The use of state-of-the-art models by policy makers to address global energy and environment challenges: The case of transport policy

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Executive summary

The world is facing formidable challenges, especially in the areas of energy and the environment. Immediate actions on these issues are required, and the ways in which the policies are determined and the kind of tools used for that purpose are of high importance. This research presents a timely debate on the utilisation of knowledge in the process of determining policies, the tools used to produce such knowledge, and the relationship of the actors involved in the producing and using the knowledge in the policy making process. Matters arising from this debate and possible solutions to the existing problems are central to this research. In this context, the research focuses on the field of transport. The transport sector is the main consumer of oil worldwide and responsible for considerable, and increasing, amount of green house gases emission. Although the research examines the transport sector only, its findings are nevertheless applicable to other policy domains, where similar issues of knowledge production and utilisation are likewise critical in addressing energy and environment challenges.

Increasing mobility levels, globally and locally, create a challenge for authorities at all institutional levels to understand the consequences of various transport policies and make their decisions accordingly. In that sense, transport modelling emerges as an important tool for decision making. However, this research demonstrated that there are barriers to achieving a seamless transfer between the knowledge produced via state-of-the-art modelling and the knowledge decisions are based on. The motivation of this research has been to understand these barriers and finding ways to overcome them.

The research methodology is based on examining two main areas parallel: the policy process and the use of models within it on the one hand, and on examining the models used – focusing on travel demand models – on the other hand. Following a review of the literature in both areas, the primary method used in this research has been semi-structured interviews with modellers, planners and decision makers from various levels of governments in the UK and Israel. In addition, two workshops, with similar actors and including academics were held - one halfway through the project and one towards its end – to reflect on the main research findings and provide some review of the research up to that point. The interviews, workshops and the discussions throughout the research by the project team have shed light on the problems that limit the usefulness of advanced modelling tools for decision making in the policy process and helped to point to ways in which the contribution of state-of-the-art models to better policy choices can be increased.

The literature on knowledge utilisation and the use of models in policy making demonstrates that the users of the knowledge that is produced within the process, the type of users (actors) involved in the policy making process and the ways in which these actors interact with each other are of high importance. Moreover, the knowledge produced must be accessible, understandable, produced in a flexible environment and available to be shared, communicated and negotiated. An important tool for knowledge utilisation in decision-making in transport policy is modelling. Although there are different uses of models in policy-making, this research is interested in the use of models as aids to decision making. With respect to the literature on knowledge utilisation, the
modelling exercise and its interaction with the decision making process needs to be transparent and inclusive of different actors.

The literature on the use of models suggests the need for developing understandable, reliable, user friendly, efficient and flexible models in order to better support decision-making. However, transport modelling has been advancing with other priorities in mind, primarily increasing the models ability to represent and capture real life - travel behaviour in our case - in order to provide policy makers with better, more accurate and more plausible, forecast of the likely impacts and consequences of different policy choices. These two different approaches, or drivers, for model development results in tools that even if advance state-of-the-art constrain, and in many respects leave behind, the state of the practice, overall limiting the usefulness of the model for policy makers. From sketch planning models to the current state-of-the-art activity based models, the increase in models’ behavioural realism has meant models are better suited to help evaluate contemporary transport policies – like demand management policies. But this increase in behavioural realism also meant increasing the model complexity, and with it reducing its usefulness in the field. To investigate this trade-off between increasing behavioural realism and making models more complex two case studies have been chosen to study the use of models in the policy process.

The UK case study took place in a medium-sized county-council that has recently completed its third Local Transport Plan. The interviews have been conducted with a policy analyst, a planner, a politician and a consultant. On the one hand, some of the interviewees believe that the models already give too much detail, even though state-of-the-art models are not in use in that county, and they need to be simplified in order to be understandable. On the other hand, some believe that the models in their current form are not developed enough and do not answer their needs. Moreover, it seems the politicians are reluctant to get familiar with the models and rely on their project team to understand the model results for them, as well as on their personal judgement. This suggests a disconnection in the use of the models’ results by the politicians, planners and modellers. It is hoped that by using a graphical user interface to visualize and better communicate the impacts of different policies to the policy-makers a connection will be made in the chain delivering the model results, in some way, up to the decision makers. The research finds, however, that the use of such tools can also be counterproductive.

The Israeli case, focusing on the national / metropolitan levels and on transport mega-projects, showed that the decision-making process in transport relies more on modelling than in the UK case. In Israel, the outcomes of modelling exercises are more likely to effect and determine policy choices. However, like in the UK case, the limitations and the weaknesses of the models in assisting decision making are acknowledged by experts in the planning process in Israel. Perhaps due to the magnitude (financially, spatially and politically) of the projects in Israel, in which the use of models was examined it was apparent that the reliance and even belief in the model outcomes was much larger in Israel, with important consequences on the decisions made.

Models have a very important role to play in the policy-making process, but their full potential to support policy choices is constraints for various reasons. The two reasons relate to the complexity of state-of-the-art models and to communications of the model results (and also its assumptions and limitations) to those using it and ultimately those
making decisions. The research finds that there is a difference between what modellers define as a good model and what policy makers define as a useful model. In this research, good model is a useful model and that means the model needs to be tailored to answer the initial planning questions and the policy needs and must be understandable and accessible for policy makers. This suggests that the state-of-the-art models might need to be simple. How to develop such a model is an issue for future research. In general, and before such models are developed there is a need for better communication throughout the policy-making process. Lack of communication between modellers, planners and decision-makers substantially limit the usefulness of models for policy making. To improve the communication a common language between all of the above actors must be developed, and this can only achieved through closer collaboration, including already at the education and training stages of each of the professions involved in policy making and the use of models in it.

Although in theory, the development of models towards more complex and detailed structures is important in order to generate more realistic results, in practice use of such models is problematic. A complex model is not always needed to achieve better results in a decision-making process. What is more important is to ask the right questions; develop models that answer those questions; establish better communication between the actors involved with the use of models in the policy process, including modellers, economists, planners, managers, lawyers, policy makers and politicians; set a feedback and monitoring procedure in order to track the impacts of models and their use on decisions; and establish a platform where practitioners and decision makers, social scientists and modellers can work together in order to engage in each others’ activities and research and also increase their skills through training. Implementing such guidance would help transport modelling reformulate itself.

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1. Introduction

We are facing immense challenges, which are global in nature, in particular in the energy and environment sectors. Action to meet these challenges must be taken immediately and there are numerous options available for each of the specific problems that must be addressed, be it oil depletion (or ‘peak oil’), climate change, or air pollution, and each option often presents further more challenges. Whatever the problem is, dealing with it is largely a question of an appropriate policy that must be tailored and enacted by various institutions at various spatial levels as it is generally accepted that there is a need for a government or other public authority intervention to deal with such issues. A prerequisite for ‘an appropriate’ policy is having good knowledge and understanding of the way and extent to which a certain policy(ies) can be effective in meeting a certain objective(s). Given the complexities involved in gaining such an understanding, let alone tempting to estimate and quantify (in advance) various impacts of policies, there is a need to use sophisticated models to support decision making.

Over the years, even with respect to more recent challenges related to energy and the environment, substantial advances in understanding the above complexities, through the use of mathematical and statistical models and advanced computational power have been made. Despite that, it is not always clear that such advances are helping to shape better policies which will be more effective in meeting the objectives set, especially with respect to environmental objectives. Contrary to that, we often see that despite policy efforts the problems only intensify. There are numerous explanations for this apparently ineffective policy making, the most notable is the political process of policy making, the ‘bounded rationality’ of policy makers, coupled in the case of energy and environment related problems with many (scientific) uncertainties that add to the complexity. Energy and environment related challenges will surely be classified as ‘wicked’ (Rittel and Webber, 1973) or ‘messy’ (Ney, 2009) policy problems, as would transport be.

Nevertheless, there is no doubt that (quantitative) ex-ante analysis of policies has an important role to play in the policy making process and the use of advanced models in such an analysis is critical. In this context, especially two aspects are important. First, do policy makers have access to state-of-the-art models, modelling techniques and the relevant ‘scientific’ knowledge to inform them of the likely implications of policies they are considering? And if not, what are the consequences of this. Second, whatever modelling ‘software’ and ‘hardware’ is available for policy makers for ex-ante analysis, do they use it and if so, how much understanding they gain from it, and how this in turn influence (or not) their policy choices and actions. For various reasons, explored in the research reported below, there seem to exist a gap between the ‘knowledge’ state-of-the-art modelling can provide those tasked with forming and deciding on policies and the ‘knowledge’ they actually rely on and make use of. Understanding this gap and trying to reduce is the motivation for this research.

To address the above questions we focus on one particular policy domain, that of transport. The transport sector is a major consumer of oil worldwide, and its need for oil continues to increase rapidly. Worldwide oil consumption in general is expected to
increase dramatically in the next 30 years, with a quarter of this growth for transportation and the bulk of that for the private automobile. Increases in transport of passengers and goods and the associated increase in oil consumption mean that CO₂ emissions will also continue to rise, with detrimental effect on the climate, alongside a variety of adverse environmental impacts such as air pollution and noise (see Button and Hensher, 2003 for a full review). While in the face of various environmental problems other sectors have reduced their Carbon footprint over time, the transport sector is not successful in achieving this (Figure 1). At the same time, transport is a vital element in increasingly globalized socio-economic networks, often referred to as the blood system of society.

Much of the transport policy analysis relates to understanding ‘travel behaviour’, focusing on how various actors in the transport and mobility system are likely to react to various policy actions. It is this behaviour that is translated, in the energy and environmental context, to oil consumption and emissions. Concern with the environmental implications of increased mobility results in policy makers increasingly required to understand the environmental consequences of various transport policy actions. Especially with respect to ‘travel behaviour’, but also transport more generally, significant advances have been made in state-of-the-art modelling (Cascetta, 2009) which might not necessarily result in more informed policy choices, the gap referred to above. As one of our interviewees, a high official in a national planning system (dealing with all land use planning) noted: “Transport models are the most developed and most influential in the planning process”.

In this context, the objective of the research is:

**To understand the nature of and reasons for the gap in (transport) policy making between the ‘knowledge’ state-of-the-art modelling techniques can provide policy makers with and the ‘knowledge’ on which they base their decisions on.**

As noted, for political reasons, it might be that policy makers ignore the modelling results, or try to only use the modelling process to support pre-decided policies (solutions looking for problems as coined by Kingdon, 1984). While this is an important and unavoidable part of policy making, it is outside the scope of this research, which focuses on the ‘objective’ use of analysis to inform policy making.

This report summarises the research efforts in the project on the use of state-of-the-art models by policy makers to address global energy and environment challenges: the case of transport policy, and is structured as follows. Next, the methodology followed in the research is described and then a literature review is provided that covers the two main aspects of the research: the use of models in policy making and development of state-of-the-art models in transport and their use in policy making. The empirical analysis in the research, reported in the fourth chapter, focused on two case studies which are presented separately, the first considered policy making in the context of one region (county) in the UK and the second looked at the use of models in the Israeli context of transport policy. The report then discusses the main issues and questions arising from the empirical analysis, before conclusions, some recommendations and issues for further research are presented.
Figure 1: Trends in CO2 emission by sector in the EU-27 countries 1990-2007

2. Methodology

The research methodology is composed of two main distinct aspects which complement each other. One aspect focuses on the modelling tools: which models are used, how they compare to state-of-the-art models, etc. The emphasis is on travel demand modelling elements, where major advances have been made in research and practice in recent years. The other aspect focuses on the policy process: how the results from the quantitative analysis (models) are used, are they understood, etc. It is the combination of both that will allow us to come to conclusions with respect to the research objective.

