Towards a dynamic modeling of coevolution processes between transportation and land-use : Construction of a research agenda

Working Paper

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Abstract

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1 Introduction

1.1 Context

1.2 Scientific positioning

Within an evolutive urban theory [Pumain et al., 2006], a considerable body of knowledge on urban systems self-organisation has recently been built through the construction, the exploration and the calibration of thematic-based models of simulation, of which the serie of Simpop models is emblematic [Pumain, 2012a]. The elaboration of an integrated platform for the construction and the evaluation of geographical models, including the development of the user-friendly, yet powerful by the transparent access to grid computation ressources, Model Experiment software OpenMole [Reuillon et al., 2013], but also an epistemological framework and associated meta-heuristics for model validation [Rey-Coyrehourcq, 2015], was central for the establishment of evidence-based thematic conclusions, which differentiation with the consequent previous amount of geographical research lead by similar methods of agent-based modeling and simulation was indeed the introduction of novel methods and tools going a step further for the validation stage. A illustrative example is the application of the Calibration Profile algorithm (which reveals a single parameter influence on model performance within the whole parameter space) to the sufficient and necessary parameters to reproduce existing urban systems patterns on a long time scale by the SimpopLocal model [Schmitt et al., 2014], and other methods such as PSE algorithm aimed to detect rare outputs of a model, were successively applied, to the Marius model in that case [Chérel et al., 2015].

At first sight this methodological and scientific context seems rather disconnected from our geographical objects of study which are the processes of coevolution between transportation network and urban growth, in a generic form (i.e. at any scale temporal and spatial scales, and in any geographical context) in a first approach and of course geographically contextualized once the entreprise of this paper will have been completed. These works are indeed the giants on which shoulder we intend to stand on. We rely on Bretagnolle concluding considerations in [Bretagnolle, 2009], insisting on the need to pursue the various empirical findings on long-time network and cities interactions, by modeling approaches which should shed light on underlying coevolution processes. We propose to explore that paradigm which has been poorly tackled and has many obstacles associated with. Theoretically, Bretagnolle's work is positioning precisely within the evolutionnary urban framework, which assets include the compliance with complexity approaches which allow to take into account the particularities of urban systems such as their non-ergodicity [Pumain, 2012b]. Methodologically, it seems intuitively suitable to our purpose, what will be confirmed further. Indeed, many of the issues we will identify, espacially related to modeling, should be efficiently tackled building on it.

1.3 Modeling the coevolution : overview of the scientific landscape

Many disciplines have found interest in studying city growth, transportation network growth, or both including some of their interactions. Each has its own problematics, corresponding models and time scales. We propose an overview of the scientific landscape on the subject, to better understand typical issues that can arise.

Land-Use Transportation Interaction Models A wide range of models that have been developed mainly in an aim of transportation planning are the so-called Land-Use Transportation Interaction Models (LUTI). Transportation planners (historically beginning in the US for road infrastructure planning) mainly propose that kind of model to evaluate the impact of a new infrastructure on the evolution of the urban system through the impact on land-use. Recent reviews give an broad idea of existing approaches and capabilities of such models [Chang, 2006, Iacono et al., 2008, Wegener and Fürst, 2004]. Different scales can be considered (e.g. from the scale of the metropolitan area to the regional scale in the frame of regional planning). Contrary to most common ideas, these models do not necessarily rely on equilibrium assumptions [Kryvobokov et al., 2013]. Furthermore, operationnal models are still developped today and state-of-the-art models do provide accurate forecasts on an intermediate time-scale. Various features can be included, such as in [Delons et al., 2008] where a detailed structure of the metropolitan housing market for Paris region gives targeted high-resolution forecasts. The main feature of interest for our question is the fact that these models consider transportation network as static, and simulates the evolution of a dynamic land-use. It means that the characteristic time-scale is smaller than the time scale of infrastructure evolution.

Network Growth Modeling

Coevolution Approaches

1.4 Proposing a research agenda

The purpose of this paper is therefore to identify crucial obstacles to a dynamic modeling of coevolution, notions and methods associated, and to propose a research agenda making a synthesis of key problems that in our perspective need to be tackled to be able to construct such models.

The rest of the paper is organised as follows : we analyse first separately each axis proposed before, developing for each a specific problematic and proposing associated research projects. We make then a synthesis of these various aspects, establishing the research agenda.

2 Analysis

2.1 Giere's Deamon, or when disciplinary compartimentation narrows perspectives

As Laplace had its Deamon that was the embodiement of a determinist and reductivist approach to science , we could imagine Giere's Deamon, the embodiement of perspectivism.

2.2 Empirical analysis : “Lost in the Smog”

2.3 Methodological Foundations, need for concrete

2.4 Modeling the Governance : the Grand Pari(s)

3 Synthesis

3.1 Proposition of a research agenda

3.2 Towards calibrated dynamic models of coevolution

4 Conclusion

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