of outcomes of transportation models is too low	**4.19**	*3.40*	3.96	4.13
Transportation models are not userfriendly	**4.61**	*3.65*	4.46	4.59
Transportation models cannot be used interactively	4.31	*3.29*	**4.46**	3.88
Transportation models cannot be adjusted well to user demands	**3.82**	*2.81*	3.42	3.63
Transportation models are too focused on a specific part of the land use/transport system	3.56	*2.88*	3.85	**4.25**
Transportation models provide insufficient support for evaluating projects	**3.90**	*2.40*	3.15	2.84

Table 9
Role specific views on usability of transportation models (highest score for each statement in **bold**, lowest in *italic*).

	Model specialist 71	Planner 59	Strate gist 35	Evaluator 17	Designer 4	Policy operator 17	Advisor 15	other 11
The output of transportation models have an excessively strong legal role	4.73	3.92	4.86	*3.76*	**5.00**	3.88	4.80	4.64
Transportation models provide insufficient support for evaluating projects	2.94	*2.88*	4.06	3.47	3.75	4.18	**4.27**	3.45

Table 10
Relation between operational distance to the transportation model and usability of transportation models.

The transportation model that I use is operated by ...	...me	...people employed within my organisation	...people working outside my organisation
	86	**81**	**47**
Transportation models are not transparent	4.03	4.60	4.96
The communicative value of outcomes of transportation models is too low	3.63	3.99	4.53
Transportation models are not userfriendly	3.78	4.60	5.13
Transportation models cannot be used interactively	3.81	3.85	4.81
Transportation models cannot be adjusted well to user demands	3.22	3.47	4.17
Transportation models are too focused on a specific part of the land use/ transport system	3.43	3.57	3.60

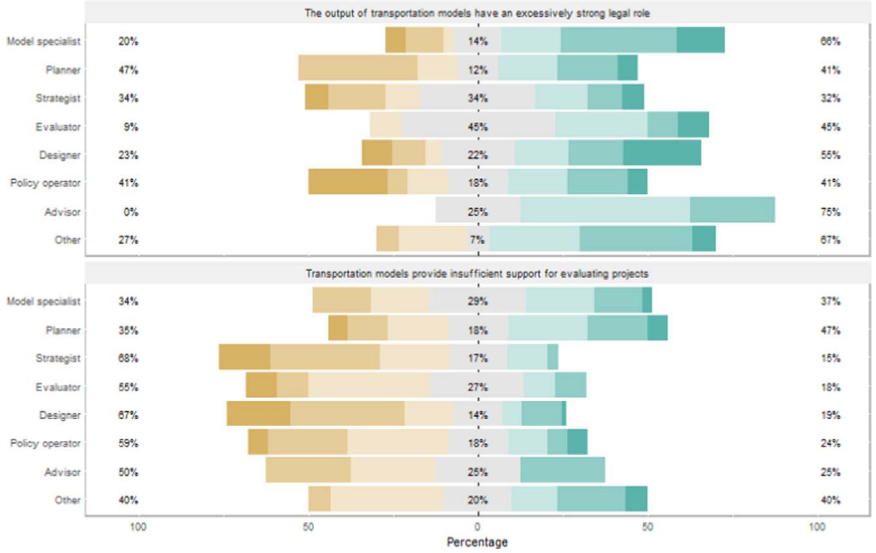

Fig. 4. Role specific responses on usability of transport models.

multidisciplinary settings at a strategic level.

Lack of trust is indicative of a depreciative professional culture with the potential to hamper communication and strategy-making in much wider areas (see e.g. the problems around Cost Benefit Analysis in: Beukers et al., 2011). It would be very constructive to find ways to understand the root causes of this lack of trust and how to change the situation for the better. Detailed understanding about this matter is most needed and therefore research on this topic is a necessity.

Another reason for the abovementioned differences in perceived utility value might be that different stakeholders involved in transport planning processes value differently policy issues such as cost efficiency versus social equity, levels of service in transport systems versus environmental sustainability. As a result, transport models do not necessarily provide the information that all these stakeholders perceive as the most relevant. Model specialists are often transport engineers with detailed knowledge of and interest in transport systems and their levels of service, and as a result they are likely to consider their own models adequate for addressing the problems that matter the most to them in the first place. To prevent this circular logic to reduce the perceived usability of models in planning processes, it is important to allign model outputs with performance indicators that are relevant for all stakeholders. This is especially important when we consider the use of models to support collective learning in multidisciplinary settings in which transport and mobility are framed in an increasingly holistic way.

The present situation can therefore be understood as a dominant paradigm in transportation modelling hesitating to perform a most necessary shift. This paradigm is characterised by highly complex models that are created and operated by consultants with excessive expertise in transport issues. These consultants typically work outside the organisations that end up using the model outputs and therefore do not share with their clients similar worldviews on what really matters. As a result, existing models are experiencing never-ending incremental improvements aimed at meeting the needs and expectations of decision-makers. This might have a paradoxical effect of decreasing trust in the models instead of increasing perceived model quality. As consultancies firms typically run for financial profit, this might contribute to build a serious lack of trust in professional relations between classes of professionals involved in transport planning. It is therefore important to critically reflect about the extent to which embracing a new transport modelling paradigm is possible and desirable. This paradigm would bring models closer to those who need their outputs. In this paradigm, it is likely that the role of consultants will shift from model operators to transport modelling educators and from model developers to model co-creators.

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