The core of the methodology used in this research is semi-structured interviews and workshops with modellers and decision makers at various levels of governments in Israel and the UK. While in the UK the focus was on one county and its transportation master plan, the focus in Israel was on the metropolitan level and decision making with respect to investments in mass public transport systems. The way transport planning is organised and managed in Israel means the analysis very much reflects also on the use of models at the national level.

Prior to the empirical work, a review of the literature was undertaken with respect to the development of travel demand modelling over time and the benefits from such development, and a review of the literature on the use of (transport) models in policy making.

The interviews aim to cover the degree of familiarity of the respondent with travel demand models, their expectations from the models, their use of the information provided by the models, and whether they can point to the weaknesses and strengths of the models in assisting decision making. The interviews also ask the respondents for their opinion on the models’ impact on the decision making process and on decisions taken. Finally, the interviews aim to try and understand the way the model’s output is displayed to decision makers and how they make use of the information presented to them.

To supplement the personal interviews, two workshops were held during the project as a mean to reflect on the (interim) findings of the research team, to provoke a wider discussion on the main issues with a larger stakeholder group including planners, policy makers, and academics (those participating in the interviews were not included in the workshops), and to enrich the findings from the interviews. The first workshop was held at the Technion, Israel in June 2011, halfway into the project, and the second one was held at the University of Oxford, UK in October 2012 towards the end of the project.
3. Literature review

3.1 Knowledge Utilisation and the use of models in policymaking

The use of models differs according to the area they are used in and their purposes. Models can be used as an eye-opener, in order to draw attention to a new scientific phenomenon; they can be used as tools for challenging opposing ideas by using different methods; and they can be used for creating consensus among different stakeholders and for management purposes as tools to assist stakeholders in policy decisions (Pfaffenbichler, 2011). Here, we are concerned with the last use of models as stated by Pfaffenbichler (2011) which is their use in policy making.

The main objective of every modelling exercise in the decision making process is to produce, based on relevant information, knowledge for different stakeholders to take policy decisions. Therefore, the knowledge utilisation and the use of knowledge gain importance in the debate of model use for decision making. Rich (1997) states that “use may simply mean that information has been received and read; does not necessarily imply that the information has been understood” (Rich 1997). In decision making, reliance on knowledge which is based on the analysis only is rare and decision makers might not use the information from the technical analysis. Porter and Hicks (1994) argue that technical analysis usually serves more of an enlightenment tool than an instrumental function. For knowledge to be applicable it should be influential: “[...] Influence means that information has contributed to a decision, an action, or to a way of thinking about a problem [...]” (ibid). Landry et al. (2001) explain the ways in which knowledge can be used and see knowledge utilisation as a process that has six stages from transmission of the research results to the cognition of them by the authorities, referring to them in reports, showing effort to adopt them in policy making, being influenced by them in their decisions and using them in the application (Table 1). “Each stage is presumed to be more important than the previous one, and the entire scale is cumulative in the sense that all these stages of knowledge use are important indicators and build on each other” (ibid., 405). In the process of knowledge utilisation, there are important measurements to undertake in order to achieve a greater success and climb up the stages of research utilisation. Landry et al. (2001) discuss the criteria for this purpose after conducting a research on knowledge utilisation in Canadian universities. It is important to mention that some of these factors are relevant in this research. First, “users’ context, which is a measure of the receptivity of users to research, significantly explains the climb for the first five echelons of the ladder of knowledge utilisation” (ibid. 408). Secondly, an increase in dissemination efforts such as an increased knowledge exchange between the researchers and the users in early stages of the research makes it more likely for researchers to climb up the stages of knowledge utilisation. Moreover, making products more customised for users and building up social relationships between researchers and users help to increase the knowledge utilisation (ibid.).
Table 1: Stages in the Ladder of Knowledge Utilisation (Landry et al. 2001: 399)

<table>
<thead>
<tr>
<th>Stage 1 Transmission:</th>
<th>I transmitted my research results to the practitioners and professionals concerned.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 2 Cognition:</td>
<td>My research reports were read and understood by the practitioners and professionals concerned.</td>
</tr>
<tr>
<td>Stage 3 Reference:</td>
<td>My work has been cited as a reference in the reports, studies, and strategies of action elaborated by practitioners and professionals.</td>
</tr>
<tr>
<td>Stage 4 Effort:</td>
<td>Efforts were made to adopt the results of my research by practitioners and professionals</td>
</tr>
<tr>
<td>Stage 5 Influence:</td>
<td>My research results influenced the choice and decision of practitioners and professionals.</td>
</tr>
<tr>
<td>Stage 6 Application:</td>
<td>My research results gave rise to applications and extension by the practitioners and professionals concerned.</td>
</tr>
</tbody>
</table>

Second, in addition to the findings of Landry et al. (2001), Gudmundsson (2011) discusses the instability of the knowledge utilisation process by pointing out the possible and often inevitable changes that might occur when the research is in progress. Therefore, apart from the fact that the knowledge needs to be utilised through the process discussed above, it also needs to be produced in a flexible environment. The researchers need to be open to changes that might occur during the knowledge utilisation process. More specific to our research, Gudmundsson (2011) asks whether models or modellers are ready for changes on the context side and in the policy agendas and whether transport modellers are well equipped to detect and respond to those changes (Gudmundsson, 2011: 8). At this point, communication during the process of policy making which is discussed under ‘adaptation of research products’, ‘dissemination efforts’ and ‘linkage mechanisms’ by Landry et al. (2001) gain further importance. Likewise, Pereria and Corral (2002) describes decision support tools as a “platform” that helps involved actors access and negotiate information. Therefore, this platform becomes more than just a machine that produces facts (Pereria and Corral, 2002). Thus, rather than obstructing the delivery of the knowledge by their complex structures, models can become more accessible in a platform where the knowledge is shared, discussed and transformed where necessary.

In order to understand the structure of this platform it is important to define the actors and their relationships within the platform. Landry et al. (2001) simply defines the actors as users, practitioners and professionals concerned and suppliers, researchers who produce knowledge. In the ladder of knowledge utilisation, the interaction between users and suppliers begins before the first stage of the ladder as the suppliers need to communicate with the users, and vice versa, in order to start the process. Following this, suppliers transmit their results to the users and in the next five steps it is the users who evaluate results. However, as mentioned earlier Landry et al. (2001) emphasise the importance of sharing knowledge in early stages of the knowledge utilisation, meaning that the process prior to knowledge transmission is crucial. Furthermore, as the entry to the ladder of knowledge might occur in different stages, the user-supplier interaction can be observed in different stages of knowledge utilisation.
Davidson et al. (2007) stress the importance of communication between modellers and practitioners in order for transport planners to understand how the new approaches can better address their planning needs. According to Schofer (2007) from a practical standpoint, relationships seem to thrive best in environments where there is more communication, flexibility and focus on meeting the business needs of the transportation agency. At the same time, lack of communication can create barriers to planning and decision making. In a study exploring the barriers to decision making in transport in the UK, May et al. (2008) demonstrate the challenges that different actors face during the planning process. With the help of surveys conducted with local authorities they found that there is a lack of contact between different departments of local authorities, transport operating companies and business interests in terms of providing and obtaining data. A vast number of published articles can be found in the literature exploring the problems in decision making process and how to overcome these. For instance, a series of strategies for achieving participation at different levels of decision making in transport are presented by May (2005) in a guidebook for decision makers where the importance of consulting different interest groups and making decisions together with those groups are highlighted.

There is no single way to formulate the decision making process. Apart from understanding the knowledge utilisation, and the use and sharing of knowledge between different interest groups, there is a need to understand the use of different planning tools that support decision-making. In the case of transport policy and planning, models are arguably the most important tools for decision making. According to Vickerman (2008), in policy making, models can be used in as decision tools in themselves or as aids to the decision making (Vickerman, 2008: 2). Although the former is not so common, in both cases the use of models contain a certain level of interpretation, applied mainly by the modeller, and this can create ambiguities in the decision making process.

Models carry the risks of being adapted to the purpose of the policy as both the input and the output of the models can be interpreted according to the policy decision. As Niess (2011) states models may share with other knowledge technologies the fate of being used politically rather than analytically, perhaps even distortively rather than supportively (Niess, 2011). Although it is acknowledged, such use of models is outside the scope of this research.

Models can predict what is likely to happen in the future but their results would not be meaningful unless they fulfil some important criteria. As Curtis (2011) states “first, a transport tool can achieve overall success where it meets the demands in each of four dimensions – conceptual, operational, communicative and institutional”, some of which were discussed earlier, and “second, knowledge may be accepted where there is trust which can provide the condition for credibility or legislation of the tool” (Curtis, 2011: 195). Moreover, Jonsson et al. (2011) mention that tools used to support the decision, in this case the models, need to be both effective and efficient. The importance of using the appropriate model for particular problems is mentioned, the planners or modellers need to make sure that the models meet the needs of the planning process. Furthermore,
models need to be designed to facilitate the process for their users; the users need to be able to adjust the model to answer specific questions (Jonsson et al., 2011).

Models can also carry the risks of being too complicated, time consuming and expensive. Previous research suggests that the tools offered by scientists to support planning and transport practices are “too complex, too narrowly focused, incompatible with unpredictable/flexible nature of planning, overwhelmingly focused on technological tools and not addressing the wide variety of actors involved in the planning process” (Pfaffenbichler, 2011: 270; also see Vonk et al., 2005). Therefore, they might not be preferred by politicians as a method to support decision making. Brömmelstroet and Bertollini (2011) draw attention to the results of an international conference which were later published in a special issue of Transport Reviews in 2011 where the need for models to support the learning process of different interest groups is underlined as well as the need for those groups to understand the basic philosophy and assumptions of models. Moreover, as mentioned earlier, the need to enhance the relationship between the model developer and the model user is emphasised along with developing a common language among transport modellers with the “people that are not insiders in the domain of modelling” (Brömmelstroet and Bertollini, 2011).

The literature on the use of models in decision making suggests that there is a gap between the production of knowledge from the use of models and the usage of such knowledge. In order to close this gap, the actors involved need to reach a better understanding of the decision making process that is combined with transparent, understandable, reliable, user friendly, efficient and flexible tools or models. This gap, which is the focus of this research, is very much related to development of the models over time, development which aims to increase and improve the production of knowledge for those tasked with making (transport) policy decisions. This development of models is described next.

### 3.2 Development in state-of-the-art travel demand models

Travel demand modelling is an important element in the transportation decision making process. Its main objective is to produce information on the potential impact of various transport projects and policies on travel demand. Such information is crucial for evaluating the benefits of such projects and policy measures, and to estimate likely environmental impacts of these projects and policies, thus helping in guiding policy makers in the decision making process. Over the last 60 years, many travel demand models have been developed, providing quantitative analysis and travel demand forecasts which affected decision making.

Travel demand models can be classified in many ways. Although in principle all models use similar type of input and provide similar type of output, there are large differences between categories of models. The most significant one is their ability to provide different levels of behavioural realism in order to represent travellers’ response to various policy actions. Increasing the level of behavioural realism result in, or is achieved by, growing computational complexity. This growing computational complexity results in
significant differences between categories of models with respect to development costs, time development, and the required level of expertise and computational resources for the implementation of a model. It also seems to have a detrimental effect on the use of models in the practice and in their use in the policy decision making process, contributing to the gap mentioned above. However, model development are sought and made first of all to provide better, more “realistic” evidence to support the decision process. How models’ development contributes to better knowledge production is described below.

