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Involving end-users in calibration and validation processes: A key factor to favor transfer of integrated models

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Context and motivation

Environmental issues now pose a threat to human civilization worldwide [1]. The risks associated with delayed reaction and adaptation times make the situation urgent [2]. The problems are amplified by their systemic nature: First the environment is degrading on all fronts at the same time and at the global planetary scale. Second the complexity and intertwining of our socio-economic organization are extreme. As focal points of human activity, urban areas concentrate and amplify environmental pressures in a direct or indirect way. Faced with this situation, researchers mobilize; in particular systemic and pluridisciplinary approaches have the wind in their sails. Nevertheless, and despite the urgency, there is a clear lack of transfer of sustainability science findings from the academic world to the political one. In this context, opening the discussion on how to ensure and accelerate the transfer of knowledge and associated tools developed by researchers on systemic modeling at local scale towards local decision makers is critical.

The objectives of the CITiES project[1], which builds on such a statement in the framework of"Land Use and Transport Interaction" modeling (LUTI), meet this need[2], at least in part (see for example [3] for a general overview of LUTI). In particular, we tackle two important bottlenecks: the complexity of the calibration processes and the assessment of the reliability of the models. For some time now, researchers interact with institutional actors to specify relevant urban policy scenarios and indicators used in LUTI models. But it seems that these interactions with stakeholders are not enoughto favor a large diffusion of these tools: Integrating end-users in the entire modeling process, from the definition of the objectives of the modeling exercise to the validation processes, appears as a determining factor. For example, the models' calibration processes must be appropriate to the constraints and limitations of local agencies and they have, like the validation procedures too, to be consistent with their needs and objectives. Let us also note that a deep analysis of the gap between academic and operational worlds is essential for a clear understanding of the situation and to see solution. With this goal in mind we first present in this article a work which is based on a survey and which aims at improving the understanding of the conditions under which LUTI models would be accepted and used by planners and practitioners. We also present a second work which focuses on more methodological propositions related to the necessity to well formalize the objectives of the modeling exercises with stakeholders, and for the modelers, to fully respect these objectives during the calibration and validation processes.

On acceptability of LUTI models by end users as operational tools

Methodology

While many articles are proposing state-of-the-art reviews and typologies of LUTI models, few are questioning their

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[1] See section "Acknowledgments".

[2] Focusing on such integrated models that are already quite complex but simpler than other more comprehensive integrated models should allow to eventually better grasp this general issue.

empirical application and use by potential stakeholders. To shed light on conditions under which LUTI models would definitely be considered as operational and practical tools, we make use of a qualitative survey focusing on some French practitioners. Our survey is based on20 questions about practical urban modeling and the demand for LUTI models. The survey has been sent to 30 French modeling practitioners (mainly transport); we have received 15 answers from consultant firms, state departments, local authorities and planning agencies. We synthesize their feedback on experience and expectations regarding LUTI modeling. We also benefit from interviews with top academics in the domain and key actorsof transport at the national and local level[3]. We have complemented this study by a work on the literature and by our own experience. Below we briefly summarize the first lessons learnt from the survey.

Results

Overall, practitioners who answer the survey consider LUTI as potentially useful tools to explore futures and develop strategies (20-30 years) at a rather aggregated level and large scale (see [4] for atheoretical usefulness of these tools). This echoes the importance for actors to consider transport and land use in an integrated manner. Actors have different expectations about LUTI. For example, for the Grand Paris project, the goal is to provide key insights on the wider economic benefit of the transport infrastructure, mainly concerning productivity of Ile de France (IDF). For the transport authority of IDF, the goal would be to provide demographic and economic prevision, as input for transport modeling. For local urban agencies, the SCOT (*Schéma de COhérence Territoriale*) is the evident document forthe use of LUTI. On the other hand, a use for public consultations and programming has not been highlighted and, concerning environmental impact study, the actor interests are rather heterogeneous.Despite the considerable interest of planning agencies and the important research investments in LUTI, it seems that daily use of these models in simulation of regional planning policies is still at an infancy age in France. Although several research projects have implemented LUTI models in different areas, the transferability of such approaches seems, up to very specific locations, to be the same everywhere: research results are going on but there is yet no clear adoption of such approaches by all stakeholders. Some of the reasons of this disaffection appear in the survey.For example it emerges that transport models are already considered as quite complex and heavy to manage. Moreover actors rather agree with the assertion "simulations of transport models are still too roughas it is; nothing is gained by adding complexity". Related to this last point, the black box issue is considered as very important. To weaken it, the actors request more precise identifications of the assumptions about inputs and outputs, and more explanations of their impacts. They suggest keeping LUTI models as first approach for educational purposes in order to understand only major equilibriums and drivers. They request model validations and discussions with all involved partners at all stages of the model design. Clearly the survey reveals that validation, or more generally model reliability, is critical. In this regard, sensitivity analysis appears to them somewhat more important than historical validation (also because of the transparency issue).