There are three main categories of travel demand models: 1) the simplest “Sketch planning model” which provides aggregate results that allows only a simple analysis, 2) the “Four step model” which for many years has been considered as the main method in transportation planning, and 3) the “activity based models” representing current state-of-the-art in travel demand models. These three model categories are presented below with examples of their applications in planning. The focus is on the last of these models and its main advantages for policy making.

The Sketch Planning Model
For many years, the main emphasis in transport modelling has been to enrich their behavioural content and improve data-collection methods as a means to enhance their accuracy, realism and reduce costs. A parallel line of research has sought to improve transport modelling by emphasizing the use of readily available data and the communicability of simpler models features and results. This stream of research has had an important impact in practice as it offers not only reduced costs but also simplified data collection and processing requirements (Ortuzar et al, 2001). The main rational for using simpler and quick models is that consultants and modellers are often asked to study transport proposals in very short time, and with limited (financial) resources and data. This applies especially for the use of models in small and medium size cities and for relatively small-scale projects.

Such a simplified model approach is the Sketch Planning Model, which was developed specifically to provide quick response with limited data collection requirements. This tool has been put forward by many authors as suitable for long range planning and for enabling a relatively fast and inexpensive study of transportation alternatives (OECD, 1974, Sossllau et al., 1978).

Sketch planning models are usually implemented using spreadsheet software (e.g. Excel) and require relatively limited amount of input data (Carlson et al., 2005) including data on the study area (e.g. population, employment level, land use), the transportation network within it (e.g. the road network length, capacity, speed restrictions on various roads), travel patterns (e.g. mode split, Vehicle Miles Travelled (VMT), vehicle occupancy, and peak period information), and information concerning the proposed project or policy. The model outputs may include various levels of travel demand forecast including vehicle miles of travel (VMT), mode split, travel time shifts from peak hour to off peak hour and emissions forecast. The model is usually applied at an
aggregate level, and its input and output, even though may appear detailed, are superficial, based on readily available data, approximations, and rules of thumb rather than on in-depth study and detailed analysis. Therefore, the model is limited in dealing with complex planning that requires a broad study of behavioural patterns and detailed travel habits.

Sketch planning models are composed of two main components: travel impacts and emissions impacts. Usually they do not include a network representation and assignment. The travel impacts component produces forecasts of mode share changes as a result of changes in the level of service and translate these into changes in trips and VMT. The model is based on existing (and approximated) mode shares, relevant change in level of service (travel time for example) and coefficients of these variables as input, thus it cannot provide the full details needed for high-quality forecasts. Furthermore, the second component use the output information, such as changes in vehicle miles of travel (VMT) as an input for the evaluation of emissions and air quality, and therefore can only approximate them.

Case study- COMMUTER v2.0 (Carlson et al., 2005)

The COMMUTER model was developed by the US Transportation and regional programs division, Office of transportation and air quality and the Environmental protection agency to help simplify the effort required to estimate travel and emission effects resulting from Transportation Control Measures. The model can also be used to estimate the benefits of site-specific Commuter Choice programs to assist employers in designing an employer-based transportation program appropriate for them. The policy means which can be evaluated, either for a defined region within an urban area or for individual employers, are:

- Public transport fare decreases or other incentives that reduce the cost of using public transport;
- Public transport service improvements (faster or more frequent service);
- Ridesharing programs, in which employers support carpooling and/or vanpooling through on-site programs, financial incentives, or preferential parking;
- Other actions, such as increased parking charges or cash-out programs, that change the time and/or cost of traveling by any particular mode;
- Non-motorized transport commuting programs;
- Alternative work schedules, including flex-time, compressed work weeks, and staggered work hours; and
- Telecommuting.

The travel impacts component of COMMUTER is calculated by Pivot Point Logit Mode-Choice model (PPLMC). This model takes advantage of the Logit model structure which allow to calculate changes in mode shares based on existing mode shares, change in level of service (travel time for example), and the coefficients of this level of service only. Such coefficients are usually taken from mode choice models which have been eveloped for many cities and regions in the US. The emissions component of the COMMUTER model is based on EPA’s MOBILE6.2 model. Figure 2 presents the structure of the COMMUTER model.
Another empirical application of the sketch planning model is the Sketch Planning Analysis Spreadsheet Model (SPASM), which was developed by the US Federal Highway Administration in order to estimate the impacts of urban transportation alternatives in small and medium-sized urban areas (SPASM, 1998).

**The Four Step Model**

The four Step Model (FSM) is the dominant approach in the history of travel demand modelling (McNally, 2000). The FSM was developed in the 1950's at the time of the construction of the interstate highway system in the US as an analytical tool for evaluating the impacts of infrastructure investments and to assist decision making concerning the road network. As its name indicates, the FSM consists four main steps, each answers a simple question related to travel demand forecasting (see below). The model simplicity and logical structure led to its great popularity.

The FSM was developed to deal with regional applications characterized by complex road and public transport network, where direct demand functions and standard link-performance functions (that capture the relationship between travel time per unit distance and traffic volume per unit time on the links of a network), such as used in the sketch planning model, cannot provide the desired information on traffic flows. Although there is some theory misspecification regarding this type of models, as they are based on travel data rather than desirable activities which generate demand for travel, this
approach introduces more sophisticated and theoretically sound models, compared with the sketch planning model, based on ‘supply and demand’ economic theory.

Implementation of the FSM requires detailed input data. The primary need is for data that describe travel behaviour, and these are gathered via a variety of survey efforts. Household travel habit surveys with travel-activity diaries provide the main source of data required to estimate the FSM. Additional data regarding observed traffic (counts and speeds) are used to calibrate and validate the models.

Household travel surveys provide:
1. Household and person-level socio-economic data: typically including income and the number of household members, workers and cars.
2. Activity-travel data: typically including, for each activity performed over a 24-hour or longer period, the activity type, location, start time, duration, the mode, departure time, and arrival time.
3. Auto ownership data.

Stated Preference Survey is an optional extension to the household travel surveys, allowing examination of new public transport infrastructure or policy measures. In such surveys, respondents are asked how they would respond to some hypothetical scenario in the context of their activity and travel behaviour.

FSM models are aggregate models where the study area is divided into Traffic Analysis Zones (TAZ) which are geographical zones usually characterized by a uniform properties of land use and socio-economic status (neighbourhood, industrial or commercial zone, rural area etc.) representing the collected data as an aggregate socio-economic, demographic and land use data in the zone. The number of TAZs, based on the model purpose, data availability, and model vintage, can vary significantly - from several hundred to several thousands. In addition, advanced FSM models use feedback technique between the various steps in order to achieve equilibrium between demand and supply, and maximum precision.

The four steps of the model, and the question each steps answer, represent four different models (McNally, 2000):
1. Trip generation (Production/Attraction): how many trips are generated?
The objective of this first stage of the FSM process is to define the magnitude of total daily travel in the model system, at the household and zonal levels, for various trip purposes (activities). This first stage explicitly estimates the total number of trips produces in and attracted to each of the TAZ. The trip generation step is usually not sensitive to level of service, i.e. to the network performance. Generation essentially defines the total volume of travel in the study area and the remaining steps distribute this volume in space, determining the mode used and the route taken.
2. Trip distribution: where do the generated trips go to?
This model distributes the trips generated from each TAZ to the different TAZ, thus producing a matrix of trip production and attraction (T_{ij}) as a function of the activity system attributes and the network attributes (typically inter-zonal travel times).
3. Mode split (choice): what modes will be used for the generated trips?
These models are now almost exclusively disaggregate models, reflecting the mode choice probabilities of individual trip makers. The model, which can also be estimated on separate choice based sample, reflect a range of performance variables and trip maker's characteristics to produce disaggregate results which determines the mode choice probabilities of individual trip makers. The results must be aggregated at the zonal level to generate mode specific trip tables - Modal Origin-Destination trip matrices - prior to assignment (the next step). Many recent mode-choice models reflect current policies and include mode choice such as carpooling, and assess public transport mode choices resulting from high occupancy vehicle facilities and the presence of road pricing. The most common model techniques are the logit and nested logit models.

4. Assignment: which routes will be taken?
In this last step of the FSM, equilibrium of demand and supply is finally presented on the road network while the Modal Origin-Destination trip matrices are loaded onto the modal networks, usually under the assumption of user equilibrium where all paths utilized for a given Origin-Destination pair have equal impedance (for off-peak assignments, stochastic assignment is often used, which tends to assign trips across more paths, and thus better reflect the observed traffic volumes in uncongested periods. As mentioned above this step is usually not included in sketch planning models.

The time dimension (time of day) is typically introduced after trip distribution or mode choice, where the production- attraction tables are factored to reflect observed distributions of trips in defined periods (such as a.m. or p.m. peaks). In the assignment step it is assumed that the trip matrices are fixed. Advanced applications of the FSM feedback equilibrated link travel times to the mode choice and/ or trip distribution models for a second pass (and occasionally more) through the last three steps, but no formal convergence is guaranteed. The model output, including Origin-Destination trip matrices by mode and their effect on the road network including volumes and speed for all network links, are used for evaluation of investments in road infrastructure.

The standard model structure (Figure 3) is relatively inflexible. The order of the steps is well-defined and usually not changed. Possible changes are related to the use in the feedback techniques, and additional side models as a supplement to the standard FSM model.

*Case study: Travel Demand Forecasting Model*

The Travel Demand Forecasting Model was developed by the Israeli Ministry of transport together with NTA (a government-owned company charged with establishing the mass public transport system in the Tel Aviv metropolitan area) and PGL (an Israeli consulting firm) in the late 1990's for the metropolitan area of Tel-Aviv (NTA-Metropolitan Mass Transit System and Ministry of Transport, 1999). The purpose of the model was to refine and update the travel demand forecast for 2020, which has been used in the pre-feasibility phase of the first mass public transport system project (known as the Red Line).
The Travel Demand Forecasting Model project included several activities, ranging from producing updated urban scenarios to calibrate transport demand models based on the 1995 National Census and the 1996/7 National Travel Habits Survey (NTHS). The model aimed to cover the total metropolitan area of Tel-Aviv. In addition to the national surveys, the model is based on two additional transportation surveys conducted within the metropolitan area: a stated preference survey intended to be used for the calibration of a new modal split model, and a cordon and screen line survey to produce data for the calibration and validation of the model.

**Figure 3: The FSM structure**

The model structure is based on the standard four-step travel demand paradigm, with feedback procedures for the combined modal split and assignment, and the combined distribution and assignment. Moreover, the model includes hourly distribution as a supplement model to the distribution model.

The model was used to forecast for two horizon years: 2010 and 2020. Five principal trip purposes were defined for personal travel: Home-Based Work (HBW) - trips from/to home to/from the work place and from/to home to/from work related activities; Home-Based Education (HBE) - trips from/to home to/from school (any level), university, and other regular extracurricular activities; Home-Based Shopping (HBS) – trips from/to home to/from shopping activities; Home-Based Other (HBO) - trips from/to home to/from all other purposes; and Non-Home-Based (NHB) - trips with none of the trip ends at home. The model was structured to produce travel forecasts for five different...
average hour time periods during an average weekday as follows: morning peak-hour – 7
to 8 (according to the NTHS data, there is a significant peaking of trips during the
morning peak period); other morning peak-hours – 6 to 7 and 8 to 9; morning off-peak
hours- 9 to 12; mid-day peak hours – 12 to 15; and evening peak hours – 15 to 19. Other
properties of the model are shown in Table 1.

Table 1: The Travel Demand Forecasting Model properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizon Years</td>
<td>2010, 2020</td>
</tr>
<tr>
<td>Land Use / Demographic Data</td>
<td>Regional master plan (TMM3/5)</td>
</tr>
<tr>
<td>Trip Purposes</td>
<td>5</td>
</tr>
<tr>
<td>Time Periods</td>
<td>5***</td>
</tr>
<tr>
<td>Market Segmentation</td>
<td>Auto Ownership, Driver license</td>
</tr>
<tr>
<td>Zonal System</td>
<td>600 zones + 20 Subdivision zones</td>
</tr>
<tr>
<td>Trip Production Model</td>
<td>Cross-Classification</td>
</tr>
<tr>
<td>Trip Attraction Model</td>
<td>Regression Analysis</td>
</tr>
<tr>
<td>Trip Distribution Model</td>
<td>Gravity</td>
</tr>
</tbody>
</table>
| Modal Split                            | Nested Logit (3 Main modes, 2 Private Sub-
                                          Modes, 10 Mass public transport sub-modes, 4
                                          access modes)                               |
| Feedback Procedures                    | Assignment, Mode Choice, Distribution        |
| Transportation Software                | EMME/2, TransCad (GIS)                       |
| Basic Data for model Calibration       | 1996/7 NTHS and 1995 Census                  |

Two other examples for the application of the FSM are The Dallas-Fort Worth Regional
Travel Demand Model (DFWRTM) software application\(^1\) which provides technical
support and staff assistance to the Regional Transportation Council of The North Central
Texas Council of Governments (NCTCOG), and the Metropolitan Washington council of
government (MWCOG) FSM\(^2\) for the Evaluation of the National Capital Region's
Financially Constrained Long-Range Transportation Plan (CLRP) supporting ongoing
corridor and sub-area studies, which are typically performed for member state and local
governments with consultant assistance, and also used to examine the mobility of various
population segments.

Activity based model

Activity Based Models (ABM) are currently the state-of-the-art in travel demand
modelling. This new approach, which has long been recognized in the literature had its
first applications was in the early to mid 1990’s, emerged as a result of the change in
transportation planning - the shift from focusing on large investments in infrastructure to
travel demand management measures such as parking and congestion pricing - and the
need to analyse travellers’ response to new (demand management) policies. It was argued
that FSM suffers from poor forecasting accuracy due to the models’ theoretical miss-

\(^1\) See http://www.nctcog.org/trans/modeling/documentation/DFWRTMModelDescription.pdf
specification (Jovicic, 2001), i.e. their inability to recognize the existence of linkages between trips and between trips and the participation of an individual in an activity since they are calibrated and applied at the aggregate level of geographical zones (the TAZs mentioned above).

The ABM development was motivated not only by the need to have a model that is more sensitive to a wider range of policies, but also by the need to address environmental and social (equity) issues, capabilities that are missing in the sketch planning and FSM models. The ABM model can better provide such capabilities by explicitly recognizing that the demand for travel is derived from the demand for activity participation including why, when, with whom, how long, and the sequence of those activities (Bhat and Koppelman, 1999; Goulias et al., 2004). In other words, the need, or desire to engage in an activity at a different location generates a trip. Once we understand how activities are engaged in the course of a day or a week, a rigorous understanding of travel demand will follow.

Other theoretical advantages of the ABM approach include specification of the interrelationships between travel, activity participation and scheduling; the identification of spatial and temporal interrelationship between all trips and activities comprising an individual’s activity pattern; establishment of distinct set of alternatives available to the traveller in particular circumstances; and relation to alternate decision strategies involving household dynamics, level of information, choice complexity, and habit formation (Khademi and Timmermans, 2011). The ABM is a disaggregate model estimated at individual traveller level, thus accounting for variance among individuals and hence better explaining travel behaviour. The mode choice, destination choice, route choice, etc. aggregate level models are replaced in the ABM by multidimensional models of individual level travel choices.

The theoretical and technical properties of the ABM briefly mentioned above provide several key advantages to the ABM, including:

- Inclusion of a wider range of variables which influence behaviour, and thus increase the accuracy and relevance of the models for policy analysis. Furthermore, they provide a framework that would allow modelling a wider range of individual’s decisions such as whether or not to obtain a driving licence, the choice of the number of cars to own, and the choice of residence and working places (Bradley et al., 1993).
- The ability to consider secondary effects of an examined policy. Secondary effects are those adjustments to an activity pattern that are made in response to a primary impact. For example, a public transport subsidy may result in a commuter changing the mode of travel from drive alone to public transport for the trip between home and work – the primary effect. However, because the person no longer drives to work, it is not possible anymore to stop on the way home to buy groceries. Therefore, when the person returns home by public transport, it is now necessary to take the car and drive to a nearby store – the secondary effect (Shiftan & Suhrbier, 2002).
- The ability to consider induced travel - the generation of new trips as a result of improvement to the transport network (a type of secondary effect, also known as a rebound effect) as well as trade-offs between activities that require travel and those
that can be completed without travel. In the four-step model there are usually no level-of-service variables in the trip generation model, and therefore the model cannot account for generated travel. In the disaggregate ABM system, accessibility variables are fed from each level to the level above it and in this way changes in the level of service by the new or improved infrastructure can change not only the mode or destination of travel but also the amount of travel (Shiftan & Suhrbier, 2002).

Most of the practical activity based models were developed after 1990 for several reasons (Jovicic, 2001) including:

- Slow theoretical development and lack in computation power in the early years after the first presentations of the ABM approach, while the trip based modelling continued to develop, producing increasingly satisfactory forecasts.
- The emergence of new policies – such as demand management policies (e.g. road pricing) - and the increasing awareness for the need to assess environmental impacts from transport such as noise and air pollution impacts to which the activity based model is a better modelling tool.
- Technological improvements in telecommunication and the increase use of the internet and cellular phones have resulted in new possibilities and habits such as flexible working hours, telecommuting, self-employment, part time working arrangements, teleconferencing and purchasing via the internet all influence demand for travel in a way that can only be estimated with the activity based travel demand model.

Although there is no single model structure for the ABM, most of the ABMs kept the Portland model structure (Bowman et al. 1998) - the first implementation of ABM. However, several models that use a different model structure do exist, for example the Tel- Aviv ABM (Shiftan et al. 2006).

The advantages of the ABM in evaluating specific transport policies, and especially demand management policies was emphasized by Davidson et al. (2007) and Khademia et al. (2011) and is illustrated below.

**Parking policy:** while conventional models calculate the parking charge for each trip by the fixed parking charge in the trip’s destination TAZ, without accounting for the type of individual (resident, disabled, etc.), duration of parking, and the differences between parking facilities within the TAZ, the ABM allows to simulate the daily schedule of individuals thereby accounting for individuals’ characteristics, parking facility and parking duration. Thus, the model results provide better information for policy makers and allow a more realistic examination of policies such as different hourly and daily rates, including various discounts that may vary between individuals.

**Congestion pricing:** estimating the impact of congestion pricing on travel habits requires assessment of drivers’ willingness to pay. This feature depends significantly on personal characteristics (gender, household income, household size, etc.) as well as travel characteristics (trip purpose associated with activity type) and activity pattern during the day. The FSM model is limited in its ability to deal with such details, and therefore its
estimation of congestion pricing is based on rough averages of the willingness to pay, which result in aggregate biases. Similarly, the ABM is better fit for purpose when considering High Occupancy Vehicle (HOV) and/or High Occupancy Toll (HOT) lane policies.

**Demographic changes and equity evaluation:** while the FSM account for demographic characteristics at the aggregated and predefined TAZ level, the ABM is able to capture demographic variation within the TAZ – including socio-economic classes, ethnic groups, aging population, etc. One of the main advantages of the ABM is that it can analyse changes in travel behaviour by various groups in response to different policies by accounting for income, car ownership or any other variable of interest. This allows to analyse the equity impacts of various policy measures.

**Environmental justice:** the ABM approach has few advantages when considering emissions and air quality purposes, including:
1) Its Ability to capture secondary effects (rebound effects) such as induced demand created in response to the policies examined which dramatically increases the accuracy of travel demand forecasts compared with the traditional models.
2) The ABM predicts trips as parts of tours (several linked trips), and tours as part of a daily activity pattern. Hence, the ABM can predict the start and end time of each trip and time between trips allowing to determine whether a trip is a cold, or a hot start.
3) The model can identify start location, as car age and class and therefore provide better trip data for micro-simulation model in order to obtain driving profiles (acceleration and speed profiles) (Shiftan, 2000). All the above result in a much better emission and air pollution analysis and to more informed policy choices.

**Case study- Portland model**
As noted, the first operational implementation of the ABM approach was the Portland model (Bowman et al. 1998). In this model, the demand for activity and travel is viewed as a choice among all possible combinations of activity and travel in the course of a day. As shown in Figure 4, the schedule consists of a set of tours tied together by an overarching activity pattern. The pattern extends the linkage to include all the tours that occur in a single day as well as at-home activities, thereby explicitly representing total daily demand and the ability of individuals to make inter-tour and at-home vs. on-tour trade-offs. For example, the model can capture the choice between combining activities into a single tour and spreading them among multiple tours, incorporating the factors that influence this type of decision. Many situations of interest, such as demand management programs, Intelligent Transportation System (ITS) deployment and increase in fuel prices, can induce these kind of activity and travel schedule responses.

In the model, tour decisions are conditioned, or constrained, by the choice of activity pattern. This is based on the notion that some decisions about the basic agenda and pattern of the daily activities take precedence over details of the travel decisions. However, the choice of pattern is not independent of the conditional tours decisions. Rather, the relative attractiveness, or utility of a pattern depends on the expected value of the maximum utility to be gained from its associated tours. Through this expected utility, the pattern’s choice probability is a function of the attributes of all its available tours...
alternatives. This relation captures sensitivity of pattern choice, including inter-tour and at-home vs. on-tour trade-offs as mentioned, to spatial characteristics and transportation system level of service, and is a very important feature of the model system.

The model system contains five main sub-models organized in a hierarchal structure (Figure 4). At the highest level is the activity pattern model, which determines the purpose a person’s primary and secondary activities of the day, and tour type (114 alternatives in total). The following level is the time of day model, which predicts the combinations of departure time from home and departure time from primary activity (5 time periods and 15 logical alternatives). On the third level, mode and destination choice models are applied for each tour. The next levels are the work-based sub-tour model, which is a mode-destination choice model based on the mode used to go between home and work; and the intermediate stop model, a choice model for making an intermediate activity during a given half tour.