In other respects, a request concerns interoperability since the actors seem to want to keep the transport model they currently use. More generally, user-friendly software interfacing is also a key requirement. Finally, it is also crucial to pose the question about the relevance of the models developed by researchers with respect to the issues end users are confronted with.Whether small or large, as long as the cost to implement or handle a LUTI is more important than the real interest that local agencies have to use these models, they will not use these tools.We will come back to this issue in the next section.

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[3]Ministry of sustainable development and transport, French national railway network, chief economist of the *Société du Grand Paris*, Ile de France urban transport authority (STIF), etc.

Formalization of the objectives of the modeling exercises: From stakeholders to model calibration and validation

Methodology

Researchers are developing models, but are these models well adapted to the issues end users are confronted with? Developers of LUTI models represent the "real world" in such a way that it includes the objects on which the policy acts directly (tolls, road capacity, transit supply…) – or control variables – and the objects which the policy aims at having an impact on (road congestion, usage of car, usage of alternative modes…) – or state variables. To define these objects, the modeller needs inputs from the decision-maker for whom the model is designed. These inputs are used to choose the components of the models and the output indicators, but they are very rarely used in the calibration and validation processes that are, as mentioned in the previous section, key points for end-users. Nevertheless, it is crucial to rigorously and accurately define with decision-makers the criteria, which are used in the calibration and the validation procedures and according to which the model can be judged to be satisfactory for operational purposes. In other words, decision makers should say, a priori, what are the "acceptable" differences between the outputs of the model and the calibration/validation data (which are typically some observed data). Defining such criteria requires a sharper work than defining just indicators. For example, these criteria can concern the signs or the variations of some objects of interests. They can be on global trends; they can be absolute or relative andthey can be considered spatially up to added value, etc. The relative importance of the various criteria has also to be specified. Then developers have to formalize them mathematically in order to apply them, for example, in an objective function that could be used in the optimization procedure of the calibration. The definition of such objective functions is also crucial for the validation exercises based on sensitivity analysis...

Results

In our work, we are applying this methodology to an implementation of the TRANUS[4] model for Grenoble and to the SimBad model [5]. Here weonly illustrate the work on specification and formalization of policy objectives for the SimBad model. This model was conceived as a simulation tool to assess environmental, economic and social impacts of a given political decision on 25-years forecast. We used the objectives set by the official planning documents for the Lyon metropolitan area some of which are the following: (i) reduce the use of cars and increase that of alternative modes (transit, walk…) by rearranging the configuration of the public space (i.e. road and transit capacities); (ii) promote social equity by improving the accessibility of the periphery and (iii) improve the quality of life by reducing the nuisances resulting from the use of cars(e.g. noise)...These objectives were translated into indicators which are derived from the model outputs. For example, the reduction of car usage can be measured in terms of mode shares after the modal split module, but also in terms of vehicles*kilometers traveled after the route assignment module. Social equity can be measured by accessibility indicators for employment or other facilities. Here we are in the context of a multi-objective optimization problem, which is not as simple as a single objective problem. We have multiple and different criteria to satisfy; we don't have one single solution but a set of Pareto optimal solutions. In a decision maker context, finding a solution is equivalent to helping the decision maker to choose a solution among the Pareto optimal possibilities. In practice, the method has to be implemented via the decision maker who helps to differentiate solutions among the set: either a priori (with weighted objective functions, goal programming etc.), a posterior (producing all the Pareto optimal solutions and then letting the decision maker decide on the solution he prefers), or the interactive methods where iterative interactions with the decision maker allow to discriminate some subsets of solutions.

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[4]http://www.modelistica.com/english

Conclusions

With good reason, integrated urban modeling generates lot of interest for various actors. Nevertheless, as with LUTI and for the same reasons as the ones appearing in our survey, it is possible that operational actors show reluctance to use them or to build upon their results. The analysis of our survey should motivate researchers to act with caution and discernment with the development of integrated tools that could be too complex to be accepted by decision makers or other institutional players. To limit the difficulties, we suggest involving a maximum these actors at all stages of the design of the model, in particular in the calibration and validation steps (in addition to the definition of the scenarios and indicators). Validation by sensitivity analysis looks specifically promising in this context.

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