**Figure 4: Portland activity Schedule Model system**

Other examples for the implementation of the ABM approach are the San Francisco ABM (SF Model) (Jonnalagadda et al., 2001) developed as part of an overall tour-based travel demand forecasting model to provide detailed forecasts of travel demand for various planning applications for the San Francisco County Transportation Authority; and the Florida Activity Mobility Simulator (FAMOS) (Pendyala et al. 2004) for analysing the impacts of alternative transportation policies.
3.3 Behavioural Realism and Model Complexity – the pros and cons of developing state-of-the-art models

The move from sketch planning model to the four-step model and later to the activity based model increases the models’ behavioural realism – the extent to which the models represent, or capture reality. But, as Shiftan and Ben-Akiva (2011, p: 518) states, “in an effort to enhance behavioural realism, however, and to make the [model] applications sensitive to a wide spectrum of current planning and policy needs, these applications [of ABM] have reached a significant level of complexity, to the point of risking their practical use”. These tradeoffs between realism and complexity is illustrated in Figure 5, which shows conceptually how the move from trip-based (four-step) models to more advanced models increases behavioural realism and at the same time computational complexity. Figure 6 shows the same concept, but the computational complexity curve has been converted to computational simplicity so that both curves together sum up the model benefits. In this sense, as the model become more complex, or less simple, its benefits for policy making and for policy makers decreases. “For activity-based models to have the desired behavioural realism, they need to be theoretically sound and at a sufficient resolution to explain policy impacts” (Shiftan and Ben-Akiva, 2011, p: 520).

Weighing the advantages, illustrated in section 3.2, brought by the development of new models against the disadvantages of such developments, especially when accounting for the challenges in utilising the knowledge such developments can produce, as explained in section 3.1, is a real dilemma. From a research perspective there seems to be no dilemma, as efforts to further increase the behavioural realism of models continue (move to the right in Figures 4 and 5) with further development of the state-of-the-art models and the inevitable consequence of increasing complexity. To examine the extent to which this contribute to increasing the gap that exist, as noted earlier, between the production of knowledge from the use of models and the usage of such knowledge we turn to examine the use of models in real life policy making.
Figure 5: Behavioural realism and computational complexity in travel-demand models

Source: Shiftan and Ben-Akiva, 2011.

Figure 6: The relationship between Benefits, behavioural realism and computational simplicity in travel-demand models

Source: Shiftan and Ben-Akiva, 2011.
4. The use of models by policy makers

4.1 Evidence from a UK county-council

4.1.1 The policy process and models used in it

The first fieldwork of the project took place in a medium-sized county council in the United Kingdom. In the UK, the Department for Transport (DfT) is the regulatory body for national, regional and local transport plans, and responsible for determining the overall vision for transport in the UK. The department sets the policies and strategies and establishes relationship with the agencies that deliver its policies at different levels. At the local level, the Local Transport Act 2008 is the latest legislation for the local transport plans. The Act covers a variety of areas from regulations for the Local Transport Plans (LTPs – see below) to the organisation of buses and the quality of service. In the UK context, the focus of this project is the decision making process related to the LTPs and how the models are assessed and used within it.

The Local Transport Plans are important tools “to help each local authority work with its stakeholders to strengthen its place-shaping role and its delivery of services to the community” (DfT, 2009a: 5). Although the DfT sets the main policies and strategies for the LTPs, the Local Transport Act 2008 (and previously 2000) requires local authorities to produce Local Transport Plans every five years starting from 2001-06. The DfT publishes several policy documents as well as guidance documents for the local authorities. The main guidance tool is the newly developed web-based Transport Analysis Guidance (WebTAG – see http://www.dft.gov.uk/webtag/) which is produced by the DfT in line with the Green Book - an appraisal and evaluation document produced by the central government. The WebTAG consists of three units: introducing government policies and planning appraisal tools; demonstrating guidance documents for project managers including policy instruments and regulations; and presenting a more technical guidance for experts.

In terms of Local Transport Plans both NATA (New Approach To Appraisal) and SEA (Strategic Environmental Assessment) are important assessment tools. NATA is in line with the DfT's Sustainable Development policy statement and the Department's guidance Better Policy Making: Integrated Policy Appraisal (IPA). According to DfT (2009b), NATA is seen as a “form of multi-criteria analysis, in that the appraisal summary provides information about all of the impacts of a proposal” (DfT, 2009, p. 29). By this, DfT implies that NATA complements the more traditional cost-benefit analysis (CBA) by including impacts that are only measured qualitatively or that can be quantified, but cannot be monetized. SEA is a tool for assessing the impacts of certain plans and programmes including Local Transport Plans and Regional Transport Strategies on the environment and is in accordance with the requirements of European Directive 2001/42/EC. The objective of the SEA Directive is “to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development” (European Commission, 2001: Article 1). Local
authorities need to follow the SEA Directive (see stages in Figure 1) and the NATA stages (see http://www.dft.gov.uk/webtag/documents/project-manager/unit2.11.php).

**Figure 7: Stages, decisions and outputs of SEA**

Source: DfT WebTAG (http://www.dft.gov.uk/webtag)
SEA is broadly consistent with NATA and should be carried out as part of the NATA process” (ibid.). According to Figure 8, the SEA process is carried out as a part of Stage 7 that includes other appraisal tools and procedures such as transport models or land use/transport models, and Cost-Benefit Analysis procedure (ibid.).

Apart from the NATA and the SEA Directive, local authorities need to meet other requirements such as assessing the wider impacts of transport plans, providing an inclusive transport programme for local communities and considering social and distributional impacts of transport interventions, as proposed in the WebTAG.

The DfT strongly advises local authorities to consider different methods for making their decisions and suggests that it is sensible to consider whether a model is necessary or not for local transport plans as the creation of a transport model is costly and time consuming (DfT, WebTAG). However, the DfT presents an extensive section on WebTAG about general principles of transport modelling, choice of modelling approach, transport-land use interaction models, data sources and the level of detail of the models. As seen in Figure 7, modelling can be used for understanding the current and the future situations, thus, used in the early stages of planning.

The medium-sized county council used as the UK case study in this project has recently prepared its third LTP which will be effective from 2011 to 2030. The planning process of the LTP3 has been slightly different than the previous two LTPs. First of all, unlike the previous plans which were for 5 year periods, LTP3 is a long term plan with a projection year of 2030. In this sense, LTP3 can be seen as a long-term plan that aims for consistency in policy making. Second, the need for making a plan which would cover a longer period was suggested by the county council, not by central government. In this sense, LTP3 can be regarded as a bottom-up process, based on local needs and values. Third, the objectives of the plan were determined by the county council based on consultation with the public and the cabinet members and not given directly by the government as in the previous plans.

The County Council determined four local transport goals based on the national and regional goals proposed by the central government. These are:

- To support the local economy and the growth and competitiveness of the county
- To make it easier to get around the county and improve access to jobs and services for all by offering real choice
- To reduce the impact of transport on the environment and help tackle climate change
- To promote healthy, safe and sustainable travel

The LTP3 process followed four main steps before presenting the final plan to the Cabinet. The steps are: identifying the objectives, deciding on the policies, setting the scenarios and preparing the first draft of LTP3. Figure 8 which is based on the publicly available documents on the County Council’s website and our interview with the head of the Local Transport Planning Group represents these four initial stages.
As seen in Figure 8, each step of the LTP3 involved public, NGO and stakeholder consultation and important decisions are made according to the consultation results. The county council adopted the plan as a policy on April 2011 following its approval by cabinet in March 2011.

**Figure 8: Four steps in the LTP3 process**

4.1.2 The use of models in the policy process

The models used in the LTP3 process described above vary from traffic models to accessibility models and policy simulation tools. These models use various software: SATURN - Traffic model; Emme2 – Travel demand forecasting software; Accession - Accessibility model for public transport; VISSIM - Microsimulation Model for small scale projects; and Intra-SIM - a transport policy simulation tool for decision makers. SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is a package of network analysis programs developed at the Institute for Transport Studies at the University of Leeds in 1981 (SATURN, 2011). Although it can be used for large networks, “SATURN is most suitable for the analysis of relatively minor network changes such as the introduction of one-way streets, changes to junction controls, bus-only streets, and whose evaluation requires a detailed analysis of traffic behaviour at junctions” (ibid.). Emme2 is a travel demand forecasting system for urban, regional, and national transportation planning (Inro, 2011). It provides a flexible approach to modelling that “allows users the freedom to leverage established techniques or create new methods to address local needs” (ibid.) Emme2 was designed in 1980s and has been improved since; the newest version of this programme is Emme3 (ibid.). Accession is a software package that uses GIS to map travel time, cost and distance indicators for public transport. It was designed by the UK Department for Transport and developed by MVA.
and Citilabs (Basemap, 2011). VISSIM, as mentioned above, is a microscopic simulation program for multi-modal traffic flow modelling and has been developed by the PTV AG, a company based in Germany (VISSIM, 2011). It can simulate, at high level of detail, urban and highway traffic, including cyclists and motorized vehicles. Finally, Intra-SIM is a decision support and simulation model. “The model allows multi-criteria analysis, for example consideration of low carbon transport pathways and wider economic and social impacts. The model is being used in the LTP and Delivering a Sustainable Transport Strategy (DASTs) regional studies” (TSU, 2010).

In line with the above description, the software packages mentioned above have been used for different purposes in the LTP 3 process. The SATURN and Emme2 packages have been used to plan the traffic flow on highways and junctions whilst the Accession software has been used to rearrange the bus network. In order to plan new housing developments within the county, the microsimulation tool, VISSIM, has been used. The purpose of the Intra-SIM was to estimate and show potential changes in a number of key indicators for the different scenarios that were developed for the LTP3. With Intra-SIM, mainly the short and medium term (up to 2026) changes have been assessed and presented in the SEA. Intra-SIM can be described as a graphical user interface that communicates to the user, policy makers at the council country in this case, the effect of different policies on different criteria (e.g. air pollution) across the county are estimated, partly by some of the other models mentioned above.

The Intra-SIM model is especially relevant for the purpose of this project as it aims to create a platform where policy makers can make sense of the modelling results and the plans that are produced in the process. In this sense, Intra-SIM is a testing ground for policies.

Except for Intra-SIM, which is used at a later stage of the planning process, the models mentioned above were mainly used in the first step of the process when determining the objectives. Yet, the VISSIM model was also used later on to develop the policies and the scenarios, where Intra-SIM plays a major role.

In order to understand the roles and use of models in the decision making process of the LTP preparations, four interviews were conducted with the planning group and the cabinet member for transport between March and May 2011. The interviewees were with:

- Head of the Local Transport Plan Group (Policy analyst)
- Team leader of the local area transport team (Planner)
- Cabinet Member for Transport (Politician)
- Consultant\(^3\) (part-time) Intra-SIM project leader (part-time Senior Researcher)

---\(^3\) This interview was conducted in order to understand how the Intra-SIM model works and as such is not included in the report. For a more detailed review of interactive simulation tools see [http://www.vibat.org](http://www.vibat.org) or Hickman et al. (2010).
The outcomes of the interviews can be grouped into three parts: the role of models in decision-making, the use of models in decision making and understanding the models.

In terms of the role of models in planning and policy analysis there are two contradictory views arising from the interviews conducted, which are similar to the dilemma presented in Section 3.3 concerning the tradeoffs between behavioural realism and complexity. On the one hand is the view that the models give too much detail and they need to be simplified in order to be understandable, more efficient and affordable for local authorities. On the other hand there is the view that the models in their current form, those used in the county council, do not answer all the questions that are asked in a planning exercise. For example, the more traditional models, those which are not of the activity-based type, do not include socio-economic factors, suggesting that activity based models, which are currently considered state-of-the-art, need to be used.

Quoting from our policy analyst:

“The general view I think would be [that] the models give too much detail... We [need] to take the results of that and simplify it, simplify and simplify just coming down to [an understandable level] ... that gives you the information at a sort of level that the councillors can deal within their constraints of time”.

On the other hand, the planner mentioned that:

“‘X’ model goes only so far in detail. It doesn’t go to the very fine detail. It has just the key routes in ‘Y city’ models. (...) [Models] helps us to understand the strategic impacts [of a development]”.

Having stated the different views on how the models should be designed and detailed, the policy analyst’s views on the role of models in policy making give us a better idea about the necessity of models in policy making:

“Models are important; they give us confidence to make recommendations to the councillors... When the councillors come down to make their choices, how much of the model is on their mind... We have to do the interpretation of it... If we didn’t have the model we could have never done this. I am sure we could have come up with good guesses but we wouldn’t have anything to back that up”.

However, it is debatable how much the politicians and decision makers rely on the models’ results. Politicians and planners/modellers have different views on the use of models in policy making. In the case of the UK county examined, politicians do not necessarily rely on models or feel the need to understand them:

“We don’t spend much time [on trying to understand the models] because we’ve got whole office full of people doing that. I am not a traffic planner... being a politician I am always involved in what’s happening in the local... So I can go to a briefing from the traffic planners but put my impression of local knowledge in to that to see whether that makes sense or not. So I think I can be very critical of what information is coming to me without spending too much time on it”.

As mentioned in the interview, politicians rely on their judgements - based on their local knowledge - more than on model’s analysis. On the contrary, policy analysts
acknowledge models as important tools for policy making and feel more confident when their decisions are based on the model results as mentioned in the previous paragraph. However, they do realise the fact that the politicians do not consider models as guides in policy making in the first place.

Traditional models might not meet the requirements of certain policies. Policies concerning environment or social inclusion would need different perspectives, which the conventional modelling cannot always supply. In such cases, other methods such as qualitative information from focus group meetings or professional judgements and different assessment methods would be needed. As our interviewees emphasized, models have constraints in policy making and therefore planners and policy makers must not just rely on them but look for other supplementary methods. Quoting from the interview with the policy analyst:

“Models have limits. That is where the assessment methods such as SEA come in use. SEA uses outcomes of the models as well as professional judgement”.

Likewise, planners have similar views:

“We wouldn’t want to just rely on models, we have to apply our experience in ‘Y city’ in particular to the situation. The model only tells you what is likely to happen so it doesn’t tell you the exact situation so you can only take models so far. It might not be very easy to understand for decision-makers but it is really important for coming to strategy…”

Lastly, the discussion on the attitude of the policy makers towards models shows that the politicians are not so interested in what the model offers as they are not usually experts in this area and they cannot conceive all the relevant information in meetings where the time is limited. The interviewee responsible of transport in the council cabinet mentioned that the information given at the meetings is not possible to comprehend even though this information is largely simplified:

“The biggest problem I found was that it wasn’t possible to disseminate that information... because it was too much for them [the cabinet members] to take on board unless they spend two days in their offices. There was such a wealth of information which we had to take some sort of overview. Plenty of information for us”.

Whether a more easy to understand model is what needed for decision makers is debatable.

4.1.3 Main empirical findings and issues

The interviews with various actors in the County Council mainly revealed some contradictory views on models and their use in policy making. The impression arising from the interviews were that models are well integrated into the policy process, but not necessarily useful. Similarly, models are seen as essential but of limited use/value at the same time for different actors. Furthermore, some acknowledge the importance of the model results, and feel more confident to make decisions based on such results, but feel the next level up in the decision making is sceptical about the use of model. This level acknowledged in the interviews that own judgment and knowledge of the ‘real’ world is more important.
It is interesting that the DfT is open about the use of models and, officially, advise local authorities to judge themselves if the use of models is necessary or not, but at the same time provides extensive guidance on the use of specific model as part of the evaluation of alternative plans. Furthermore, to the best of our knowledge, all the county councils rely on modelling in the planning process, perhaps pointing to the DfT unofficial view or to the practices that are so strongly embedded in both the DfT (and its predecessors) and the county councils.

Because of the high cost of acquiring new models and running them (including the cost of collecting the relevant data) for a specific county, different authorities use different types of models, with respect to current state-of-the-art, often relatively ‘old’ types of models. As one of our interviewees stated, the SATURN model was developed for ‘justifying’ road construction but is still used today to analyse various other policies, mainly because there are no resources to update the model.

One outcome of the lack of resources to update the county’s models is the need to outsource the modelling work (thus saving the need to buy the model). This put the modelling work and knowledge produced further away from the decision making.

The view that there needs to be a balance between considering the model results and own judgment of politicians based on, for example, their experience seems a healthy one. However, it is not clear that the right balance is achieved in practice and it might be that important information arising from the modelling analysis is too diluted when arriving at the top decision making level with respect to policies. First, the modelling work is done relatively far from the political level that needs to use it. Second, there is a feeling that the models give too much detail and need to be simplified in order to make them accessible for decision-makers and decision makers do not find it necessary to understand what is in the background of the suggestions based on the model results. Overall, there is the impression of disconnection between the policy makers using the models and their elected officials.

In the situation described above, the Intra-SIM model appears as an important tool to ‘reconnect’ between all the levels involved in using the models in the policy process, from those producing the model results, through to those translating them to policy evaluation, and those who should make the policy choices. Intra-SIM is basically a tool to communicate the results of (complicated) modelling. However, there is a risk that such a tool further turns modelling into a black box which hides the limitations of the models and allows the main assumptions to be ignored, forgotten. This might be counterproductive if, for example, the models used in the analysis are not deemed fit-for-purpose or not anymore state-of-the-art.
4.2 Evidence from transportation mega-projects in Israel

4.2.1 The policy process and models used in it

Decision making in transport is done in Israel mostly at the Ministry of Transport and Road Safety (MOT) and in coordination with the Ministry of Finance (MOF) that has to approve the budget for transport investments, including operation and maintenance. The MOT is responsible for transport planning in Israel and for building, operating and maintaining the various transport infrastructure and for regulations of the various services. It is also responsible for issuing and managing the bids for construction and operation of various infrastructure projects and services when these are carried out by the private sector.

Decision making in Israel is highly centralized in the sense that most of the decisions take place at the ministry level rather than at the local level, even when the projects are mostly local in nature. The main reason is that the funding largely comes directly from the government rather than from the local authorities. The local authorities, however, are responsible for infrastructure within their jurisdiction. With respect to public transport (projects), the local authorities are usually involved in the planning within their jurisdiction, but the MOT is in charge of providing licenses to operate the services, thus has the final say on every public transport project. Local authorities participate in infrastructure budget usually up to 30%, where in the case of public transport projects it is usually about 15%. Public transport planning is done mostly by the MOT but the operators, especially the large ones, are also involved in the process, the final approval of all plans, however, is by the MOT.

While the decision process is highly centralized at the MOT level, the MOT operates through various sub-companies who are either own by it or co-owned with the a local authority / authorities (examples include The National Road Company, Israel Rail, NTA – the Tel-Aviv area, Netivei-Ayalon – also in the Tel-Aviv area, Yefe-Nofo – in the Haifa area, and The Jerusalem Transportation Master Plan Team). There is some lack of clear responsibility, and overlap between these companies. For example, both NTA and Netivei-Ayalon are in charge of planning public transport in the Tel-Aviv metropolitan area. The lack of local Transportation Planning Authorities complicates the decision process and put a heavy load on the MOT.

Each of the various companies of the MOT promotes the projects under its responsibility. Accordingly, they are the ones who initiate the model development to support the project design as well as the model approval by the higher level of decision makers at the MOT and MOF. Furthermore, the companies are the ones executing the planning, bidding, and management of the projects within their responsibility, although most of the central, important decisions have to be approved by the MOT and MOF. The companies will either develop the models with their own manpower, although more often they will outsource the model development or parts of it to private consultants. The senior management people at these companies are very important actors in the decision making process and stands between the modellers - who either work within their company or work as consultants for them - and the policy makers at the MOT and MOF. We refer to
this senior management as the ‘professional officials’ who contribute to the planning, guide the modelling and evaluation effort and make the recommendation on the chosen alternative to the MOT and the local authorities involved. These professional officials are in some cases general managers of the companies, but in most cases they are only at high-management level and a non-professional general manager will be appointed above them and will usually accept their recommendation and will support them and deliver them to the MOT. This situation might open the door for biases in the use of models, yet we ignore this option in our research, while we do examine how it might influence the objective use of models in the decision making process.

The travel demand models used in Israel are of very high standards. The Tel-Aviv metropolitan area has just completed and starting to use a new activity based model (ABM) which represents the state of the art in travel demand models today. The Jerusalem metropolitan area is in the process of developing such a model. The Haifa and Beer-Sheva metropolitan areas have regional models, which are the traditional trip based, FSM, but of high quality. Recently, the MOT has also developed a nationwide model. These five models serve most of the transport planning needs in Israel.

The travel demand models are in most cases being constantly improved and updated but occasionally specific needs will motivate the development of a new model. This was the case with the development of the NTA model (NTA - the government-owned company charged with establishing the mass public transport system in the Tel Aviv metropolitan area) that was the main model for the Tel-Aviv area before the development of the new activity based model and the model used during the introduction of the new ABM model. The NTA model was developed specifically for the planning and design of the Tel-Aviv mass rapid public transport system, and accordingly it was highly focused on an advanced mode choice model. The development of the ABM for the Tel-Aviv metropolitan area and the Jerusalem area (under development) came in response to focus on various travel demand management policies, such as various parking and road pricing policies. It was realized that the better understanding of travel behaviour resulting from the use of these models is important for making controversial decisions that might not be politically accepted.

While the professional level fully believed that such models are really needed for such purposes, it is not clear to what extent the policy makers shared this view and motivation, and whether policy makers supported the model developments because they also believed it was necessary or because they felt they need the best state-of-the-art models to support their decisions. The above sets the context to examine the use of models in the policy process in Israel.

4.2.2 The use of models in the policy process

The Israeli case study focused on the use of models in the planning and decision making process of the mass transit projects in the three largest metropolitan areas in Israel: Tel-Aviv – where the first light rail line (which will partly be underground and will be part of a light rail and bus rapid transit network) is at the initial construction stages; Jerusalem –
where the first light rail line has just started operation (and similarly will be part of a future network); and Haifa where a bus rapid transit network is under development. In order to understand the role and use of models in the decision making process five interviews were conducted in June 2011 with various actors in those projects including:

- High official at the Ministry of Transport (Decision Maker 1)
- (former) High official in the Ministry of Interior– (Decision Maker 2)
- General Manager of company responsible for project A (Professional Official 1)
- General Manager of company responsible for project B (Professional Official 2)
- (former) General manager of company responsible for project C (Professional Official 3)

The interviews were supplemented with a workshop in which other policy makers, practitioners and academics took part.

It was clear from the interviews that in the Israeli case there is a very powerful actor standing between the modellers and the politicians or the decision makers at the ministry of transport. This actor is the group referred to above as the ‘professional officials’ and consultants in the government ministries and planning authorities. In the kind of mega projects discussed here, the planning process is accompanied by a steering committee composed of the intermediate level’s representatives and consultants from the government ministries and planning authorities and the local municipalities involved. This is the level that considers the engineering needs of the transport system very much through the use of, and based on, models. This level also balances the engineering needs, or model results, with the political- economic constraints, before plans move to the decision makers for approval. As Professional Official 2 described it:

“There is an intermediate level between the professional and the political levels, composed of professional officials and consultants... I am, as a presenter of the intermediate level’s official... analyse the results of the models and decide to what questions the model should provide answers, what questions the model does not provides answers and what is the chosen alternative... before it [the models outcome] moves on to the politicians…”

The open channel of communication these actors have - especially the general managers interviewed - with other actors in the planning process, and the confidence in them from those other actors, gives them a great level of influence on the decision making explained Professional Official 2. Furthermore, except for the final step of selecting the one alternative to proceed with, Professional Official 2 stated that:

“There are many planning issues [in] which the decision makers are the professional level [the intermediate level].”

However, the politicians naturally have a say as well, and in cases their ‘needs’ must be considered and accompanied – Professional Official 1 explained that this is in order to establish collaboration and trust relationships. In one of the projects, a new mayor opposing the project was elected, partly based on a campaign that promised to abort the project. After the election the mayor realised this is not possible, also since the budget comes from the Ministry of Transport and will otherwise be lost, and a compromised had to be agreed between him and the company (general manager) responsible for
constructing it. The company ‘saved’ one of the future lines the mayor wanted to abolish - where models showed future demand justify this line, and had to agree to extend another line to neighbourhoods the models show there is not enough (future) demand to justify it.

It was apparent that the models play a much greater role in the policy process in Israel than in the UK and that the various actors consider the model as an important tool in the decision making. Professional Official 1 described this very clearly. He first explained that ‘everything’ they do is:

“What the models say” and “where the model shows there is demand”.

He also noted on a more general level that:

“*There is a great belief by decision makers in the integration of the travel demand models in the planning process*” and that “*People believe in the model, that’s why there is no problem to get 10m [NIS] to finance the project of the new model*”

Professional Official 3 explained that:

*“The model [is] used by the decision makers not only as a tool for decision making, but also as a support and backup tool for decisions made”.*

He also noted, about the model used during his time as the general manager that:

“The model was great”.

At the same time, more balanced and moderate views on the role of models were also given, and even by the same interviewees. Decision Maker 1 explained:

“Without models you can’t do anything...Models help to say what will be in 30 years...so you need models.” [Although] “I’m not sure all the models really know to forecast the future ...[there is] no way to know if the model is a good model or bad model...We need to forecast so we need to use models”.

Having said that, he supported the decision, described above, to extend the line in one of the projects to areas where the model failed to show economic feasibility (due to low demand) on accessibility and equity grounds and the need to serve a major hospital by public transport - for the benefits of those who do not have access to a private car.

Despite his opinion on the model used in his company, Professional official 3 also expressed a more moderate view on models in general:

“One of the important objectives [of the model] is providing a forecast about future implications [results by] the project for some projection year... providing accurate forecasts is [the] main weakness of the models... It is necessary to understand the limitations of the model, and identifying strengths and weaknesses by investigation of previous models and [by] the comparison of forecasts and actual development”.

Decision Maker 2, who also wears the academic hat and to some extent reflected on the questions as an outsider to the process (or by looking back to when he had an official role) described the role of models in the planning process in Israel as follows:
"The transportation models are very significant and have great effect on the planning process... I think their [the models] effect is excessive... There are many problems in models and they need further development..."

He also further explained that:

"The models are 'black box' for some of the officials involved in decision making... [because of] their complexity, and the need of professional knowledge in their operation. They are not accessible to external intervention of policy makers and other unprofessional officials".

Professional Official 2 added in this context that:

"Most decision makers who use a model are not familiar with the model’s properties such as the model structure, model assumptions, explanatory variables etc....”.

The issue of communication between different actors and with relation to the use of models was prominent in the various discussions. In this respect the Israeli case study revealed several positive aspects. Perhaps the most notable referred to the use of the model results within the companies responsible for the large projects. As noted above, in some cases the models are developed in the companies, and the actual modelling work is mostly done in-house. Professional Official 3 said that:

"The direct communication between the modellers and decision makers [in the company] created a system of trust between the actors involved and increased the involvement and understanding of decision makers in the process... [and] enabled to better define the model’s objectives, and furthermore, to better use the model outcomes. In addition, the modellers [enabled to] developed a model that provides better answers”.

The down side of in-house model development was, however, also acknowledged. Professional Official 3 explained there is:

"[A] big problem of ownership of a specific model].

Decision Maker 1 gave the example of a model that had to be changed because it was “so bad”, but the company responsible for the project (and model) did not want the new model, fearing it will show that their decisions are not valid anymore. This hints to the weight of model results in making or at least justifying decisions in the policy process, an issue we return to below.

An unexpected and important influence of models on the process was mentioned by two professional officials. Professional Official 1 explained that the modelling results bring all sides to talk about the same numbers, and thus provide some common ground to start the discussion from. In the case of Professional Official 3, who had to deal with many different local municipalities in his project, he stated that model results are a good influence on the discussion because they are considered more objective, ‘clean’.

4.2.3 Main empirical findings and issues

Overall, the interviews carried out in Israel revealed similar ambiguities to those found in the UK case with respect to the use and role of models in the policy process. On the one
hand the impression was given that all decisions are fully backed up, and in cases perhaps even determined, by model results and at the same time the was a realisation of models’ limitations. Decision Maker 2 noted that transport models are the most developed and most influential in the planning process. “Too influential, too significant in my mind” he noted, yet also added: “but they should not be ignored”. He remembered a period in the 1960s when quantitative modelling was abandoned, but now it is back due to development and advances in computers, developments that aim to include social and environmental effects in the models – a “heroic attempt” in his words.

Two explanations for the heavy weight of models in the planning process in Israel can be that in Israel, according to Decision Maker 1, the ‘professional’ people have a very strong influence on the decision making more than in other countries. It can also be explained by what Decision Maker 2 refers to as “addiction to numbers” – a point we return to in the next section.

Compared with the UK, it seems in Israel there is much more reliance, and faith in the models, even if their limitation were also pointed out. This might be related to the type of policies and projected for which models are used. In Israel the stakes are much higher given the size of the projects and therefore the complexity and risk involved in the decision making. In turn, it can be argued, this also results in much more efforts (time, money, expertise) in developing the models and in modelling work in the Israeli case which perhaps only intensify any issues concerning the use of models in the policy process highlighted in both case studies.

Perhaps due to the relative importance of models in the projects studied in Israel, communication around the model results and the use of the models seemed to be much more positive in this case compared to the UK. However, this better communication, it seems, stops when model results need to reach the political level for making the most important decisions, like which alternative to choose. In this sense there seems to be no differences between the two countries and the different cases examined and no matter how sophisticated or not the models are, and whether special tools (like Intra-SIM) are used to help in the communications or not, the models remain black boxes. Given that transport policy decisions are at the end political decisions this is a problem.
5. Discussion

The discussion that follows is based on the literature reviewed and on both the UK and Israeli case studies, thus on the interviews described above, the discussions during the two workshops and the discussions amongst the research team during the course of the project.

It has to be emphasised at the outset, the starting point for the discussions, which has not changed during the project, is that models have a very important role to play in the planning process and the knowledge they produce for policy makers is vital. Furthermore, the evolution in model development, as presented in Section 3.2 resulted in more information and better knowledge that the models provide to base policy decisions on. However, it is also clear that there are problems with the current use of models in the policy process. These problems seem to be in part related to, and exacerbate by, the advances made in model development and the resultant increase in their complexity (Figures 5 and 6 – Section 3.3), but not only. One thing that was clear from both case studies and the models considered within them – including those considered today as not state-off-the-art, is that there is a gap between what can be considered good, or the best model from a modelling perspective and what can be considered the most useful, or useful from a policy perspective. This gap should be a worry to both modellers and policy makers and to those concerned with good governance and with making informed policy choices.

Those problems referred to above might be categorised as related to one of more of the following:

- The type of models used
- The information / knowledge models produce
- Communication between those who develop and run the models and those who use the results it provides
- The nature of the political policy-process

Participants at the UK workshop, mainly academics but also practitioners and policy makers, were presented with Figure 6 and were asked to point out where in their opinion is the current level of model development with respect to the maximum point on the curve representing the model’s benefits. The majority view was that at present we are right of the maximum benefits point, i.e. the models are too complex and the disadvantages of state-of-the-art models are larger than the benefits from the level of behavioural realism they provide.

It is evident that many of the problems with the use of models in the policy process arise from not using the ‘right’ models. This does not necessarily point to a fault in the model but a mismatch between the models and the environment in which they are used. It was stated by one of the workshop participants that the ‘best’ models, or the models that should be used, are “models that policy makers understand”. General Manager 2 argued that:
“First we must examine who are the decision makers and what the objectives are…[In some cases] there is no problem of model’s understanding...[However,] understanding the model’s results by decision makers is a necessary condition [for good model] but not a sufficient one”.

This can be interpreted as: understanding of the model by those supposed to use it is the first condition for a good model and should get priority in designing a model.

Decision Maker 2, in the Israeli case, stated that “planning must give an added value” and it seems at present models do not necessarily help to provide it. The models used in policy making are not always the best models to answer the question raised in the planning process; the model might be too complicated or too simple to meet the requirements of planning for that particular area and for the policies investigated.

The case studies showed different aspects of the problem. In Israel the models can be described as too complex, and the experience from Tel-Aviv indicates that state-of-the-art models when used in practice, ABM in this case, do not necessarily provide the expected better understanding of travel behaviour. But it can be still stated that the main benefit from improved models is in better understanding of travel behaviour. In the UK, a conclusion that arise is that the models used were seen as too complex by those needing to use their results, and at the same time, from a professional modelling perspective, seen as not state-of-the-art and not fit for purpose, considering the policy objectives and policies that were considered. In this respect, the use of a tool to communicate and graphically illustrate the model results might be counterproductive as it hides rather than overcome the weaknesses of the model.

How good the model is depends also on who its users are. The process of developing and running a model, but mainly using its output and accordingly what kind of information is produced depends on the users. Although there is a clear recognition that models cannot predict the future, there is nevertheless demand by decision makers to get prediction, unequivocal conclusion from the model results, rather than insight and a forecast with a wide range of variation. Advanced models do not necessarily provide more information, but assumingly better information, and this improvement in quality is not always appreciated by decision makers. In general, policy makers must be in a position to be able to ask the modellers ‘difficult questions’ about the results, but this is not possible if they do not understand the models and the results. This needs to be addressed in the longer term by bringing closer all those involved in the use of models in the policy process, which we discuss in the final section.

Another way to bring closer the models and those using them is through better communication of the model results, and also the model assumptions and limitations, to decision makers. The use of the model for policy purposes does not necessarily depend on the model’s level of complexity, but on how the modelling process and especially the results are presented to decision makers. Communication is important both to achieve an optimal engineering tool for planning and decision making and for increasing the involvement of decision makers in the modelling process in order to create better
understanding of the model capabilities and limitations, leading to better use of the results.

However, at present, given the nature of the policy process (discussed below), those responsible for communicating the model results (up the decision chain) face the dilemma of ‘truth vs. beauty’ in presenting results. Should the full, difficult to understand results be presented or the more ‘beautiful’ (simple) results – for example should a range (10 to 30%) or a single value (20%) be presented to decision makers. In the UK case study, in order to make the results clear to decision makers, the different results (values) for different policies obtained for different decision criteria had to be colour coded.

Lack of communication between modellers, planners and decision-makers substantially limit the usefulness of models for policy making. In this respect a graphical user interface, as discussed in the UK case, is seen as an important tool and a potential improvement for knowledge transfer. Such a tool can provide simulation of the model results (forecasts) with a convenient and friendly graphical user interface which can create an easy and clear language that all those involved, and especially decision makers, can understand. However, one of the participants in the Israeli workshop did raise concern about the use of such tools, explaining that:

“I am [in] doubt about the use of this kind of tool… the presentation of the model’s results as well as understanding [of] their implications is a more complex [matter] than [to] receive all the answers at the click of a button”.

Policy choices, in transport like in any other policy domain, are political choices made largely by elected politicians. The whole process of policy making is a political process, partly why policy problems often referred to as ‘wicked’ or ‘messy’ (see section 1). This nature of the process has a detrimental effect on the use of models and it is not accounted for in the model development, which is done at the research labs with focus only on increasing behavioural realism and not practical functionality. Model developers must acknowledge that the political reality of policy making is not going to change.

Often, the main barrier to better use of models in the policy process is decision makers not being interested or not having the time to engage in understanding the models (results). This reluctance to engage, however, might be related with the models being or perceived to be, too complicated to understand.

Decision Maker 2 raised the problem he termed ‘addiction to numbers’ amongst various actors supporting the policy process and the decision makers, which results in ignoring many of the models’ problems. First, engineers and economists - the main professions involved in transport planning, especially of mega-projects - ‘love’ numbers, thus feel comfortable with the models and might understand them more easily, compared to policy makers and politicians who often will have a different background. In addition, contributing to the addiction are lawyers who, the Decision Maker 2 describes:

“Love things which are objective, cannot be disputed and therefore also love numbers”.

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He also called for more reliance on knowledge and experience of planners and architects and argued that those involved in (transport) decision making should take more responsibility and rely less on the models’ results. This includes also relying less on the models when justifying decisions.

With the current organisation around the use of models and their development there are risks that lock-in effects prevent a different approach to model development and models’ use amongst those most involved: researchers, practitioners/consultants, and politicians. The risk of a professional capture of the system, together with a political capture and an academic capture all act against change in direction of model development and use. The academic ambition is to produce the most realistic model and to increase behavioural realism when it comes to transport policy. When they develop state-of-the-art models they need the practitioners to be able to apply and test the models in the field. The practitioners have also a financial interest in adopting state-of-the-art models which presumably will give them a market advantage. Given the scale of transport projects and the stakes in making a particular decision, politicians naturally only want to have the best models to assist in the decision making, without being able to judge to what extent state-of-the-art models can contribute to them making best or better decisions.

As we have seen, development of a model within an agency responsible for a project is likely to result in a model more suitable for the decision making concerning that specific project and policy objectives. But it can also result in a sense of ownership of the model and resistance to develop/use better models if those become available.

A gap certainly exists between those who develop and operate the models on the one hand and the policy makers and politicians that need to use them on the other hand. Yet, there is also a risk for a gap between those developing the models and pushing state-of-the-art and those using them and determining the state-of-the-practice. There is a risk, as noted in the UK workshop, for an unhealthy relation between researchers and practitioners. The researchers are racing ahead to improve models while the practitioners cannot catch up. In the practice however, practitioners turn to academics to give them the best models, even if these models cannot be useful for them as they are too complicated, complex.

In this sense it can be understood how better models are not necessarily more useful models. Developing more sophisticated models would not necessarily make the decision-making process easier, but could create models that are difficult to use, that require extensive data, knowledge and computation and that have the risk of making errors due to their complexity.

At present, and for the reasons discussed above, it seems the balance in model development should shift towards the use of more ‘simple’ models, despite their disadvantages in the investigation of various transport policies. Such models have greater chance of being used more efficiently in the policy process.
Model development for a specific case or model selection should always start with the question of whether there is a need for a model for the planning purposes, including consideration of budget and data availability, or the cost of obtaining it. Following a decision that a model, for example a travel demand model, is required, the model objectives and the questions it should answer must be determined. Model development without proper definition of model objectives may produce problematic forecasts which may cause inadequate planning in the short-term and general distrust in models in the long-term. These objective and questions must be clearly communicated by policy makers to those developing the models. It is then that model assumptions and data needs can appropriately be examined. In the UK workshop, there was a general agreement that many of the problems with models occur right at the start when data are gathered and the assumptions are made. Thus, the initial stages of modelling are of high importance to determine the quality of the whole process of the use of models in policy making.
6. Conclusions and further research

Mathematical and statistical models are essential tools for understanding complex phenomena such as those related to the challenges we face with respect to energy and the environment. As such, they are essential to direct policies that target these challenges. Advanced models, which can assist policy makers in formulating policies based on robust analysis of the likely impacts and effects of each policy considered, are constantly developed and used. Yet, policy makers might not have access to such models, and if they do they might not use them and/or not understand their results, as was evident with the travel demand models in transport policy. This is likely to have determinate effect on the policies that are eventually devised and implemented and may result in non-optimal decision making process.

In this context, the research aimed to investigate the contribution of quantitative analysis to the formulation of policies to address energy and environment challenges, focusing on the transport sector, and more specifically on travel demand models. In all respects, the use and role of models in the transport sector and transport policy domain is similar in nature to their use in other sectors and policy domains. Similarly, all the research evidence, findings and conclusion are likewise applicable to other sectors and policy domains.

This research explored the barriers for better use of advanced modelling in the practice in the course of the policy process. While there is no question that (quantitative) ex-ante analysis of policies has an important role to play in the policy making process and the use of advanced models in such an analysis is critical, the use of such models, it turns out, is in many respects problematic. Although only two case studies were analysed, there is no reason to believe that the findings and conclusions do not apply to all places with a similar planning system to that of the UK and Israel.

For various reasons, explored in the research, there exist a gap between the ‘knowledge’ state-of-the-art modelling can provide, those tasked with forming and deciding on policies, and the ‘knowledge’ they actually rely on to make decisions. On Landry’s (2001) ladder of knowledge utilisation it seems we are ‘stuck’ at the first stage of transmitting the results (of models) and far from the stage where these results become a cognition in the policy makers mind. The main reasons for this gap were explored in the previous section, but the development of more and more complex models, not unique in any way to transport modelling, seems to be one of the main, if not the main, reason. In theory the more complex models are better, otherwise they would not be considered as ‘development’, especially in capturing behavioural realism in the case of travel demand models. But this development does not translate to increasing the role and usefulness of models in the practice, in supporting decision making in the policy process, or to moving up the ladder of knowledge utilisation.
What should be the way forward to increase the contribution of models to policy decision making? How should we try to reduce the gap referred to above? Some indications were given in the previous section.

First, efforts need to focus on developing ‘simple’ state-of-the-art models. Developing models that policy makers understand is a pre-condition for a good model and does not necessarily mean going back in time to previous types of models, since also these in most cases were not ‘understandable’ to policy makers. There is a need to find better ways for these models to be more beneficial for planning. The principles for developing such models should include advancing flexible models that expose the assumptions to decision makers and show different alternatives and demonstrate how different assumptions change the results. This will require some direction in the efforts to improve the models. The new direction must take account of people needing to make decisions with the help of models, e.g. politicians, policy makers, and also take account of the political nature of policy making and thus the need for transparency and simplicity.

When new models are developed and introduced into the practice, there should be, as General Manager 3 suggested, a period of overlap where both the old and new models are used and results carefully compared. Differences in results must be analysed. There is also a need to determine that the new model indeed is more useful, or can be made so with some adjustments. This also calls for monitoring of the performance of various models and the development of a feedback procedure to report and investigate the use of models in policy making on a regular basis. Satisfaction of different users with the model should be the main criteria examined. In this context, there is certainly room for developing, preferably as part of the models, friendly user interface, one that all actors in the policy process can use and understand and one that strive to turn the model from a black-box to a transparent one.

Alongside the efforts to develop different models there is room for improving the communication of the results and model assumptions and limitations between the actors involved with the use of models in the policy process, including modellers, economists, planners, managers, lawyers, policy makers and politicians. Developing a common language between those involved, for example, policy makers and modellers, is an important step in improving communication. Cross-sectoral activities are very important. There is a great need for practitioners and decision makers; social scientists and modellers to work together from time to time and engage in each others’ activities and research and also increase their skills through training. In the case of transport, during modelling/engineering degrees at universities more emphasis should be put on teaching the importance of using models in the policy process and the current problems. Likewise, there should be more teaching of the main modelling approaches in planning degrees and all type of students should also meet in the ‘field’. It is mainly through such education and training that a common language might be created.

This new approach to model development and use of models can start via new research that will build on this research. Several routes are identified for such research. First, bringing together, like in this project researchers who mainly work in transport policy
and transport modelling to think how a state-of-the-art simple model might look like. Second, and again involving researchers from different backgrounds and also practitioners and policy makers focus on communication might be improved and a common language developed amongst those taking part in using models in the policy process. There are currently guides accompanying every model, but these do not provide any guidance on how to deal and try to eliminate any of the problems identified in this research, focusing only on the model manuals and technical operation. Thus, a third route, taking the current policy process and the models used in it as given, will aim to develop an official guidance on the use of models in policy making.

It is well known that modelling work and model development is an art more than a precise science. This art needs to reinvent itself!
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APPENDIX (Interview questions)

Semi-structured interviews with decision-makers; staff (high-rank officers, i.e. head of the planning department) at local authorities; modellers & planners whether internal or external; and coordinators.

Decision-makers: (constraints: limited time, unwillingness to be interviewed due to lack of knowledge, time or privacy)
(An investigation on decision makers’ background might change the course of the questions – education, previous experience in planning issues need to be investigated before the interview)

How do you approach to modelling outcomes or planning suggestions? What are your expectations from the model? Do you think it is important to use models in decision making; if so, why? What is your and your institution’s approach to decision making? Could you tell us how a project is developed in time?

How often do you exchange ideas with the planning group, modellers or the consultants? How easy is it to understand the outcomes of the quantitative analysis? Does the planning group (need to see the structure of the local authority) explain all facts of the project sufficiently? Do you feel you need more information (or less information) or a consultant to explain the results and strategies briefly? Or do you feel better when you can access the information on your own? How much of your or your institution’s vision you think is determined by the planning process? How much of it can be reflected to the final agenda within this process?

Staff (modellers, planners, academics) internal or external: Interviews can be structured in three different frameworks according to the policy approach of the institution:

Section 1 - willingness to adopt models in the policy making process
• Are models being used in the policy making process?
• If so, which models (traditional or state-of-the-art) are in use; and why?
• If traditional models are used, what is the reason for that? Is the institution familiar with new approaches and state-of-the-art models? If so, what is the reason of not adopting new models?
• What is the strategy for decision-making? How do you start working on your projects, in what order?

Section 2 (If the institution is using models) - understanding the models
• Are the models generated by using internal resources (staff, funding and equipment) or are they outsourced?
• Both in cases of using external (expertise, equipment) and internal resources what is the relationship between modellers and the policy group (including elected
politicians)? How easy to exchange ideas? What sort of techniques are used in order to do so?

- Are the results of the models understood by the policy group?
- What is the strategy for decision-making? How do you start working on your projects, in what order?

Section 3 - using models in policy making

- What is the strategy for decision-making? How do you start working on your projects, in what order?
- Are the results of the models used in decision making; if so, to what extent?
- Do the models cover all aspects of different policies or are there any lacking issues? (Especially in terms of energy and environmental issues)
- Are the models reliable?
- What is the role of models in decision making?
- What are the limitations (challenges) of using models in decision making?

Coordinators: semi-structured interviews

Definition of the interviewees’ role

How often do you meet decision makers and the staff? Do you meet the decision-makers separately or do you organise meetings together with the staff and/or technicians (i.e. modellers, academics both internal and external)? What kinds of difficulties have you come across so far? How do you approach decision-makers in this process and what kind of communication techniques do you use?